MORPHOLOGICAL CHARACTERS, YIELD ATTRIBUTES AND YIELD OF SESAME (*Sesamum indicum* L.) AS INFLUENCED BY NITROGEN AND NAA

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CERTIFICATE

This is to certify that the thesis entitled " MORPHOLOGICAL CHARECTERTS, YIELD ATTRIBUTES AND YIELD OF SESAME (Sesamum indicul L.) AS INFLUENCED BY NITROGEN AND NAA" submitted to the DEPARTMENT OF AGRICULTURAL BOTANY, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (M.S.) in AGRICULTURAL BOTANYY, embodies the results of a piece of bona fide research work carried out by MD. ABUBAKAR SIDDIK, Registration. No. 07- 02406, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.

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

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DEDICATED TO
MY
BELOVED PARENTS

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ABSTRACT

The experiment was undertaken in the Farm laboratory of Sher-e-Bangla Agricultural University, Dhaka, during Kharif 1 season, April to July 2013 to examine the response of different levels of nitrogen and foliar application of 1-napthaleneacitic acid (NAA) on morphology, yield contributing attributes and seed yield of sesame (*Sesamum indicum* L.) variety BARI Til 4 . In this experiment, the treatment consisted of three different N levels *viz*. N_0 = 0 kg N/ha, N_1 = 60 kg N/ha and N_2 = 120 kg N/ha and four different level of NAA *viz*. A_0 = 0 ppm, A_1= 25 ppm, A_2 =50 ppm and A_3 =75 ppm. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. The total treatment combinations were 12 (3x4). Results of the experiment showed a significant variation among the treatments in respect of the majority of the observed parameters. The N significantly increased morphological characters - plant height, number of leaves plant^{-1}, fresh and dry weight of shoot and root; yield contributing characters - number of pod plant^{-1}, pod diameter, pod length, seed weight plant^{-1}, seed weight plot^{-1},thousand seed weight compared to control. The maximum seed yield (1.26 t/ha) was obtained from 60 kg N/ha and suggesting that N can contribute to promote vegetative growth and yield of sesame. As N, NAA also stimulated the all morphological characters except leaf and branch number plant^{-1}of sesame. The maximum number of pod plant^{-1}, pod diameter, pod length, seed weight per plant, seed yield (1.22 t/ha) significantly increased with 50 ppm NAA. These results indicate that NAA has positive effect on reproductive attributes of sesame. The interaction between different levels of N and NAA did significantly influenced on almost all morphological parameters and yield contributing characters and seed yield of sesame. Separately, the leaf and branch number plant^{-1} of sesame did not show any significant difference with combined use of N and NAA. The maximum value of yield contributing characters, seed yield of sesame was observed with the combined dose of N_1A_2 (60 kg N/ha along with 50 ppm NAA) whereas the lowest values were obtained from control, N_0A_0 (0 kg N/ha and 0 ppm NAA) treatment combination. The maximum seed yield (1.49 t/ha) was obtained from 60 kg N/ha with 50 ppm NAA treatment combination. Based on the present results, it can be suggested that the combined use of 60 kg N/ha with 50 ppm NAA have increased plant morphology and seed yield of sesame.

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LIST OF ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
N	=	Nitrogen
NAA	=	1-Napthaleneacetic Acid
PGRs	=	Plant growth regulators
et. al.	=	And others
TSP	=	Triple Super Phosphate
MOP	=	Muirate of Potash
RCBD	=	Randomized Complete Block Design
DAS	=	Days after sowing
ha^{-1}	=	Per hectare
g	=	gram (s)
kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
wt	=	Weight
LSD	=	Least Significant Difference
^0C	=	Degree Celsius
NS	=	Not significant
Max	=	Maximum
Min	=	Minimum
%	=	Percent
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of Coefficient of Variance

Chapter I

INTODUCTION

Sesame (*Sesamum indicum* L.) is a flower bearing annually cultivated oil crop under the family of Pedaliaceae. The wild sesame is originated from Africa and the cultivated type is originated from India which also grown in Burma, India, China, Sudan and other countries in the world including Bangladesh (Ogasawara, 1988). It is widely naturalized in tropical regions around the world and is cultivated for its edible seeds, which grow in the form of pods and introduced over 3000 years before. Sesame is highly tolerant to drought or any other environmental variations where other crops may fail to grow (Raghav *et al.*, 1990). The world harvested about 4.76 million metric tons of sesame seeds in 2013 and the largest producer was Burma. The world's largest exporter of sesame seeds was India and Japan was the largest importer because they uses sesame seed in bakery industry (FAO, 2012). Bangladesh ranks twenty and share 0.8% in the total production of sesame in the world. According to cultivation and production it occupies third position as an oil crop in Bangladesh followed by rapeseed and mustard (BARI, 2001).

The sesame contains very high percent of oil in the range of 42-45%, 20% of protein and 14-20% of carbohydrate (BARI, 1998 and BINA, 2002) which is tasteless, nutty flavor and plays a vital role in human diet and used as a cuisine across the world (Hansen, 2011). It has 47 percent oleic and 39 percent linoleic acid and is rich in Omega 6 fatty acid, but lacks Omega 3 fatty acid. The nutritive value of sesame is excellent due to the most stable vegetable oils, with long shelf life, the high level of natural antioxidants: sesamin, sesamolin, and sesamol which inhibit the development of rancidity in the oil. It is also used in salad and margarine. The flour that remains after oil extraction is called sesame meal which is an excellent high-protein feed for poultry and livestock (Oplinger *et al*, 2011). It has been also reported that the addition of sesame to high lysine meal of soybean produces a well-balanced animal feed (Raghav *et al.*, 1990). The sesame meal also contains 35 to 50 percent protein, has good effective carbohydrates, and contains water-soluble antioxidants sesaminol, glucosides that provide added shelf-life to many products. Hill, (1972) reported that sesameolin is an antioxidant that is used for its synergistic effect in pyrethrum which increases the toxicity of insecticides.

Presently, Bangladesh faces an acute shortage of edible oil due to insufficient production of cooked oil in the country. Our production only ensures 4 g of oil per person whereas every man can consume 10 g of oil day^{-1}, indicates that extra 6 g added through import from other oil producing countries. Separately, it has been recommended that an adult should consume 22 g oil day^{-1} for better health. Thus we are experiencing 70% deficit of edible oil till to date. To meet up the demand of edible oil we are spending 160 million US dollar every year (Wahhab *et al*., 2002).

Sesame is one of the most important oil crops in Bangladesh and grown in all regions. In the year of 1999-2000, the crop covered an area of 96000 acres in Bangladesh with production of 25000 M tons (BBS, 2005). Recent BBS (2013) reported that 84310 acres of land cultivated for sesame and production was 30972 metric tons. The above information suggests that although the land of cultivation of sesame is decreasing whereas the production is increasing trend from 1999 to 2013. But in a view of population growth, the requirement of edible oil is increasing with high in demand than the production. It is therefore, highly expected that the production of edible oil should be increased considerably to fulfill the increasing demand. The production may be increased either by increasing cropping area under oil crop or increasing yield. But it is difficult to extent the area of oil production in our country due to over population, high demand of cereal crops etc. That is why the farmers of our country did not get enough interest to grow oil crops. In addition, Rahman *et al*., (1994) stated that sesame yield is very low in Bangladesh due to lack of proper management practices. Therefore, it is a general consensus that increasing yield per unit area is most reasonable way to increase total production of sesame. The yield of sesame may be increased by using numerous improved technologies and practices such as use of high yielding varieties and suitable practices. As practices, proper balanced supply of nutrients and application of plant growth regulators (PGRs) are one of the most important factors to increase higher yield.

It has been reported that fertigation is the depending source of nutrient that can be used to boost up growth and yield of crops (Sinha *et al*., 2003 and Zhao *et al*., 1997). Nitrogen (N) is one of the most important nutrient elements that accelerate the growth of the plant because it is a constituent of chlorophyll thus ensure crop growth vigorously (Dobermann and Fairhurst, 2000). The significant response of the number of leaves to N may have led to increase in photosynthetic activity thereby resulting in the improvement of morphological characters i.e. produced more branches and simultaneously enhanced pod production and thus increased seed yield (Shehu *et al*., 2009). The N can contribute to increase seed yield and protein content in seed by synthesizing more protein as N is a part of protein chemistry. Nitrogen (N) has an important role in seed protein and physiological functions of the plant and supports the plant with rapid growth, increasing seed and fruit production and enhancing quality of leaf and oil seed yield (Allen and Morgan, 2009). Previous many authors showed that the N significantly increased morphophysiological parameters such as leaf area and rate of photosynthesis etc. Separately, they also reported that N increases the vegetative growth but delayed maturity of seed yielding plants and excessive use of this element may produce too much of vegetative growth, thus food production may be impaired and suggesting that N management is crucial in cropping system and for normal plant growth and development (Maini *et al*., 1959). Unfortunately, N content of Bangladesh soil is very low and need to supply N fertilizer in proper amount in available form and at right time to make sure for better seed production. These results suggest that the optimum doses of N/ha for sesame seed yield is needed to examine.

Plant hormones are produced naturally by plants and are essential for regulating their own growth. They act by controlling or modifying plant growth processes, such as formation of leaves and flowers, elongation of stems, development and ripening of fruit. In modern agriculture, people have established the benefits of extending the use of plant hormones to regulate growth of other plants. The application of plant growth regulators in agriculture has started in the1930s in the USA. The plant hormone auxin is involved in a plethora of different developmental processes during the life cycle of a plant (Davies, 2010). In most tissues the auxin responses are concentration dependent and different tissues respond in a distinct manner to varying amounts of exogenous auxins (Thimann, 1937). Auxin was identified as a plant growth hormone because of its ability to stimulate differential growth in response to gravity or light stimuli (Bonner, 1952). Applications of IAA or synthetic auxins to plants cause profound changes in plant growth and development. Higher auxin concentrations might often be inhibitory, so the optimum endogenous level must be tightly controlled. Haque *et al*., (2005) stated that PGRs at 80 ppm as foliar spray have positive regulatory effect on morphological growth and yield contributing attributes of sesame.

In this study as a source of auxin, 1-napthaleneacetic acid (NAA) was used which commercial name Planofix. Sesame yield was increased by application of Planofix through increasing the number of flower clusters plant^{-1} and reduced percentage of flower drop during Kharif 1 in Bangladesh (Shakur, 1985). The NAA enhance endogenous levels of PGRs including gibberellins because auxin is necessary to gibberellins biosynthesis, which affect growth, physiological attributes and finally yield. Therefore, limited study has elucidated that NAA can modify the morphophysiologycal attributes and yield of sesame under SAU environmental conditions.

However, to my knowledge little is known whether different doses of N along with different doses of NAA regulate the growth, yield of sesame using new variety of BARI Til 4 which is pest and disease resistant. In view of above points a field experiment containing the treatments of N and NAA was conducted with the following objectives:

- To analyze the independent effects of N and NAA on the morphological characters and yield of sesame variety BARI Til 4.
- To investigate the interaction effects of N and NAA on morphological characters and yield of sesame variety BARI Til 4.
- To find out the best combination or combinations of N and NAA for better seed yield of variety BARI Til 4.

Chapter II

REVIEW OF LITERATURE

Among the oilseed crops, sesame occupies the third positions in Bangladesh. The proper fertilizer management and foliar application of plant growth regulators (PGRs) essentially influences it's morphological characters and yield performance. Experimental evidences showed that there is a profound influence of nitrogen (N) and 1-napthaleneacetic acid (NAA) on this crop. A brief of the relevant works performed in the past are presented in this Chapter.

2.1 Effect of nitrogen (N) on morphological parameters and seed yield of sesame:

Bijani *et al.* (2014) was conducted an experiment to evaluate of the effects of nitrogen and biological fertilizer on sesame crop as a factorial experiment based on a randomized complete block design with three replications in the research farm of the university of Zabol. Experimental factors were nitrogen (N) fertilizer at four levels (0, 160, 240 and 320 kg ha^{-1} N as urea) and nitroxin at two levels (inoculated and non-inoculated). When 240 kg ha^{-1} of urea was applied, number of lateral branches, 1000-seed weight, number of seeds per capsule, number of capsules per plant, and protein content increased by 50, 12, 18, 45 and 11%, respectively. The interaction of treatments revealed that inoculation of seeds with nitroxin along with 75% recommended N application increases plant height, seed and oil yield, respectively, by 28, 58 and 56% compared with non-inoculated seed and non N fertilizer application.

Haruna (2011) conducted a field trial during the rainy seasons of 2009 and 2010 to study the effects of nitrogen and intra row spacing on the growth and yield of sesame. In this experiment three levels of nitrogen in the form of urea (0, 50, and 100 kg N ha^{-1}) was used. Plant height, leaf area index, number of branches $plant^{-1}$, total dry matter $plant^{-1}$ and days to 50% flowering were optimized at 100 kg N ha^{-1}. Numbers of capsules $plant^{-1}$, capsule weight $plant^{-1}$, grain yield $plant^{-1}$ and grain yield ha^{-1} were optimized at 50 kg ha^{-1} of nitrogen. Maximum number capsules $plant^{-1}$, capsule weight $plant^{-1}$, grain yield $plant^{-1}$, grain yield ha^{-1} was recorded at 50 kg N ha^{-1} and planting at 15 cm intra row spacing in this area.

Field experiment was conducted by Muhamman *et al.* (2010) during 2005 and 2006 rainy seasons at the Teaching and Research Farm, Faculty of Agriculture, Adamawa State University, Mubi, Nigeria to study the effect of nitrogen (N) and phosphorous (P) rates on some growth and yield characteristics of sesame. The treatments consisted of four N rates: 0, 30, 60 and 90 kg ha^{-1} and four P rates: 0, 15, 30 and 45 kg ha^{-1}. Result obtained showed a positive relationship among the characters measured which also contributed meaningfully both directly and indirectly to total seed yield per plant with number of branches and plant height making the highest direct contributions, respectively.

Fumis (2004) stated that The sunflower plants were grown in vermiculite under two contrasting nitrogen supply, with nitrogen supplied as ammonium nitrate. Higher nitrogen concentration resulted in higher shoot dry matter production per plant and the effect was apparent from 29 days after sowing (DAS). The difference in dry matter production was mainly attributed to the effect of nitrogen on leaf production and on individual leaf dry matter. The specific leaf weight (SLW) was not affected by the nitrogen supply. The photosynthetic CO_2 assimilation (A) of the target leaves was remarkably improved by high nitrogen nutrition. However, irrespective of nitrogen supply, the decline in photosynthetic CO_2 assimilation occurred before the end of leaf growth. Although nitrogen did not change significantly stomatal conductance (gs), high-N grown plants had lower intercellular CO_2 concentration (Ci) when compared with low-N grown plants. Transpiration rate (E) was increased in high-N grown plants only at the beginning of leaf growth. However, this not resulted in lower intrinsic water use efficiency (WUE).

Study was conducted by Malik *et al.* (2003) during (2001) to see the influence of different nitrogen levels on productivity of sesame under varying planting geometry. The experiment comprised of three nitrogen levels (0, 40 and 80 kg ha^{-1}) and four planting methods (single row flat sowing, paired row planting, ridge sowing and bed sowing). Various growth and yield parameters of the crop were influenced differently by various nitrogen levels and planting methods. Among nitrogen levels, N_2 (80 kg ha^{-1}) treatment gave maximum seed yield (0.79 t ha^{-1}) and maximum seed oil content (45.88%) while among sowing methods bed sowing (50/30 cm) gave highest seed yield (0.85 t ha^{-1}) and seed oil contents (44.06%).

Abdel-Galil and Abdel-Ghany (2014) had reported that Increasing nitrogen fertilization rates from 107.1 to 178.5 kg N ha^{-1} resulted in significant increment in yield and its attributes of ground nut and sesame crops.

Field trials were conducted by Haruna and Aliyu (2012) during the rainy seasons of 2005, 2006 and 2007 at the Research Farm of Institute for Agricultural Research, Samaru, Nigeria to study the yield and economic return of sesame cv. Ex-Sudan as influenced by poultry manure, nitrogen, and phosphorus application. The experiment consisted of four rates of poultry manure (0, 5.0, 10.0, and 15.0 t ha^{-1}), three levels of nitrogen in the form of urea (0, 60, and 120 kg N ha^{-1}) and three levels of phosphorus in the form of single super phosphate (0, 13.2 and 26.4 kg P ha^{-1}) applied to the treatments. Applications of 5 t poultry manure ha-^{1}, 60 kg nitrogen ha^{-1} and 13.2 of phosphorus ha-^{1} seems to be the ideal rates for sesame production at Samaru, Nigeria and is therefore recommended.

Taylor *et al*. (2008) showed that the response of sesame to fertilizer was studied in 11 trials at four different sites, in which phosphorus was applied at rates from 0 to 26 kg ha^{-1} to the seed bed and nitrogen at rates from 0 to 60 kg ha^{-1} after thinning. Yield responses, found only to the main effects of nitrogen and phosphorus, are discussed in relation to soil type and previous cropping history of the sites and used to calculate gross cash returns from fertilizer use. Seed oil content was affected by environment, but responses to nitrogen and phosphorus were inconsistent.

A field study was conducted by Umar *et al*. (2012) to evaluate the performance of two sesame varieties in response to nitrogen fertilizer level and intra row spacing at the Research Farm of Institue for Agricultural Research Samaru in the Northern Guinea Savanna of Nigeria, during the wet seasons of 2009 and 2010. The treatments consisting of four nitrogen levels (20, 40, 60 and 80 kg N ha^{-1}), three intra row spacing (5, 10 and 15cm) and two varieties. The study resulted that application of 80 kg N ha^{-1} at 5cm intrarow spacing produced the highest grain yield of both varieties.

In order to study the effect of nitrogen regimes on vegetative growth parameters of sesame an experiment was conducted by Haghnama *et al*. (2009) in Ramian, Golestan province, Iran. The experimental treatments were two nitrogen amount (50 and 100 kg N ha^{-1}) and two sesame row spacing (40 and 60 cm). Investigation on main effects of experimental treatments showed significant increase in leaf area index and dry weight of shoot in sesame when nitrogen level increased.

Auwalu *et al.* (2007) conducted a field experiment and observed that the effect of nitrogen level (0, 30, 60 kg ha^{-1}) on the productivity of sesame (*S. radiatum*). They suggested that the farmers should grow vegetable sesame during rainy season and apply 30 kg ha^{-1} N in a single dose 2 weeks after sowing. It also produced high total marketable yield.

Pathak *et al.* (2002) evaluated the effect of nitrogen levels (0, 15, 30 and 45 kg ha^{-1}) on the growth and yield of sesame. N at 45 kg ha^{-1} 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 seed weight (2.9 g). N at 45 kg ha^{-1} also recorded the highest value for seed yield, net return and benefit cost ratio.

Alam (2002) evaluated the effect of N at 45, 60 and 75 per feddan on sesame cv. Giza-32 was studied. N as ammonium nitrate was applied after thinning and three weeks thereafter increasing N rate increased plant height, length of fruting zone, number of branches and capsule per plant and capsule length were highest with 60 and 75 kg ha^{-1} N per feddan.

Patra (2001) found out effects of N on yield and yield attributes of sesame cv. Kalika. N was applied at 0, 30, 60 and 90 kg ha^{-1}; plant height, branch per plant, capsule per plant, 1000 seed weight and seed yield significantly increased with 60 kg ha^{-1} N.

Tiwari *et al.* (1999) reported sesame cv. Co-1, Tka-9 and Tka-21 produce mean seed yield of 3.71, 3.17 and 2.57 t ha^{-1} respectively, while N rates 0, 30, 45, 60 and 75 kg ha^{-1} and produce mean yield 1.66, 2.27, 3.17, 4.19 and 4.41 t ha^{-1} respectively.

Sinharoy *et al.* (1990) found that application of 30 and 60 N kg ha^{-1} increased plant height, number of branches per plant, number of capsule per plant and gave average yield of 651 and 801 kg ha^{-1}.

The increase in plant height due to application of nitrogen may be attributed to better vegetative growth of sesame. These results are in conformity with the findings of Malik *et al.* (1988) who also reported that plant height increased with increasing levels of nitrogen.

Maximum number of capsules plant^{-1} (97.88) was produced at the nitrogen level of 80 kg ha^{-1}, followed by 40 kg N ha^{-1} which produced 92.50 capsules plant^{-1}. Minimum number of capsules plant^{-1} (88.55) was recorded in control treatment. It can be attributed towards more availability of nitrogen resulting in enhanced vegetative growth, leading to improved fruiting. These results are in line with those reported by Sharma and Kewat (1995).

There is highly significant difference among nitrogen levels for number of seeds capsule^{-1}. Maximum number of seeds capsule^{-1} (62.83) was produced when nitrogen was applied at the rate of 80 kg ha^{-1}. While minimum number of seeds capsule^{-1} (61.42) was produced in N_0 (control) treatment. Increase in number of seeds per capsule in N_2 (80 kg ha^{-1}) treatment might be attributed to better growth of the plant which ultimately increased number of seeds as compared to control. These results are in line with the findings of Subramanian *et al*. (1979).

The 1000-seed weight was significantly affected by nitrogen levels. The highest 1000- seed weight (3.42 g) was recorded in N2 (80 kg ha^{-1}) treatment, followed by N_1 (40 kg ha^{-1}) treatment that resulted in 3.22 g of 1000-seeds. While control resulted in lowest 1000-seed weight (2.97 g). These results are in line with those of Mankar *et al*. (1995) who reported that 1000- seed weight increased with increasing rate of N.

The response exhibited by sesame to nitrogen application as observed in increased plant height, LAI, number of branches per plant and the total dry matter per plant in all seasons could be attributed to the ability of N in promoting vegetative growth. This is in conformity with the findings of Okpara *et al.* (2007), who reported significant increase in such growth characters of sesame due to applied N. The number of days to 50% flowering was increased with nitrogen application. This could be attributed to the fact that nitrogen have been reported to increase leaf size and chlorophyll content, delayed maturity time and increased vegetative growth period (Haruna *et al*. 2011).

Yield components such as number of capsule per plant, capsule yield per plant, seed yield per plant and seed yield per hectare were all optimized at moderate N level (50 kg N ha^{-1}) and not the highest N level (100 kg N ha^{-1}) as in growth characters. This could be because excessive nitrogen has been reported to reduce fruit number and yield but enhances plant growth (Aliyu *et al*., 1996). This finding corroborated those of Roy *et al*. (1995), Gnanamurthy *et al*. (1992), Osman (1993), Okpara *et al*. (2007), Fathy and Mohammed (2009), Haruna *et al*. (2010).

Yield of sesame cv. Ex-Sudan was highest at moderate rate of applied poultry manure and nitrogen (5 t ha^{-1} and 60 kg N ha^{-1}) and not the highest doses. This could be because excessive nitrogen has been reported to reduce fruit number and yield for sesame but enhances plant growth (Aliyu *et al.* 1996). This finding corroborated those of Bonsu (2003), Fathy and Mohammed (2009).

2.2 Effect of 1-napthaleneacetic acid (NAA) on morphological parameters and seed yield of sesame:

A field experiment was carried out by Shashikumar *et al.* (2013) during kharif season of (2011) at Agricultural Research Station, Annigeri, Dharwad district (Zone-03), University of Agricultural Sciences, Dharwad to study the effect of growth regulator, organic and inorganic foliar nutrient sprays. The treatments comprised of RDF + foliar spray of 3% panchagavya, 5% cow urine, 2% Di- ammonium phosphate (DAP), 2% urea, 0.5% chelated micronutrient, 40ppm Naphthalene Acetic Acid (NAA), 1% salicylic acid, 2% DAP + 0.5% chelated micronutrient, 40 ppm NAA + 0.5% chelated micronutrient + 2% DAP, 1% salicylic acid + 2% DAP, control (RDF+ no spray), farmer's practice (50 kg DAP ha^{-1}). Application of RDF + foliar spray of 40ppm NAA + 0.5% chelated micronutrient + 2% DAP (T_9) recorded significantly higher grain yield (1298 kg ha^{-1}) and number of pods/plant (38.73).

Rajendran *et al.* (1998) conducted a field investigations which carried out during the summer of (1998) to evaluate the efficacy of various growth regulating chemicals such as NAA, CCC, ethrel, mepiquat chloride and methanol on the growth and yield of sesame. The treatments consisted of foliar application of the following chemicals at the pre-flowering stage of the crop: NAA (50 ppm), CCC (100 ppm), ethrel (100 ppm), mepiquat chloride (125 ppm) and methanol (5.0%) with a control, using a randomised block design. The results of the study revealed that the yield and its various attributes, the methanol treatment performed the best followed by NAA and ethrel.

An experiment was carried out by Haque (2005) at the field laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during March to July, 2005 to investigate the effect of GA_3 and NAA on morphological, growth and yield contributing characters of sesame (Binatil- l). Different concentrations of GA_3 and NAA *viz*., 0, 20, 40, 60, 80 ppm were applied as foliar spray at 25 DAS. In most of the cases, growth and yield were increased along with increased in concentration of GA_3 and NAA were noticed. The results of the experiment revealed that GA_3 and NAA at 80 ppm as foliar spray had positive regulatory effect on morphological growth, yield and yield contributing attributes of sesame.

Shahrior (2007) investigated the effect of NAA on morphological, growth and yield contributing characters of sesame (Binatil-1) at the Field Laboratory of the Department of Crop Botany, BAU, Mymensingh from February to May 2007. Different concentrations of NAA *viz*., 0, 50, 100, 150, 200 ppm were applied as seed treatment, foliar spray and seed treatment with foliar spray at 25 DAS. In most of the cases, growth and yield were increased with increasing of concentration and NAA at 200 ppm concentration was found to be the best for morphological growth, yield and yield contributing attributes of sesame.

An investigation aimed to enhance the yield of sesame by overcoming physiological problems such as flower drop and poor seed set was carried out by Prakash *et al*. (2003). Plant growth regulators such as Planofix, cytozyme, chamatkar, cycocel and micronutrients such as Zn, Mn and B were employed. The traits such as number of capsules, number of seeds per capsule, 1000 seed weight, shelling percentage, seed yield and oil content were studied. All these characters were more enhanced by planofix and $ZnSo_4$ than by other treatments.

Garai *et al*. (1990) was conducted a field trials in the rabi seasons during (1982-84). Mustard was given 10, 20 or 40 ppm. NAA, 5, 10 or 20 ppm. 2,4-D or no growth regulators. In a 2nd trial in the pre-kharif seasons of (1982-83) sesame cv. B_{14} was given 10, 20 or 40 ppm. NAA, 25, 50 or 100 ppm. IBA, 5, 10 or 20 ppm 2,4-D or no growth regulators. Seed yields of *B. juncea* and sesame were increased by all growth regulators tested except 20 ppm. 2,4-D. Seed and oil yields were highest with 20 ppm. NAA in *B. juncea* and with 25 ppm IBA in sesame.

Dani (1979) reported that foliar application of NAA at 20 ppm increased the grain yield and number of flowers and inflorescence in pigeon pea.

Shinde and Jadhav (1995) reported that foliar application of NAA at 50 ppm increased the harvest index by seven per cent and dry matter production in red gram.

Gupta and Singh (1982) revealed that foliar application of NAA at 40 ppm to groundnut increased the shelling percentage, 100 seed weight and protein content.

Kalita (1989) found significant increase in the number of pods in green gram by foliar application of NAA at 20 ppm. Application of NAA at 50 ppm significantly increased the cluster number in green gram.

Application of one per cent urea with NAA at 40 ppm significantly increased the yield by 268 kg ha^{-1} in chillies (Katwala and Saraf, 1990).

Ghosh *et al.* (1991) showed that application of NAA at pre flowering stage significantly increased shelling percentage in groundnut. Foliar application at 40 ppm significantly increased the 100 seed weight in green gram.

NAA was also found to increase the harvest index in pear millet (Rangacharya and Bawankar, 1991). Foliar application of 50 ppm NAA increased the amino nitrogen concentration in black gram.

Singh *et al.* (1995) reported that application of NAA increased the umbel length and more umbel number in onion.

Singh and Awasthi (1998) reported that protein content was increased by foliar spray of NAA at 40 ppm in green gram.

According to Sujatha (2001) foliar application of NAA at 40 ppm significantly increased the number of seeds per pod in green gram.

Foliar spray of NAA at 30 ppm at flowering increased the average pod weight, seed pod ratio and number of flowers in green gram as reported by (Sujatha, 2001).

Radhamani *et al.* (2003) observed that increase in test weight was due to NAA at 10 ppm in green gram.

Foliar spray of NAA at 30 ppm concentrate was found to be more effective in increasing the number of branches, total dry weight, number of pods per plant, 1000 grain weight and grain yield, and chlorophyll content as reported by Ramanathan *et al.* (2004) in black gram.

Karim *et al.* (2006) obtained that higher protein content (23.99%) in chickpea with 100 ppm of NAA.

Naphthaleneacetic acid is the organic substance which promotes the growth of plant and leads to more productivity, Varma *et al.* (2009) reported that NAA application increased seed yield in black gram.

Planofix (NAA) increased number of pods plant-^{1}, dry pod yield and 100 seed weight in groundnut (40 and 50 days after sowing) (Singh and Sharma, 1982).

Suty (1984) reported that Rhodofix (NAA) at 3.4 g ha-^{1} increased the number of pods per plant, seeds per pod, 100 seed weight and yield in faba bean.

Bai *et al.* (1987) applied eight foliar sprays of 25 mg L- 1 NAA at 7 days intervals to *Vigna rediata* and reported a significant increase in seed yield and yield components.

Planofix (Naphthalene Acetic Acid) had a significant effect on plant height, number of fruiting branches, volume of boll and yield in cotton (Abro *et al.*, 2004).

Naphthalene Acetic Acid 20 ppm showed better performance in enhancing the straw and grain yields of wheat cultivars (Alam *et al.*, 2002).

Zaferanchi *et al*. (2011) investigated that the effect of two plant growth regulators, Naphtalene acetic acid (NAA) and Benzylamino purine (BAP) on yield, yield components, oil and protein content of sesame genotypes an experiment was carried out at the research farm, Shahid Bahonar University of Kerman in growing season (2006). The studied factors were two plants growth regulators BAP NAA each of which containing three levels as well as control with four sesame genotypes. Foliage spray at 30 ppm and 200 ppm of NAA and BAP concentrations were carried out at the beginning of flowering stage. The results of analysis of variance showed that NAA and BAP treated plants showed a better performance in yield, yield components and some parameters.

Chapter III

MATERIALS AND METHODS

The experiment was undertaken during Kharif 1 season, April 2013 to July 2013 to examine the response to different levels of nitrogen (N) and 1-napthaleneacetic acid (NAA) on morphology, yield and yield attributes of sesame variety BARI Til 4.

3.1 Experimental site

The experiment was carried out at Sher-e-Bangla Agricultural University Farm, Dhaka-1207, Bangladesh. It is located at $90^{0}22^{'}$ E longitude and 23°4l′ N latitude at an altitude of 8.6 meters above the sea level. The land belongs to Agro-ecological zone of Modhupur Tract, AEZ-28.

3.2 Climatic condition

The experimental area is under the sub-tropical climate that is characterized by less rainfall associated with moderately low temperature during rabi season, (October-March) and high temperature, high humidity and heavy rainfall with occasional gusty winds during kharif season (April-September).

3.3 Soil condition

The soil of experimental area situated to the Modhupur Tract (UNDP, 1988) under the AEZ no. 28 and Tejgoan soil series (FAO, 1988). The soil was sandy loam in texture with pH 5.47 - 5.63. The physical and chemical characteristics of the soil have been presented in Appendix I.

3.4 Materials

3.4.1 Seed

A pest and disease resistant and high yielding variety of sesame, BARI Til 4 developed by the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur and was used as an experimental material. The seed was collected from the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Before sowing of the seed in the experimental plot, germination test was done in the laboratory and results of percentage of germination was over 90%.

3.4.2 Fertilizers

The recommended doses (BARI, 2014) of Triple super phosphate (TSP) as a source of phosphorus (P), Muriate of Potash (MP) as a source of Potash (K), Gypsum as a source of Sulpher (S) and Boric acid as a source of Boron (B) were added to the soil of experimental field along with different levels of Nitrogen (N) in the form of Urea and NAA according to the treatment of the experiment.

3.5 Methods

3.5.1 Treatments

Factor A: 3 levels of N (kg ha^{-1})	**Factor B: 4 levels of NAA (ppm)**
$N_0 = 0$	$A_0 = 0$
$N_1 = 60$	$A_1 = 25$
$N_2 = 120$	$A_2 = 50$
	$A_3 = 75$

3.5.2 Treatment combinations

There are 12 treatment combinations of different N and NAA doses used in the experiment under as following:

1. N_0A_0
2. N_0A_1
3. N_0A_2
4. N_0A_3
5. N_1A_0
6. N_1A_1
7. N_1A_2
8. N_1A_3
9. N_2A_0
10. N_2A_1
11. N_2A_2
12. N_2A_3

3.5.3 Design and layout

The experiment consisted of 12 treatment combinations and was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. The total plot number was 12 × 3 = 36. The unit plot size was 2 m × 1.5 m = 3 m^2. The distance between blocks was 1 m and distance between plots was 0.5 m and plant spacing was 30 cm × 5 cm. The layout of the experiment is presented in Appendix II.

3.5.4 Land preparation

The land was ploughed with a rotary plough and power tiller for four times. Ploughed soil was then brought into desirable fine tilth and leveled by laddering. The weeds were clean properly. The final ploughing and land preparation were done on 1 April, 2013. According to the lay out of the experiment the entire experimental area was divided into blocks and prepared the experimental plot for the sowing of sesame seed. In addition, irrigation and drainage channels were made around the plot.

3.5.5 Fertilization

In this experiment fertilizers were used according to Bangladesh Agricultural Reserch Institute (BARI, 2014) Information which is given under as follows:

Name of Nutrients	**Name of Fertilizers**	**Rate of Application (kg ha^{-1})**
Nitrogen (N)	Urea	As per treatment
Phosphorus (P)	Triple Super Phosphate	140
Potash (K)	Muriate of Potash	45
Sulpher (S)	Gypsum	105
Boron (B)	Boric acid	10
Zinc (Zn)	Zinc Oxide	5

The amounts of fertilizer as per treatment in the forms of urea, triple super phosphate, muriate of potash, gypsum, boric acid and zinc oxide required per plot were calculated. The triple super phosphate, muriate of potash, gypsum, zinc oxide and boric acid was applied during final land preparation. Half of urea was applied in each experimental unit plot according to treatment combination and incorporated into soil before sowing seed. Rest of the urea was top dressed after 20 days after sowing (DAS).

3.5.6 Plant growth regulator (PGRs)

In this experiment plant growth regulator planofix which as the source of 1-napthaleneacetic acid (NAA) was applied through foliar spray in each experimental unit plot according to treatment. It was applied two times during 25 days after sowing (DAS) and 45 days after sowing (DAS).

3.5.7 Sowing of seed

Sowing was done on 13 April, 2013 in rows 30 cm apart. Seeds were sown continuously in rows at a rate of 7.5 kg ha^{-1}. After sowing, the seeds were covered with the soil and slightly pressed by hand, and applied little amount water for better germination of seeds.

3.5.8 Thinning and weeding

The optimum plant population, 60 plants m^{-2} was maintained by thinning excess plant at 15 DAS. The plant to plant distance was maintained as 5 cm in the row. One weeding with khurpi was given on 25 DAS.

3.5.9 Irrigation

Two irrigations were given as plants required. First irrigation was given immediate after topdressing and second irrigation were applied 60 DAS with watering can. After irrigation when the plots were in zoe condition, spading was done uniformly and carefully to conserve the soil moisture for proper growth and development of plants.

3.5.10 Crop protection

As per preventive measure seed was treated with a fungicide Vitavex 200 @ 2 g kg^{-1} before showing. As a preventive measure of fungal disease, Diathen M 45 EC @ 2 ml litre $^{-1}$ of water was applied twice first at 25 DAS and second at 50 DAS.

3.5.11 General observation of the experimental field

The field was investigated frequently in order to reduce losses with weeds competition and insects infestation and diseases infection.

3.5.12 Harvesting and threshing

Previous randomly selected ten plants, those were considered for the growth analysis was collected from each plot to analyze the yield and yield contributing characters. Rest of the crops was harvested when 80% of the pod in terminal raceme turned grayish in color. After collecting sample plants, harvesting was started on July 11 and completed on July 16, 2013. The harvested crops were tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated from the plants by beating the bundles with bamboo sticks.

3.5.13 Drying and weighting

The seeds thus collected were dried in the sun for couple of days. Dried seeds of each plot was weighted and subsequently converted into yield kg ha^{-1}.

3.6. Data collection

Ten (10) plants from each plot were selected as random and were tagged for the data collection. Some data were collected from 30 days sowing with 10 days interval and some data were collected at harvesting stage. The sample plants were uprooted prior to harvest and dried properly in the sun. The seed yield $plot^{-1}$ was recorded after cleaning and drying those properly in the sun. Data were collected on the following parameters:

1. Plant height (cm)
2. No. of leaves $plant^{-1}$
3. No. of primary branches $plant^{-1}$
4. Fresh and dry weight of Shoot (g)
5. Fresh and dry weight of Root (g)
6. No. of pod $plant^{-1}$
7. Pod length (mm)
8. Pod diameter (mm)
9. Seed weight $plant^{-1}$ (g)
10. Seed weight $plot^{-1}$ (g)
11. Seed weight of 1000 seed (g)
12. Yield (t ha^{-1})

3.6.1 Plant height (cm)

Plant height was measured three times at 10 days interval such as 30, 40 and 50 DAS. The height of the plant was measured by scale considering the distance from the soil surface to the tip of the randomly ten selected plants and mean value was calculated for each treatment.

3.6.2 Number of leaves plant^{-1}

Number of leaves per plant was counted three times at 10 days interval such as 30, 40, 50 DAS. Mean value of data were calculated and recorded.

3.6.3 Number of primary branches plant^{-1}

The number of primary branches per plant was counted three times at 10 days interval such as 30, 40 and 50 DAS of sesame plants. Mean value of data were calculated and recorded.

3.6.4 Shoot fresh and dry weight (g)

The shoot fresh weight of ten plants was taken by weight balance on fresh condition. After sun drying of fresh shoot, it was kept in oven for 72 hours at 80^{o} c for each treatment then dry weight was taken by balance. Mean of shoot fresh and dry weight was calculated and expressed in g.

3.6.5 Root fresh and dry weight (g)

The root fresh weight of ten plants was taken by weight balance on fresh condition after removing the soil properly from root. After sun drying of fresh root, it was kept in oven for 72 hours at 80^{o} c for each treatment then dry weight was taken by balance. Mean weight of fresh root and dry root was calculated and expressed in g.

3.6.6 Number of pod plant^{-1}

The number of pods of main inflorescence from ten plants were counted and calculated as per plant basis.

3.6.7 Pod length (mm)

Pod length was taken by Slide calipers from ten plants for each treatment. The mean length of pod of sesame was calculated and expressed in mm.

3.6.8 Pod diameters (mm)

Pod diameter was taken by Slide calipers from ten plants for each treatment. The mean diameter of pod of sesame was calculated and expressed in mm.

3.6.9 Seed weight of plant^{-1} (g)

Total pod were collected from each of sesame plant. The pods were cut, threshed and dried. The dried seeds were weighed. Then the weighed seed yield was converted to gm.

3.6.10 Seed weight plot^{-1} (g)

Total sesame plants were collected from each plot .The plants were cut, threshed and dried. The dried seeds were weighed. Then the weighed seed yield was converted to gm.

3.6.11 Thousand seed weight (g)

A composite sample was taken from the yield of ten plants. The thousand seeds of each plot were counted and weighed with a digital electric balance. The thousand seed weight was recorded in gm.

3.6.12 Yield (t ha^{-1})

After threshing, cleaning and drying, total seed from harvested area were recorded and was converted to t ha^{-1}.

3.7 Data analysis

The data obtained from the experiment were subjected to statistical analysis following analysis of variance technique (Russell 1986). The mean differences were tested through, least significant difference (LSD) method.

Chapter IV

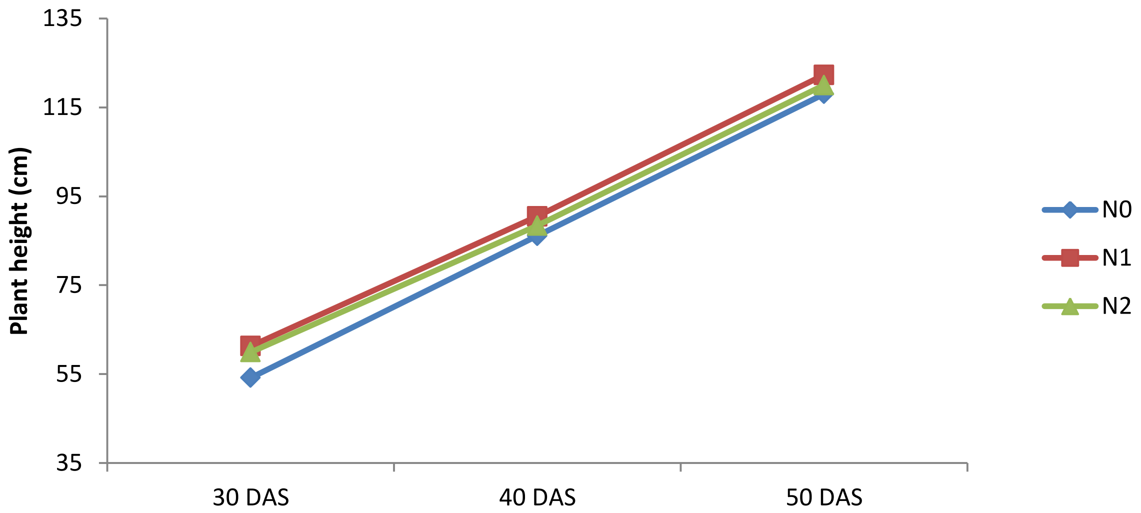
RESULTS AND DISCUSSION

The results obtained with different levels of nitrogen (N) and1-napthaleneacitic acid (NAA) and their combinations are presented and discussed in this chapter. Data about morphological parameters, yield contributing characters and seed yield of sesame have been presented in both Tables and Figures and analyzes of variance and corresponding degrees of freedom have been shown in Appendix.

4.1 Plant height (cm)

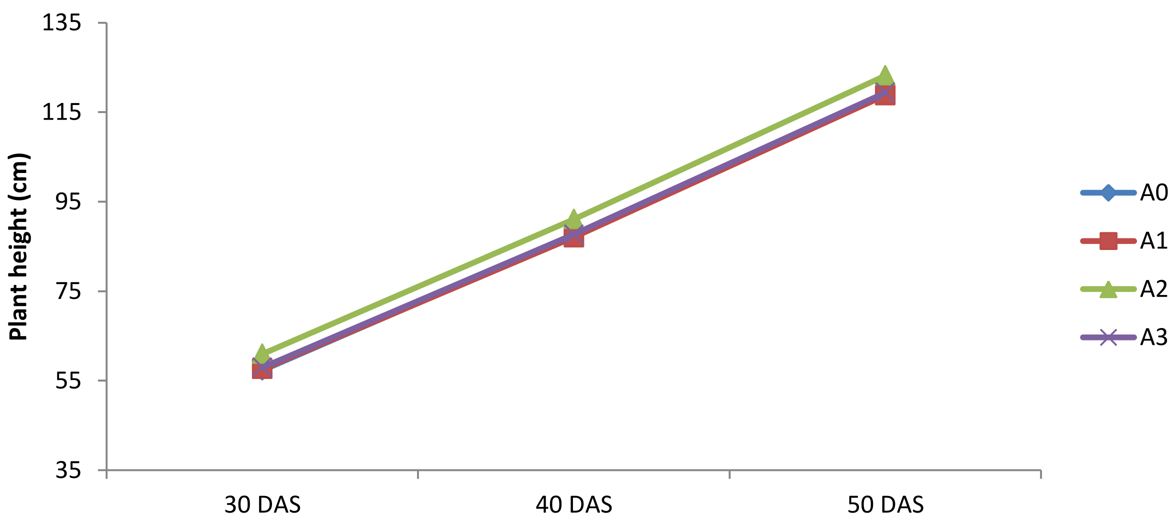
In this experiment different levels of nitrogen (N) fertilizer showed significant effect on plant height of sesame at 30 days after sowing (DAS), 40 DAS and 50 DAS (Fig. 1 and Appendix III). At 30 DAS, the highest plant height (61.31 cm) was observed from the N_1 (60 kg N ha^{-1}) which was statistically similar with N_2 (59.95 cm) and the lowest (54.17 cm) was observed from N_0, 0 kg N ha^{-1}. At 40 DAS, the highest plant height (90.47 cm) was observed from the N_1 (60 kg N ha^{-1}) which was statistically similar with N_2 (120 kg N ha^{-1}) (90.40 cm) whereas the lowest (86.10 cm) was observed from N_0. At 50 DAS, the highest plant height (121.3 cm) was observed from the N_1 which was statistically similar with N_2 (122.3 cm) whereas the lowest (118.0 cm) was observed from N_0. So the highest plant height at 30 DAS, 40 DAS and 50 DAS was from N_1 (60 kg ha^{-1} N) which similar to obsereved by Pathak et al. (2002), Patra (2001) and Alam (2002).

In this study, I used planofix as as a source of 1-Naphthaleneacetic acid (NAA) to examine the role of planofix on elongation of sesame plant height. Planofix had insignificant effect on plant height of sesame at 30 DAS whereas significant effect at 40 DAS and 50 DAS (Fig. 2 and Appendix III). At 30 DAS, the highest plant height (60.98 cm) was observed from the $A_{2,}$ 50 ppm NAA and the lowest (57.31 cm) was observed from A_0 (0 ppm NAA). At 40 DAS, the highest plant height (91.10 cm) was observed from the A_2 (50 ppm NAA) and the lowest (87.06 cm) was observed from A_0 which was statistically similar with A_1 (25 ppm NAA) and $A_{3,}$ 75 ppm. At 50 DAS, the highest plant height (123.2 cm) was observed from the A_2 and the lowest (118.0 cm) was observed from A_0 treatment which was statistically similar with A_1 and A_3. These findings are in agreement with those of Bharud *et al.* (1986), Lakshmamma and Rao (1996) and Kelaiya *et al.* (1991).



N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1} nitrogen applied as urea,
N_2– 120 kg ha^{-1} nitrogen applied as urea, DAS (days after sowing)

Fig. : 1. Effect of differents levels of nitrogen at different days after sowing (DAS) on the height of sesame plant



A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix
DAS (Days after sowing)

Fig.: 2. Effect of differents levels of NAA at different days after sowing (DAS) on the height of sesame plant

The results suggest that among the growth regulators NAA was found to be the most effective to increase plant height.

Interaction of nitrogen fertilizer doses and NAA doses showed significant variation on plant height of sesame at 30 DAS, 40 DAS and 50 DAS (Table 1 and Appendix III). At 30 DAS, the highest plant height (67.73 cm) was observed from the N_1A_2 (60 kg N ha^{-1} with 50 ppm NAA) treatment and the lowest (50.87 cm) was observed from N_0A_0 (0 kg N ha^{-1} with 0 ppm NAA) treatment which was statistically similar with N_0A_1 (54.57 cm) and N_0A_3 (53.72 cm). At 40 DAS, the highest plant height (94.23 cm) was observed from the N_1A_2 treatment and the lowest (82.80 cm) was observed from N_0A_0 treatment which was statistically similar with N_0 A_1 (84.67 cm). At 50 DAS, the highest plant height (124.4 cm) was observed from the N_1A_2 treatment and the lowest (114.5 cm) was observed from N_0A_0 treatment which was statistically similar with N_0A_1 (118.7 cm), N_0A_3 (118.0 cm), N_1A_1 (118.0 cm), N_2A_0 (119.2 cm), and N_2A_1 (119.7 cm). All together these results indicate that plant height was increased with the combined use of N and NAA.

4.2 Number of leaf plant^{-1}

Nitrogen fertilizers had significant effect on number of leaf $plant^{-1}$ of sesame at 30 DAS, 40 DAS and 50 DAS (Fig. 3 and Appendix IV). At 30 DAS, the highest number of leaf $plant^{-1}$ (15.42) was observed from the N_1 which was statistically similar with N_2 (15.08) and the lowest (13.08) was observed from N_0. At 40 DAS, the highest number of leaf plant $^{-1}$ (18.25) was observed from the N_1 which was statistically similar with N_2 (17.08) and the lowest (14.92) was observed from N_0 which was statistically similar with N_2 (17.08). At 50 DAS, the highest number of leaf $plant^{-1}$ (37.67) was observed from the $N_1$and the lowest (30.25) was observed from N_0 which was statistically similar with N_2 (33.50). These findings were similar to Okpara *et al.,* (2007), who reported that increased in such growth characters of sesame due to applied N. Leaf number of sesame plant increased with the increased application of nitrogen fertilizer up to a certain limit was stated by Patra (2001).

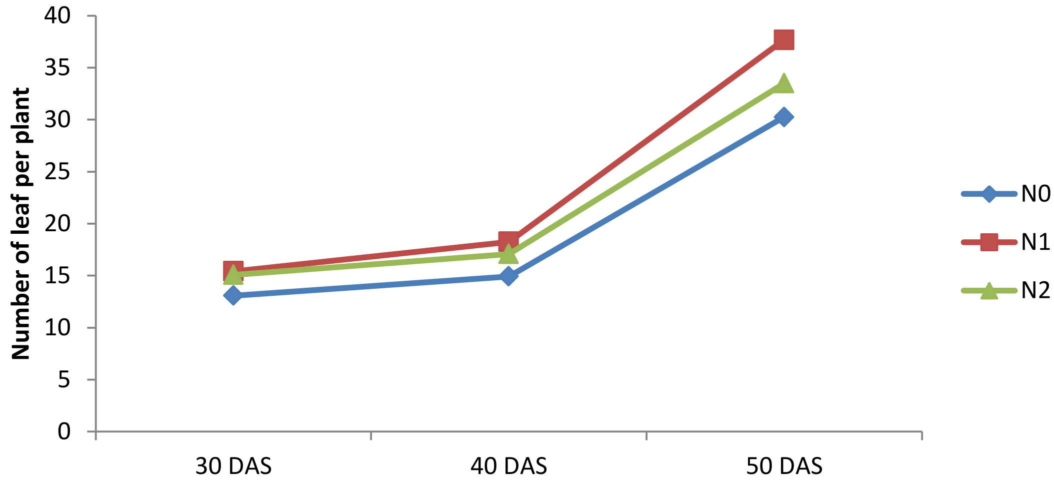
Table 1. Combined effect of nitrogen and NAA on the plant height of sesame at different days after sowing (DAS)

Treatment	Plant height(cm)		
	30 DAS	40 DAS	50 DAS
$N_0 A_0$	50.87 e	82.80 d	114.5 c
$N_0 A_1$	54.57 cde	84.67 cd	118.7 bc
$N_0 A_2$	57.53 bcd	89.13 b	120.9 b
$N_0 A_3$	53.72 de	87.80 bc	118.0 bc
$N_1 A_0$	60.13 b	89.73 b	121.3 b
$N_1 A_1$	58.70 bcd	88.83 bc	118.0 bc
$N_1 A_2$	67.73 a	96.23 a	124.4 a
$N_1 A_3$	58.67 bcd	87.07 bc	120.6 b
$N_2 A_0$	60.93 b	89.80 b	119.2 bc
$N_2 A_1$	59.60 bc	87.67 bc	119.7 bc
$N_2 A_2$	57.67 bcd	87.93 bc	121.2 bc
$N_2 A_3$	61.62 b	88.20 bc	119.8 b
LSD (0.05)	5.156	4.259	4.301
Significant level	*	*	*
CV (%)	5.20%	5.85%	4.61%

N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1} nitrogen applied as urea ,
N_2– 120 kg ha^{-1} nitrogen applied as urea, DAS = DAS (Days after sowing)

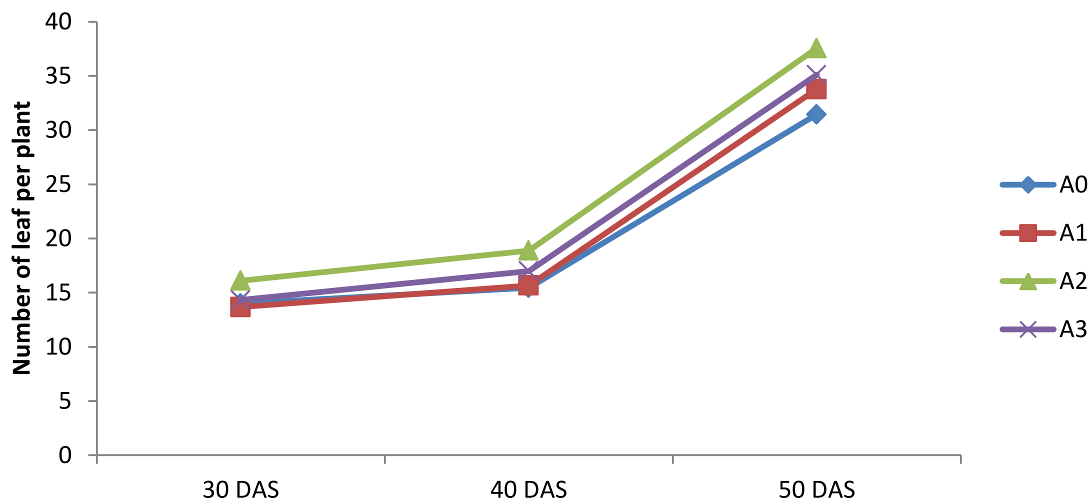
A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix
CV = Co-efficient of variance, LSD = Least significant Difference

* = Significant at 5% level



N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1} nitrogen applied as urea , N_2– 120 kg ha^{-1} nitrogen applied as urea, DAS (days after sowing)

Fig.: 3. Effect of different levels of nitrogen at different DAS on the leaf number of sesame plant



A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix
DAS (days after sowing)

Fig.: 4. Effect of differents levels of NAA at different DAS on the leaf number of sesame plant

1-Naphthaleneacetic acid (NAA) was used to examine the physiological involvement on increasing of leaf number plant^{-1} in sesame. NAA had statistically insignificant effect on number of leaf plant^{-1} of sesame at 30 DAS, 40 DAS and 50 DAS (Fig. 4 and Appendix IV). At 30 DAS, the highest number of leaf plant^{-1} (16.11) was observed from the A_2 and the lowest (14.00) was observed from A_0. At 40 DAS, the highest number of leaf plant $^{-1}$ (17.89) was observed from the A_2 and the lowest (15.44) was observed from A_0. At 50 DAS, the highest number of leaf plant^{-1} (36.56) was observed from the A_2 and the lowest (33.44) was observed from A_0. Results showed no statistical variations but had numerical variation and the highest leaf number per plant was observed from $A_{2,}$ 50 ppm NAA and lowest from $A_{0,}$ 0 ppm NAA. It is reported that application of planofix (NAA) at a rate of 200 ppm to groundnut produced higher number of leaves as also suggested by Deotale *et al.* (1998) and Reddy and Shah (1984).

The combined effect of nitrogen fertilizer and NAA doses showed significant variation on number of leaf plant^{-1} of sesame at 30 DAS (Table 2 and Appendix IV). At 30 DAS, the highest number of leaf plant^{-1} (19.23) was observed from the N_1A_2 treatment and the lowest (12.00) was observed from N_0 A_0 treatment which was statistically similar with all except N_0A_1 (12.00), N_0 A_2 (12.67), N_1A_0 (14.33), N_1A_1 (14.33), N_2A_0 (14.67) and N_2 A_2 (14.33). At 40 DAS, insignificant variation was observed with N and NAA and the highest number of leaf plant $^{-1}$ (19.33) was observed from the N_1A_2 treatment and the lowest (13.67) was observed from N_0A_0 treatment. At 50 DAS, insignificant variation was observed and the highest number of leaf plant^{-1} (40.33) was observed from the N_1A_2 treatment whereas the lowest (26.33) was observed from N_0A_0 treatment.

Table 2. Combined effect of nitrogen and NAA on the leaf number of sesame plant^{-1} at different days after sowing (DAS)

Treatment	Number of leaf plant^{-1}		
	30 DAS	40 DAS	50 DAS
$N_0 A_0$	12.00 c	13.67	26.33
$N_0 A_1$	12.00 c	14.33	32.33
$N_0 A_2$	12.67 bc	15.67	29.67
$N_0 A_3$	15.67 b	16.00	32.67
$N_1 A_0$	14.33 bc	15.67	36.67
$N_1 A_1$	14.33 bc	15.00	39.00
$N_1 A_2$	19.23 a	19.33	40.33
$N_1 A_3$	13.00 bc	18.00	39.67
$N_2 A_0$	15.67 b	17.00	31.33
$N_2 A_1$	14.67 bc	17.67	32.00
$N_2 A_2$	15.67 b	16.67	34.67
$N_2 A_3$	14.33 bc	17.00	36.00
LSD (0.05)	3.334	4.275	5.317
Significant level	*	NS	NS
CV (%)	13.55%	18.60%	14.76%

N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1}nitrogen applied as urea ,
N_2– 120 kg ha^{-1} nitrogen applied as urea, DAS (days after sowing)

A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix
CV = Co-efficient of variance, LSD = Least significant Difference

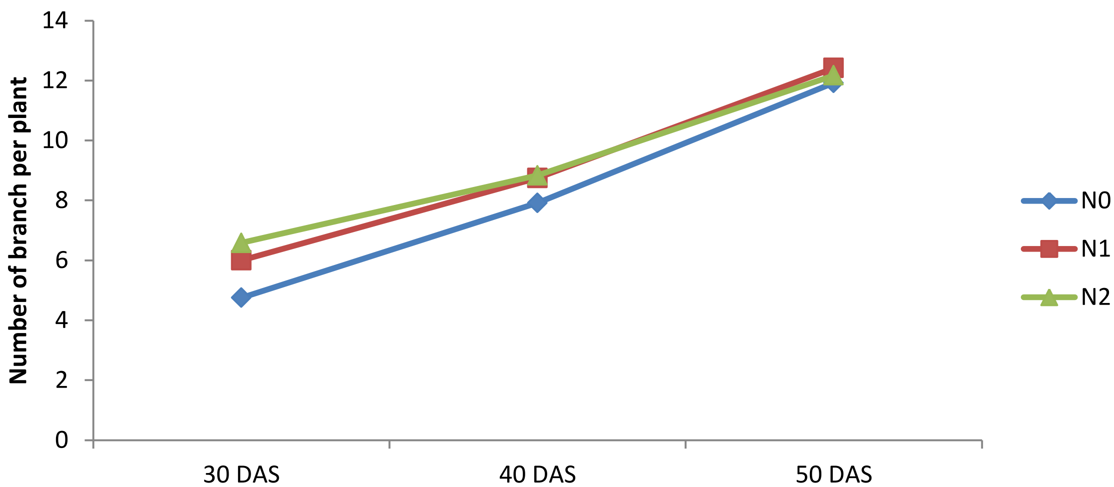
* = Significant at 5% level

4.3 Number of branch plant^{-1}

Figure 5 and Appendix V showed that nitrogen fertilizers had significant effect on number of branch plant^{-1} of sesame at 30 DAS and no significant differences were observed at 40 DAS and 50 DAS. At 30 DAS, the highest number of branch plant^{-1} (6.58) was observed from the N_2 which was statistically similar with N_1 (6.00) and the lowest (4.75) was observed from N_0. At 40 DAS, the highest number of branch plant $^{-1}$ (8.833) was observed from the N_1 and the lowest (7.91) was observed from $N_{0.}$ At 50, DAS the highest number of branch plant^{-1} (12.42) was observed from the N_1 and the lowest (10.67) was observed from N_0. As the results showed highest leaf number from N_1, 60 kg N ha^{-1}and lowest from $N_{0,}$ 0 kg N ha^{-1}; so the number of branch per plant increased numerically with application of nitrogen fertilizer as observed by Sinharoy *et al*., (1990), Pathak *et al*., (2002), Patra *et al*., (2001), Subrahmaniyan and Arulmozhy (1999).

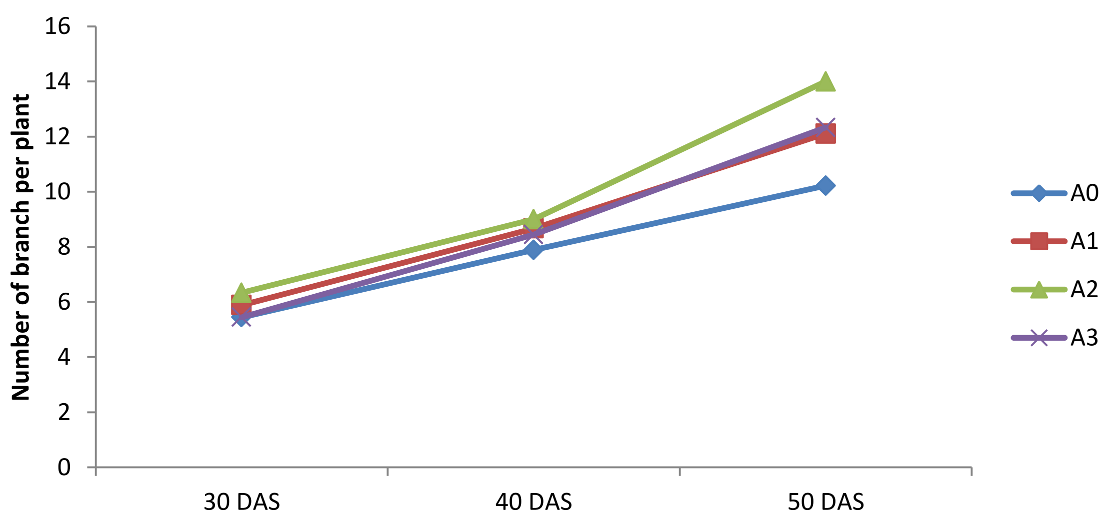
Application of NAA had showed no significant effect on number of branch plant^{-1} of sesame at 30 DAS and 40 DAS whereas significant effect showed at 50 DAS (Fig. 6 and Appendix V). The results revealed that at 30 DAS and 40 DAS the number of branch plant^{-1} was statistically insignificant and hence was not influenced by different concentrations of NAA. At 30 DAS the highest number of branch plant $^{-1}$ (6.33) was observed from the A_2 and the lowest (5.44) was observed from $A_{0.}$ At 40 DAS the highest number of branch plant $^{-1}$ (9.00) was observed from the A_2 and the lowest (7.88) was observed from A_0. At 50 DAS the highest number of branch plant^{-1} (14) was observed from the A_2 and the lowest (10.22) was observed from A_0. These results showed that initially there was no significant variation in number branch plant $^{-1}$ but significant variation found at 50 DAS. Mahla *et al.*, (1999) and Deotale *et al.*, (1998) observed significant effect of NAA in increasing the number of branches in plant.

Nitrogen fertilizer and NAA doses showed significant variation on number of branch plant^{-1} of sesame at 30 DAS but not significant at 40 DAS and 50 DAS (Table 3 and Appendix V). At 30 DAS the highest number of branch plant^{-1} (8.00) was observed from the N_1A_2 treatment which was statistically similar with N_2A_0 (7.00), N_2A_1 (6.33), N_2 A_2 (6.33) and N_2A_3 (6.66) and the lowest (3.66) was observed from N_0A_0 treatment which was statistically similar with N_0A_1 (5.33), N_0 A_2 (4.66), N_0A_3 (5.33) and N_1A_3 (4.33).



N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1} nitrogen applied as urea, N_2– 120 kg ha^{-1} nitrogen applied as urea, DAS = Days after sowing

Fig.:5. Effect of different levels of nitrogen at different DAS on the number of branch of sesame plant



A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix
DAS (Days after sowing)

Fig.:6. Effect of differents levels of NAA at different DAS on the number of branch of sesame plant

Table 3. Combined effect of nitrogen and NAA on the number of branch of sesame plant at different days after sowing (DAS)

Treatment	Number of branch plant^{-1}		
	30 DAS	40 DAS	50 DAS
$N_0 A_0$	3.66 e	7.33	8.66
$N_0 A_1$	5.33 bcde	8.00	13.00
$N_0 A_2$	4.66 cde	8.00	14.00
$N_0 A_3$	5.33 bcde	8.33	12.00
$N_1 A_0$	5.66 bcd	8.00	10.00
$N_1 A_1$	6.00 bcd	8.00	12.00
$N_1 A_2$	8.00 a	10.33	14.10
$N_1 A_3$	4.33 de	8.66	12.67
$N_2 A_0$	7.00 ab	8.33	12.00
$N_2 A_1$	6.33 abc	10.00	11.33
$N_2 A_2$	6.33 abc	8.66	13.00
$N_2 A_3$	6.66 ab	8.33	12.33
LSD (0.05)	1.691	1.674	2.583
Significant level	*	NS	NS
CV (%)	17.29%	11.63%	12.53%

N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1}nitrogen applied as urea ,
N_2– 120 kg ha^{-1} nitrogen applied as urea, DAS (Days after sowing)

A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix
CV = Co-efficient of variance

LSD = Least significant Difference

* = Significant at 5% level

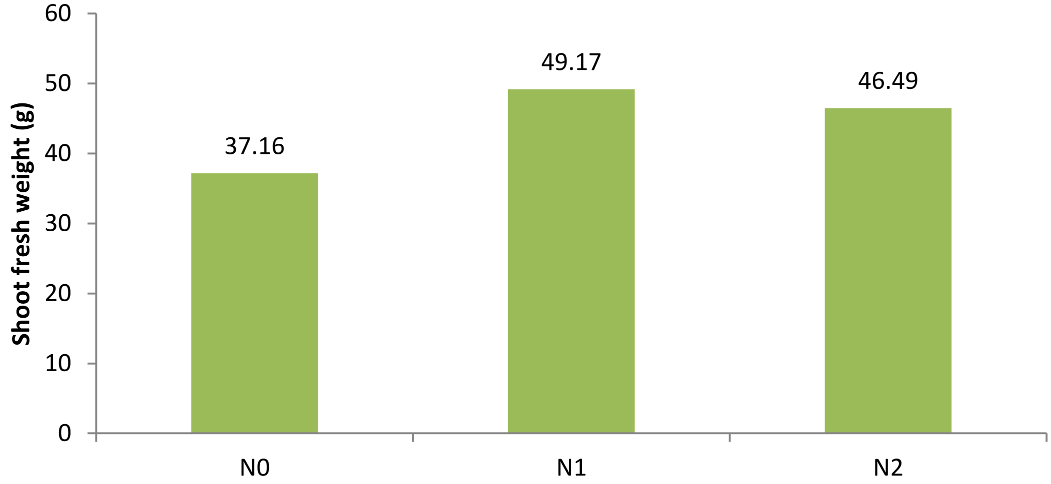
At 40 DAS the highest number of branch plant $^{-1}$ (10.33) was observed from the N_1A_2 treatment and the lowest (7.33) was observed from N_0A_0 treatment. At 50 DAS, the highest number of branch plant^{-1} (14.10) was observed from the N_1A_2 treatment and the lowest (8.66) was observed from N_0A_0 treatment. The lowest number of branch plant^{-1} at different DAS was found from $N_0A_{0,}$ 0 kg N ha^{-1} with 0 ppm NAA and highest from N_1A_2, 60 kg N ha^{-1} with 50 ppm NAA showed that branches increased with application of N and NAA.

4.4 Shoot fresh weight (g)

There was significant variation among the different levels of nitrogen fertilizer doses on shoot fresh weight (g) of sesame (Fig. 7 and Appendix VI). The highest fresh shoot weight (49.17 g) was obtained from N_2 while the lowest result (37.16 g) was recorded from N_0. The results suggest that application of N increased the shoot fresh weight of sesame plant.

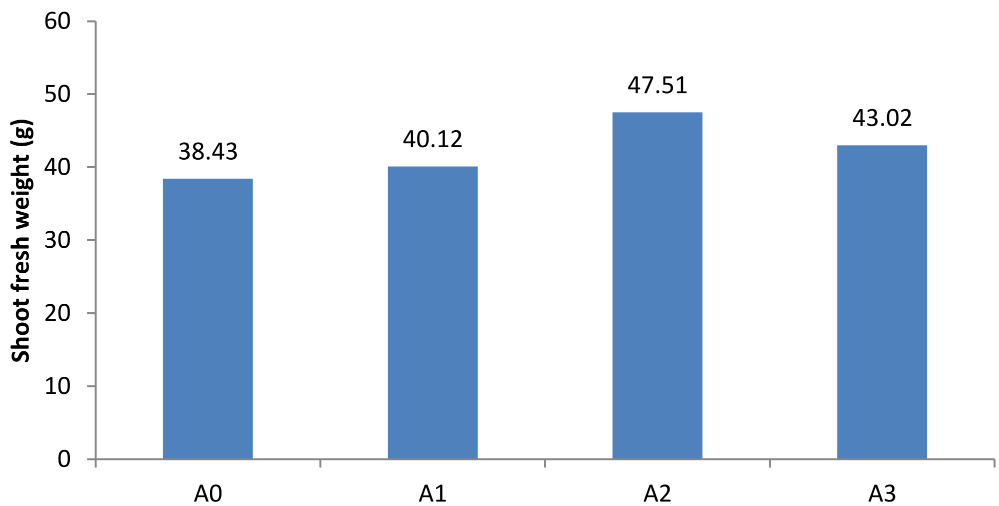
Figure 8 and Appendix VI showed different concentration of NAA had significant influenced on fresh shoot weight (g) of sesame. The highest fresh shoot weight (47.51 g) was obtained from A_2 while the lowest result (38.43 g) was recorded from A_0 which was statistically similar with A_1. These results are in conformity with the findings of Malik *et al.* (1988). Shahrior (2007) also investigated on the effect of NAA on morphological, growth and yield contributing characters of sesame at different concentrations.

The shoot fresh weight of sesame showed a significant variation due to the combined application of nitrogen fertilizer (N) and 1-napthaleneacitic acid (NAA) doses. (Table 4 and Appendix VI). The maximum fresh shoot weight (58.30 g) was recorded for the N_1A_2 60 kg N ha^{-1} with 50 ppm NAA treatment and the lowest (24.90 g) was observed from $N_0A_{0,}$ 0 kg N ha^{-1} with 0 ppm treatment combination.



N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1} nitrogen applied as urea,
N_2– 120 kg ha^{-1} nitrogen applied as urea

Fig.: 7. Effect of different levels of nitrogen on shoot fresh weight of sesame plant



A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix

Fig.: 8. Effect of differents levels of NAA on shoot fresh weight of sesame plant

Table 4. Combined effect of nitrogen and NAA on the shoot fresh and dry weight; root fresh and dry weight of sesame plant

Treatment	Shoot fresh weight (g)	Shoot dry weight (g)	Root fresh weight (g)	Root dry weight (g)
$N_0 A_0$	24.90 g	3.26 e	3.30 h	0.56 h
$N_0 A_1$	34.50 f	4.83 d	4.93 efg	1.48 de
$N_0 A_2$	47.77 cd	7.73 b	5.56 def	1.56 d
$N_0 A_3$	41.47 e	6.16 c	4.86 fg	1.30 ef
$N_1 A_0$	36.33 f	5.36 cd	4.00 gh	1.13 f
$N_1 A_1$	45.07 de	6.26 c	6.20 cde	1.60 d
$N_1 A_2$	58.30 a	10.10 a	9.73 a	3.43 a
$N_1 A_3$	48.97 bcd	7.76 b	6.90 c	2.83 c
$N_2 A_0$	41.43 e	6.26 c	5.06 efg	1.33 def
$N_2 A_1$	42.53 e	6.43 c	6.50 cd	1.73 cd
$N_2 A_2$	52.47 b	8.53 b	8.36 b	3.10 b
$N_2 A_3$	49.53 bc	7.78 b	5.23 defg	1.50 de
LSD (0.05)	4.023	1.108	1.290	0.256
Significant level	**	**	**	**
CV (%)	5.37%	9.60%	12.47%	9.32%

N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1} nitrogen applied as urea,
N_2– 120 kg ha^{-1} nitrogen applied as urea

A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix
CV = Co-efficient of variance

LSD = Least significant Difference

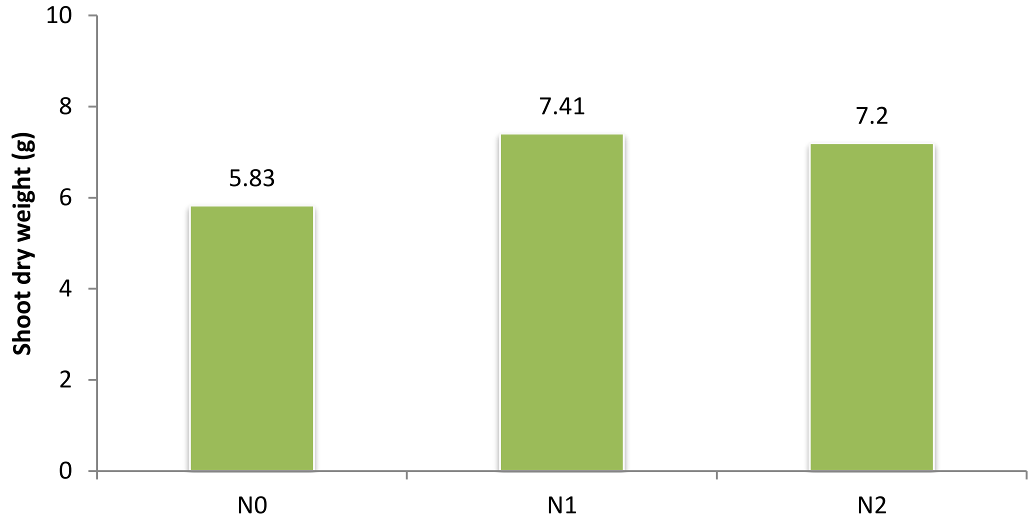
** = Significant at 1% level

4.5 Shoot dry weight (g)

Application of different levels of nitrogen fertilizer had significant influenced on dry shoot weight (g) of sesame (Fig. 9 and Appendix VI). The highest dry shoot weight (7.41 g) was obtained from N_1 which was statistically similar with N_2 (7.20 g) and the lowest result (5.833 g) was recorded from $N_{0.}$ The results showed that there was not statistical variation in $N_{1,}$ 60 kg N ha^{-1} and $N_{2,}$ 120 kg N ha^{-1}, so it was found that the shoot dry weight of sesame (g) increased with the increasing doses of N. Tiwari et al. (1998) had reported that application of nitrogen fertilizer increased dry matter production in sesame.

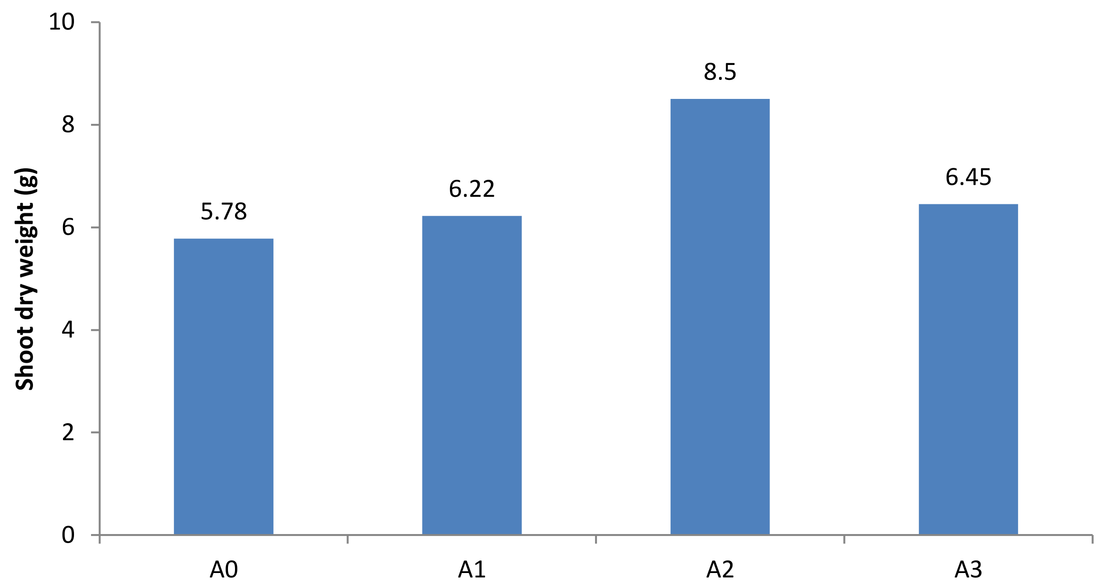
1- Napthaleneacetic acid at different concentrations had significant variation on shoot dry weight (g) of sesame (Fig. 10 and Appendix VI). The highest shoot dry weight (8.50 g) was obtained from A_2 while the lowest result (5.78 g) was recorded from A_0. From the results the application of NAA increased of shoot dry weight (g) of sesame at greater level with $A_{2,}$ 50 ppm NAA. Foliar spray of NAA at 30 ppm concentration had found to be more effective in increasing the total dry weight as reported by Ramanathan *et al*., (2004).

The Table 5 and App. VI presented the combined interaction of nitrogen fertilizer and NAA doses had significant effect on dry shoot weight of sesame. The maximum dry shoot weight (10.10 g) was recorded for the N_1A_2treatment and the lowest (3.26 g) was observed from N_0A_0 treatment. The results revealed that as fresh weight of shoot increased with application of 60 kg N ha^{-1} and 50 ppm NAA as consistent to dry weight.



N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1} nitrogen applied as urea ,
N_2– 120 kg ha^{-1} nitrogen applied as urea

Fig.: 9. Effect of different levels of nitrogen on the shoot dry weight of sesame plant



A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix

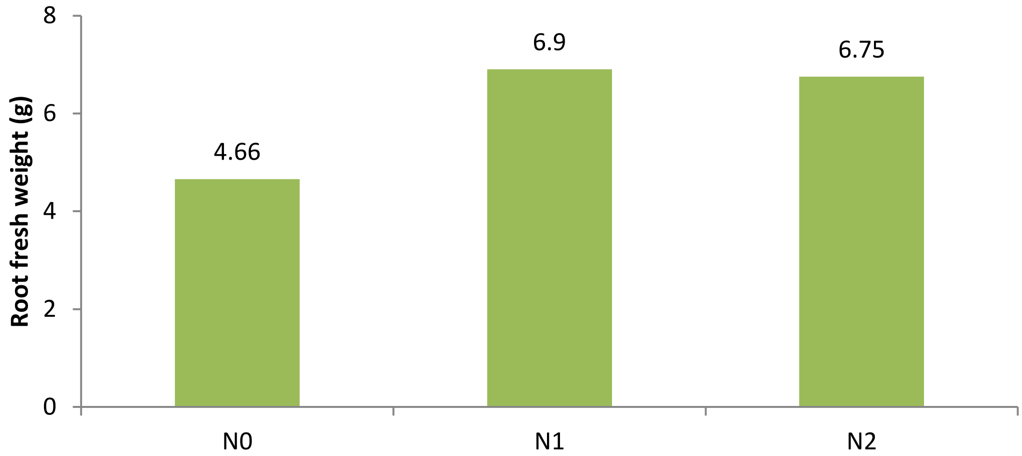
Fig.: 10. Effect of differents levels of NAA on the shoot dry weight of sesame plant

4.6 Root fresh weight (g)

The N showed (Fig. 11 and Appendix VI) indicated significant variation among the different doses of nitrogen fertilizer on root fresh weight (g) of sesame. The highest root fresh weight (6.90 g) was obtained from N_1 which is statistically similar with N_2 (6.75 g) treatment while the lowest result (4.66 g) was recorded from N_0 treatment. It can be attributed towards more availability of nitrogen resulting in enhanced vegetative growth. These results are in line with those reported by Sharma and Kewat (1995).

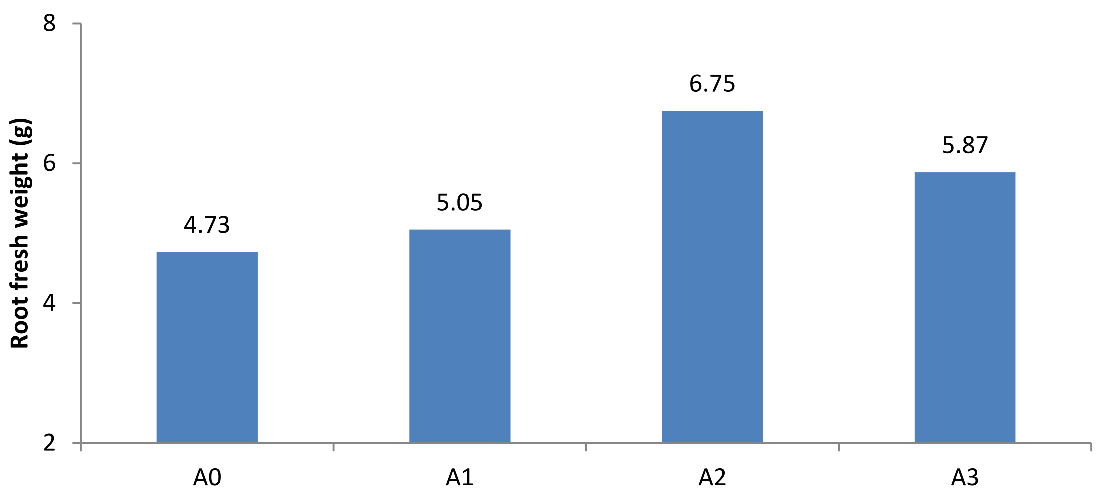
Application of 1-napthaleneacetic acid (NAA) had significant effect on root fresh weight (g) of sesame (Fig. 12 and Appendix VI). The highest fresh root weight (6.75 g) was obtained from $A_2$50 ppm NAA while the lowest result (4.73 g) was recorded from $A_{0,}$0 ppm NAA which was statistically similar with A_1 (5.05).The results showed that fresh root weight (g) increased with the application of NAA as fresh shoot weight (g). Haque (2005) had found that foliar spray at 80 ppm NAA had positive regulatory effect on morphological growth of sesame.

The combined effect of different levels of nitrogen fertilizer and NAA concentrations showed significant variation on root fresh weight of sesame (Table 4 and Appendix VI).The maximum fresh root weight (9.53 g) was recorded for the N_1A_2 (60 kg N ha^{-1} with 50 ppm NAA) treatment and the lowest (3.30 g) was observed from N_0A_0 (0 kg N ha^{-1} with 0 ppm NAA or without N and NAA) treatment. Here N_1A_2 combination showed the best result at 60 kg ha^{-1} N with 50 ppm NAA.



N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1} nitrogen applied as urea ,
N_2– 120 kg ha^{-1} nitrogen applied as urea

Fig.: 11. Effect of different levels of nitrogen on root fresh weight of sesame plant



A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix

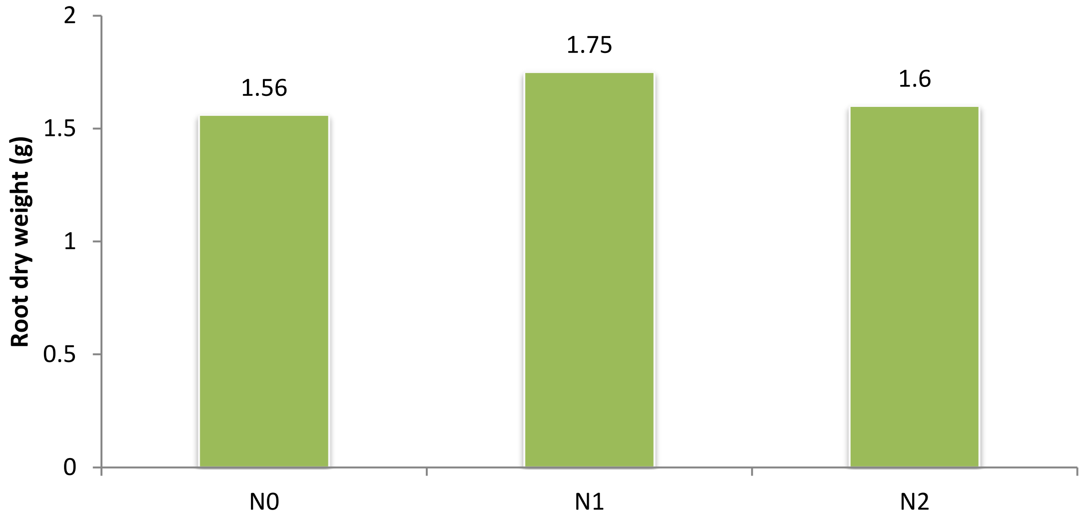
Fig. : 12. Effect of differents levels of NAA on root fresh weight of sesame plant

4.7 Root dry weight (g)

Here the results showed that nitrogen fertilizer doses had significantly effected on root dry weight (g) of sesame (Fig. 13 and Appendix VI). The highest dry root weight (1.75 g) was obtained from $N_1$and the lowest result (1.56 g) was recorded from N_0 which was statistically similar with N_2 (1.60 g). These results showed similarity with shoot dry weight (g) (Fig. 9) and suggested that nitrogen had important role in increased of root dry weight of sesame in application at proper doses.

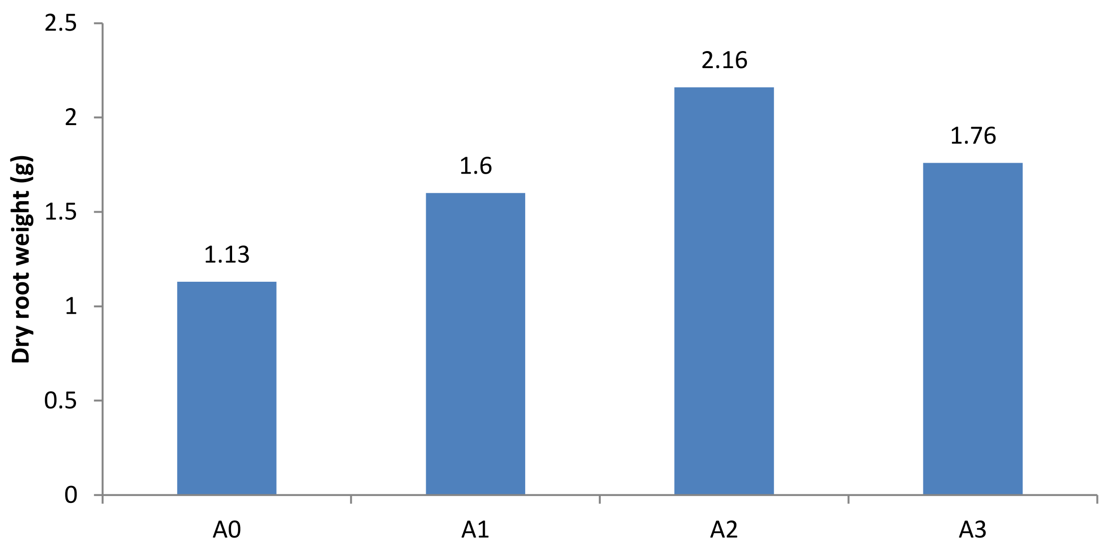
Significant influenced on dry root weight (g) of sesame had showed by application different concentrations of NAA (Fig. 14 and Appendix VI). The highest dry root weight (2.16 g) was observed from $A_{2,}$ (50 ppm NAA) while the lowest result (1.13 g) was recorded from $A_{0,}$ (0 ppm NAA). These results are consistent with fresh of root (Fig. 10). Sharma et al. (1999) had reported that foliar spray of NAA was found to be more effective in increasing total dry weight of plant which supported these results.

The interaction of nitrogen fertilizer and NAA doses showed significant variation on dry root weight of sesame (Table 4 and Appendix VI).The maximum dry root weight (3.43 g) was recorded for the N_1A_2 (60 kg N ha^{-1} with 50 ppm NAA) and the lowest (0.56 g) was observed from N_0A_0 (0 kg N ha^{-1} with 0 ppm NAA) treatment combination. These results are consistent with of root fresh weight and shoot dry weight (Table 4).



N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1} nitrogen applied as urea ,
N_2– 120 kg ha^{-1} nitrogen applied as urea, DAS = Days after sowing

Fig. : 13. Effect of different levels of nitrogen on root dry weight of sesame plant



A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix

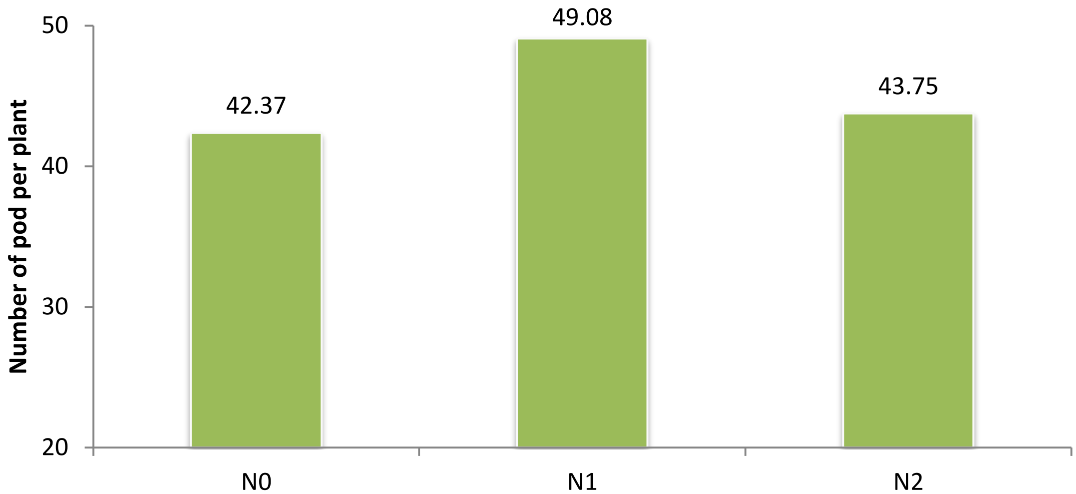
Fig. : 14. Effect of different levels of NAA on dry root weight of sesame plant

4.8 Number of pod plant^{-1}

A significant variation was recorded due to the different nitrogen fertilizer doses for number of pod plant^{-1} of sesame (Fig. 15 and Appendix VII).The maximum number of pod plant^{-1} (49.08) was recorded for the N_1 treatment and the lowest (42.37) was observed from N_0 treatment which was statistically similar with N_2 (43.75). These results are in line with the findings of Subramanian *et al*. (1979). From the result it appears that pod number plant^{-1} increased due to the increased rate of nitrogen fertilizer application up to certain level but excess application of nitrogen enhanced the vegetative growth instead of pod formation had reported by Allam (2002) and Pathak et al. (2002). These results are consistent with the vegetative characters of sesame (Fig, 1 and 3).

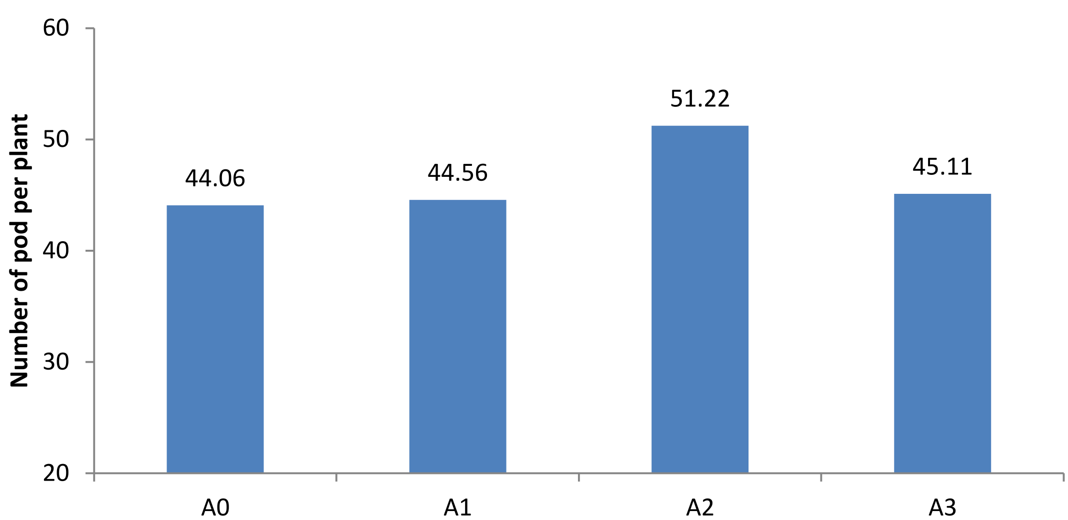
As N different concentrations of NAA had significant variation in the number of pod plant^{-1} of sesame (Fig. 16 and Appendix VII).The highest number of pod plant^{-1} (51.22) was recorded for the A_2 (50 ppm NAA) which was statistically similar with A_1 and the lowest (44.06) was observed from A_0 which was statistically similar with A_3. As reported by the scientist, the number of pod plant^{-1} increased significantly due to NAA application on various crops. The spraying of different concentrations off NAA had a great regulatory effect on number of pod per plant and increased the pod yield as suggested by Kalita *et al.* (1995), Gupta and Singh, (1982), Singh *et al.* (1982), Reddy and Shah (1984) and Devasenapathi *et al.* (1987). Studies have also shown the external application of Planofix (NAA) reduces the premature abscission of flowers and young pods, thus increases the pod and consequently the yield of groundnut (Mani and Raja, 1976).

The number of pod plant^{-1} of sesame significantly influenced by the combined use of nitrogen fertilizer and NAA (Table 5 and Appendix VII).The minimum number of pod plant^{-1} (36.67) was observed from control or N_0A_0 (0 kg N ha^{-1} and 0 ppm NAA) treatment combination which was statistically similar with all except N_0A_2 (50.67), N_1A_1 (51.67) and N_1A_3 (51.67) and maximum number of pod plant^{-1} (59.67) was recorded for the N_1A_2 (60 kg N ha^{-1} and 50 ppm NAA) treatment combination. Here without nitrogen and NAA showed the lowest result and the combination of 60 kg ha^{-1} N with 50 ppm NAA resulted best in increasing of the pod number in sesame plant. In this study, the number of pod plant^{-1} as a seed yield contributing character of sesame is indistinguishable with the parameters of the Table 1 and 4.



N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1} nitrogen applied as urea ,
N_2– 120 kg ha^{-1} nitrogen applied as urea

Fig. : 15. Effect of different levels of nitrogen on number pod plant^{-1} of sesame



A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix
DAS (days after sowing)

Fig. : 16. Effect of different levels of NAA on number pod plant^{-1} of sesame

Table 5. Combined effect of nitrogen and NAA on the pod number plant^{-1}, pod diameter and pod length of sesame plant

Treatment	Number of pod plant^{-1}	Pod length (mm)	Pod diameter (mm)
$N_0 A_0$	36.67 c	17.62 d	7.49 b
$N_0 A_1$	43.33 bc	18.93 bcd	8.06 b
$N_0 A_2$	50.67 b	18.59 cd	8.85 b
$N_0 A_3$	44.33 bc	19.40 bcd	8.96 b
$N_1 A_0$	44.33 bc	20.11 bcd	8.01 b
$N_1 A_1$	50.67 b	21.46 ab	8.36 b
$N_1 A_2$	59.67 a	23.63 a	11.59 a
$N_1 A_3$	51.67 b	20.74 bc	9.25 b
$N_2 A_0$	40.34c	19.45 bcd	8.72 b
$N_2 A_1$	43.33 bc	20.51 bc	8.99 b
$N_2 A_2$	45.33 bc	21.29 abc	8.70 b
$N_2 A_3$	44.47 bc	20.51 bc	7.79 b
LSD (0.05)	7.04	2.815	1.848
Significant level	**	**	**
CV (%)	15.55%	8.24%	9.09%

N_0 – No nitrogen applied, N_1 – kg ha^{-1} nitrogen applied as urea ,
N_2– kg ha^{-1} nitrogen applied as urea

A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix

CV = Co-efficient of variance

LSD = Least significant Difference

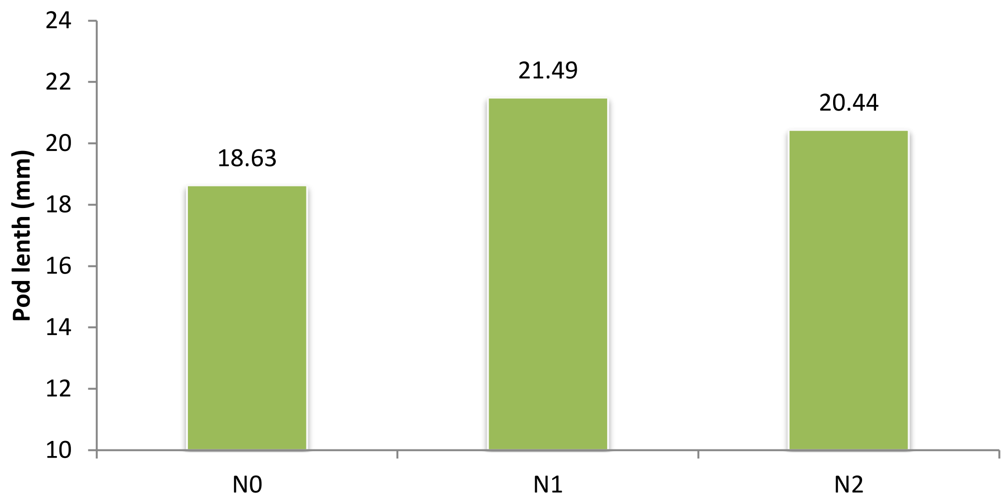
** = Significant at 1% level

4.10 Pod length (cm):

As consistent to fruit diameter nitrogen fertilizer doses had significant influenced on fruit length (mm) of sesame (Fig. 19 and Appendix VII). The highest fruit length (21.49 mm) was obtained from N_1 (60 kg N ha^{-1}) which was statistically similar with N_2 (20.44 mm) while the lowest result (18.63 mm) was recorded from N_0 (0 kg N ha^{-1}). These data resulted that application of N fertilizer increased fruit lenth (mm) in contrast with fruit diameter (mm). Patra (2001) had reported that nitrogen fertilizer application increase the pod length of sesame.

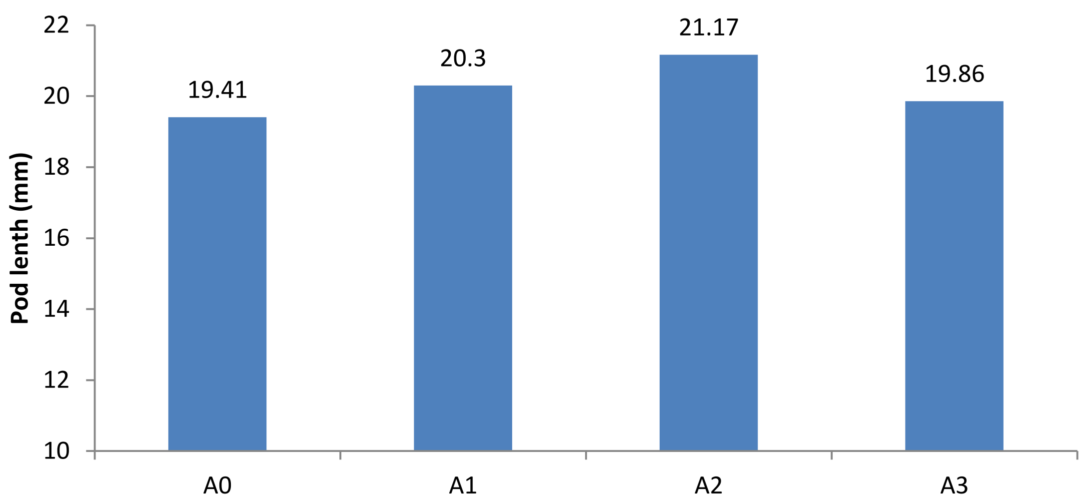
Different concentrations of NAA had significantly influenced on pod length (mm) of sesame (Fig. 20 and Appendix VII). The highest pod length (21.17 mm) was recorded from A_2 treatment which was statistically similar with A_1 (20.30 mm) and A_3 (19.86 mm) while the lowest result (19.41 mm) was recorded from A_0. Here results showed that NAA increased pod length as reported by Singh et al. (1995) that application of NAA increased the umbel length and more umbel number in onion. Previous many authors reported that auxin plays an important role on the fruit development and setting in many crops. All together the presented data suggest that NAA had positive functions on pod length (mm) of sesame.

The combined effect of nitrogen fertilizer and NAA was significant to pod length (mm) of sesame (Table 5 and Appendix VII). The maximum pod length (23.63 mm) was recorded for the N_1A_2 (60 kg N ha^{-1} and 50 ppm NAA) treatment combination and the lowest (17.62 mm) was observed from N_0A_0 (0 kg N ha^{-1} and 0 ppm NAA) treatment combination which was statistically similar with N_0A_1 (18.93 cm), N_0A_2 (18.59 cm), N_0A_3 (19.40 cm), N_1A_0 (20.11cm) and N_2A_0(19.45 cm). Results showed that best combination (N_1A_2) of increased pod length at 60 kg ha^{-1} nitrogen with 50 ppm NAA as consistent with pod diameter in the (Table 5).



N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1} nitrogen applied as urea,
N_2– 120 kg ha^{-1} nitrogen applied as urea

Fig. : 19. Effect of different levels of nitrogen on the pod length of sesame



A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix

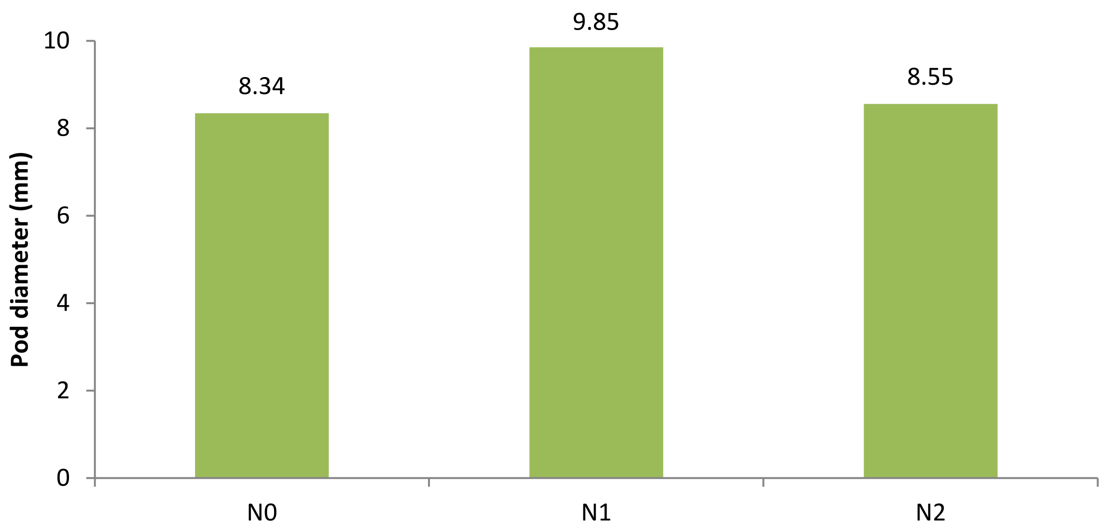
Fig. : 20. Effect of different levels of NAA on the pod length of sesame

4.9 Pod diameter (mm)

Nitrogen fertilizer doses had significant influenced on fruit diameter (mm) of sesame (Fig. 17 and Appendix VII).The highest fruit diameter (9.85 mm) was obtained from N_1 while the lowest result (8.34 mm) was recorded from N_0 which was statistically similar with N_2 (8.55mm). Here results showed that without and excess nitrogen fertilizer application founded less pod growth in diameter for sesame plant.

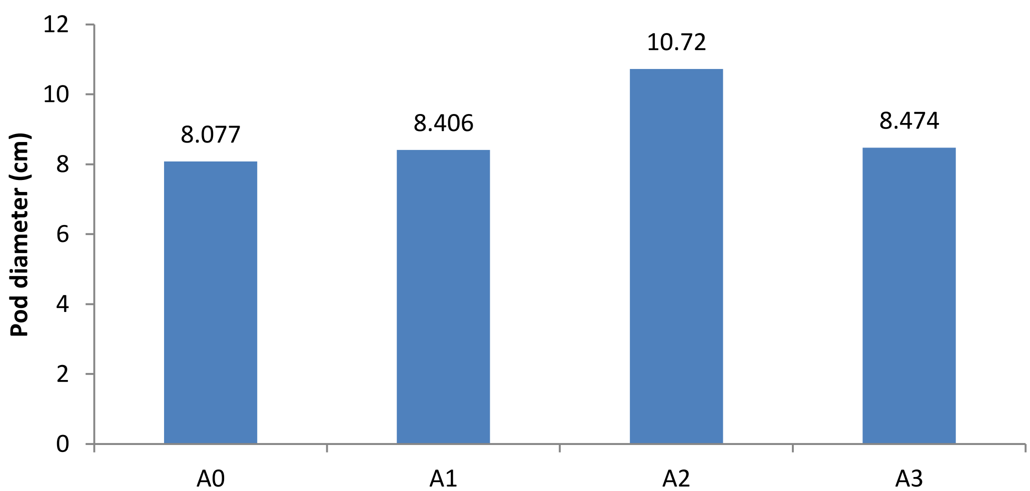
A significant variation was recorded due to the different concentrations of NAA for fruit diameter (mm) of sesame (Fig. 18 and Appendix VII). The highest Fruit diameter (10.72 mm) was obtained from A_2 treatment while the lowest result (8.47 mm) was recorded from A_0 treatment. Results showed that foliar application of NAA increased the fruit diameter (mm) upto a certain concentration of 50 ppm (A_2).

Fruit diameter (mm) was observed significant variation due to combined application of different levels of nitrogen fertilizer and NAA on of sesame (Table 5 and Appendix VII). The maximum fruit diameter (11.59 mm) was recorded for the N_1A_2 treatment combination and the lowest (7.49 cm) was observed from N_0A_0 treatment combination which was statistically similar with all except N_1A_2 (11.59 cm). Here best combination resulted of increased fruit diameter (mm) from N_1A_2 at 60 kg ha^{-1} of nitrogen and 50 ppm of NAA treatment combination.



N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1} nitrogen applied as urea,
N_2– 120 kg ha^{-1} nitrogen applied as urea

Fig. : 17. Effect of different levels of nitrogen on the pod diameter of sesame



A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix

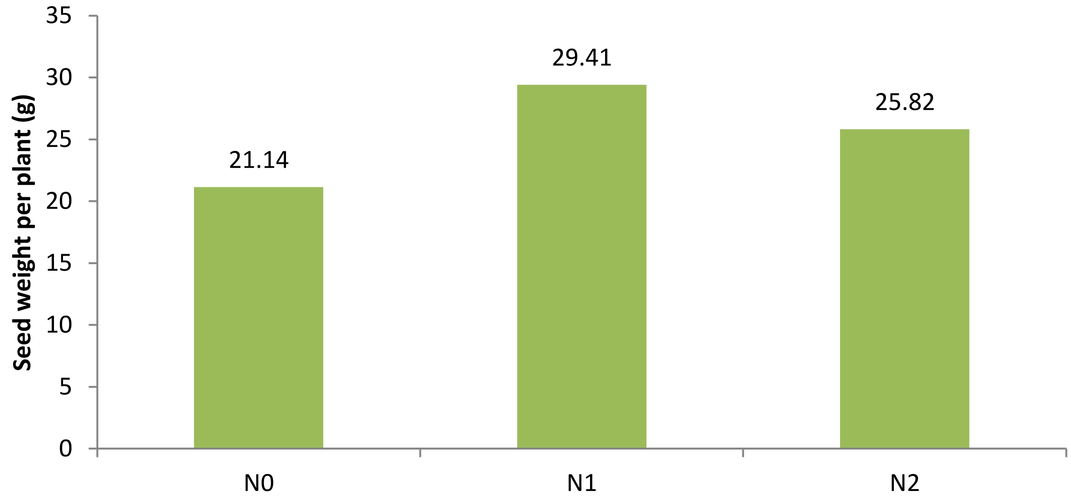
Fig. : 18. Effect of different levels of NAA on the pod diameter of sesame

4.11 Seed weight plant^{-1} (g)

In this study N fertilizer levels showed significant variation in the seed weight plant^{-1} of sesame (Fig. 21 and Appendix VIII). The maximum seed yield plant^{-1} (27.41 g) was produced by N_1 (60 kg N ha^{-1}) whereas N_0 produced the minimum seed weight plant^{-1}(21.14 g). This finding corroborated those of Roy *et al*. (1995), Gnanamurthy *et al*. (1992), Osman, (1993), Okpara *et al*. (2007), Fathy and Mohammed (2009), Haruna *et al*. (2010).The lowest number of pod seed weight was found from control or without N (N_0). Similar findings were reported by Tiwari *et al.* (2002), Subrahmanyan and Arulmozhi (1999).

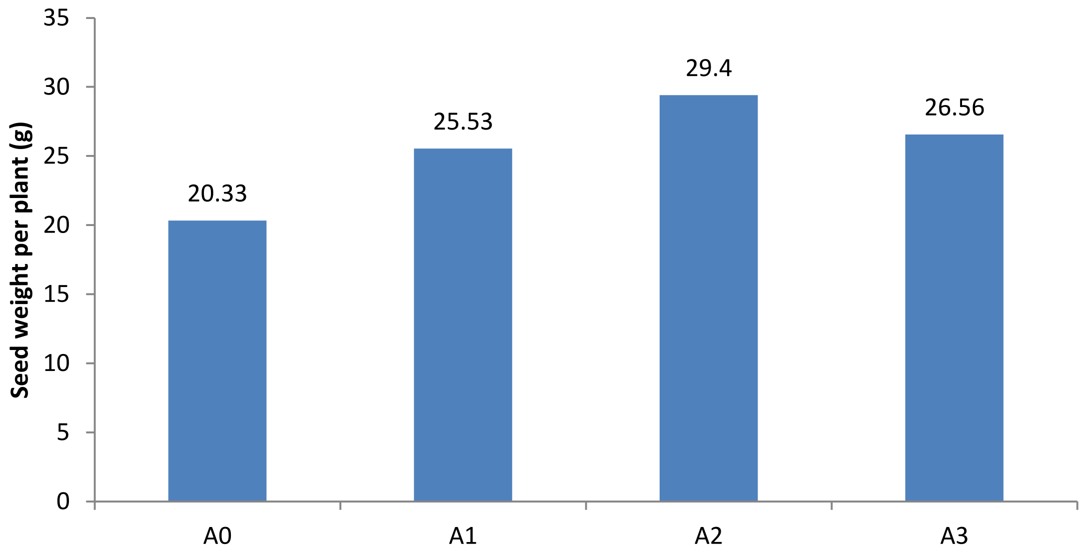
The NAA showed significant variation in the seed weight plant^{-1} of sesame (Fig. 22 and Appendix VIII). The highest seed yield plant^{-1}(29.40 g) was produced by A_2 (50 ppm NAA) and A_0 (0 ppm NAA) produced the minimum seed weight plant^{-1}(20.33 g).The presented results indicated that NAA at 50 ppm (A_2) increased seed weight plant^{-1}. Prakash during (2003), Ghosh *et al.* (1991), Sujatha, (2001). AndRadhamani *et al.* (2003) had reported that NAA significantly increased the seed weight of plants.

Interaction of nitrogen fertilizer and NAA doses showed significant variation on seed weight plant^{-1} (g) of sesame (Table 6 and Appendix VIII).The minimum seed weight plant^{-1} (13.60 g) was observed from N_0A_0 (without N and NAA) treatment combination and maximum seed weight plant^{-1} (34.67 g) was recorded for the N_1A_2 treatment combination. The results showed that the best combination N_1A_2 (60 kg ha^{-1} N and 50 ppm NAA) increased sesame seed weight plant^{-1}.



N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1} nitrogen applied as urea,
N_2– 120 kg ha^{-1} nitrogen applied as urea

Fig. :21. Effect of different levels of nitrogen on the seed weight $plant^{-1}$ of sesame



A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix

Fig. : 22. Effect of differents levels of NAA on the seed weight $plant^{-1}$ of sesame

Table 6. Combined effect of nitrogen and NAA on the seed weight plant^{-1} (g), Seed weight plot^{-1} (g), 1000 seed weight (g) and Yield (t ha^{-1}) of sesame

Treatment	Seed weight plant^{-1} (g)	Seed weight plot^{-1} (g)	1000 seed weight (g)	Yield (t ha^{-1})
$N_0 A_0$	13.60 g	163.4 e	9.16 g	0.54 e
$N_0 A_1$	20.67 f	274.1 c	9.76 fg	0.91 c
$N_0 A_2$	22.80 def	268.7 c	10.83 cde	0.89 c
$N_0 A_3$	27.50 bc	353.7 b	11.40 bc	1.18 b
$N_1 A_0$	22.27 ef	352.4 b	10.00 f	1.17 b
$N_1 A_1$	30.23 b	356.7 b	11.27 bcd	1.21 b
$N_1 A_2$	34.67 a	447.1 a	13.13 a	1.49 a
$N_1 A_3$	30.27 b	365.4 b	10.30 ef	1.19 b
$N_2 A_0$	25.13 cde	203.7 d	9.90 f	0.67 d
$N_2 A_1$	25.70 cd	270.4 c	10.70 de	0.90 c
$N_2 A_2$	26.73 c	385.7 b	10.17 ef	1.28 b
$N_2 A_3$	25.70 cd	353.7 b	11.80 b	1.17 b
LSD (0.05)	3.121	35.81	0.6815	0.1197
Significant level	*	*	**	*
CV (%)	7.24%	6.69%	3.76%	6.68%

N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1} nitrogen applied as urea ,
N_2– 120 kg ha^{-1} nitrogen applied as urea

A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix
CV = Co-efficient of variance, LSD = Least significant Difference

**= Significant at 1% level

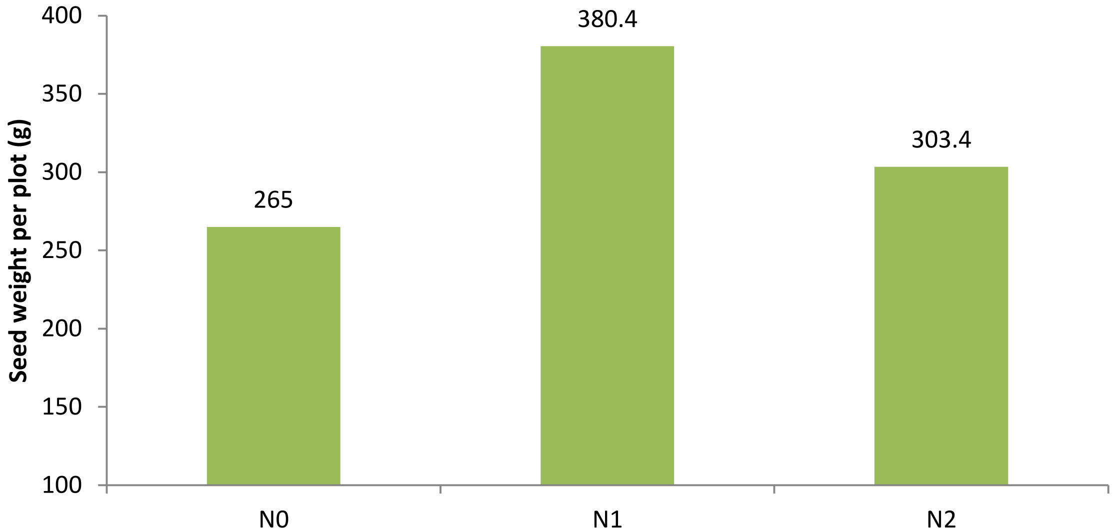
*= Significant at 5% level

4.12 Seed weight plot^{-1} (g)

The figure 23 and Appendix VIII showed that different levels of nitrogen fertilizer had significant variation in the seed weight plot^{-1}(g) of sesame. The maximum seed weight plot^{-1}(g) (380.4 g) was produced by N_1 (60 kg ha^{-1}) not from N_2 (120 kg ha^{-1}) and N_0 (0 kg ha^{-1}) produced the minimum seed weight plot^{-1} (265.0 g). From the study of results I found that excess nitrogen fertilizer application decrease seed weight plot^{-1}(g). Sesame pod number, pod length and diameter also increased with N (Fig. 15, 17 and 19) which believe to increase seed weight plot^{-1} of sesame. These findings are in agreement with Pathak et al. (2000) and Thakur et al. (1998).

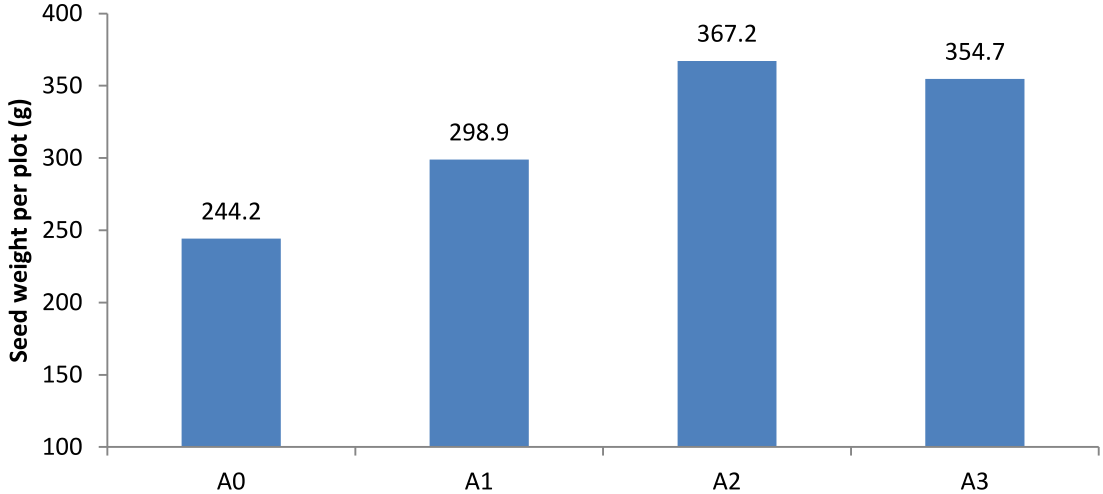
The different concentrations of NAA showed significant variation in the seed weight plot^{-1} (g) of sesame (Fig. 24 and Appendix VIII). The maximum seed weight plot^{-1}(367.2 g) was produced by A_2 (50 ppm) which was statistically similar with A_3 (354.7 cm) whereas A_0 (0 ppm NAA) produced the minimum seed weight plot^{-1} (244.2 g). These results showed significant variation in seed weight plot^{-1} (g) as similar effect of NAA to seed weight plant^{-1} (g) (Fig. 24 and Appendix VIII). Suty (1984), Bai *et al.* (1987), Varma *et al.* (2009) and many other researchers had reported that NAA had a significant effect on seed yield and yield components. Taken together, these finding indicate that NAA can promote the seed yield of sesame as N.

Application of different levels of nitrogen fertilizer and NAA doses showed significant variation on seed weight plot^{-1} (g) of sesame (Table 6 and Appendix VIII).The highest seed weight plot^{-1} (447.1 g) was recorded for the N_1A_2 (60 kg N ha^{-1} and 50 ppm NAA) treatment combination and the lowest (163.4 g) was observed from N_0A_0 (0 kg N ha^{-1} and 0 ppm NAA) treatment. These results showed that application of NAA with different levels of nitrogen fertilizer increased the seed weight plot^{-1} (g) as consistent to combined effect on seed weight plant^{-1} (g) (Table 6) of sesame plant and the best combination (N_1A_2) found from 60 kg ha^{-1} nitrogen with 50 ppm of NAA.



N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1} nitrogen applied as urea,
N_2– 120 kg ha^{-1} nitrogen applied as urea

Fig. : 23. Effect of different levels of nitrogen on the seed weight plot^{-1} of sesame



A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix

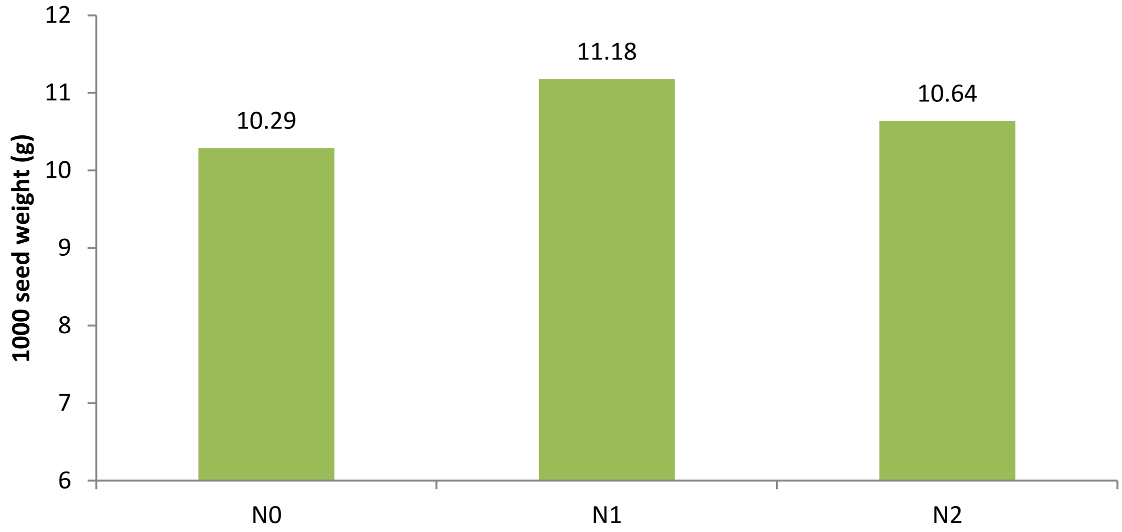
Fig. : 24. Effect of differents levels of NAA on the seed weight plot^{-1} of sesame

4.13 1000 seed weight (g)

The application of nitrogen influenced significantly on the thousand seed weight (g) of sesame (Fig. 25 and Appendix VIII). The maximum thousand seed weight (11.18 g) was produced by N_1 and N_0 produced the lowest thousand seed weight (10.29 g). These results showed that without application of nitrogen (N) resulted in minimum 1000seed weight and with the application of N the 1000-seed weight increased and got highest weight from N_1 (60 kg N ha^{-1}) . These results are in line with those of Mankar *et al*. (1995) who reported that 1000 seed weight increased with increasing rate of N. Pathak *et al*. (2002) reported that 1000 seed weight of sesame increased with 45 kg ha^{-1} of nitrogen fertilizer application.

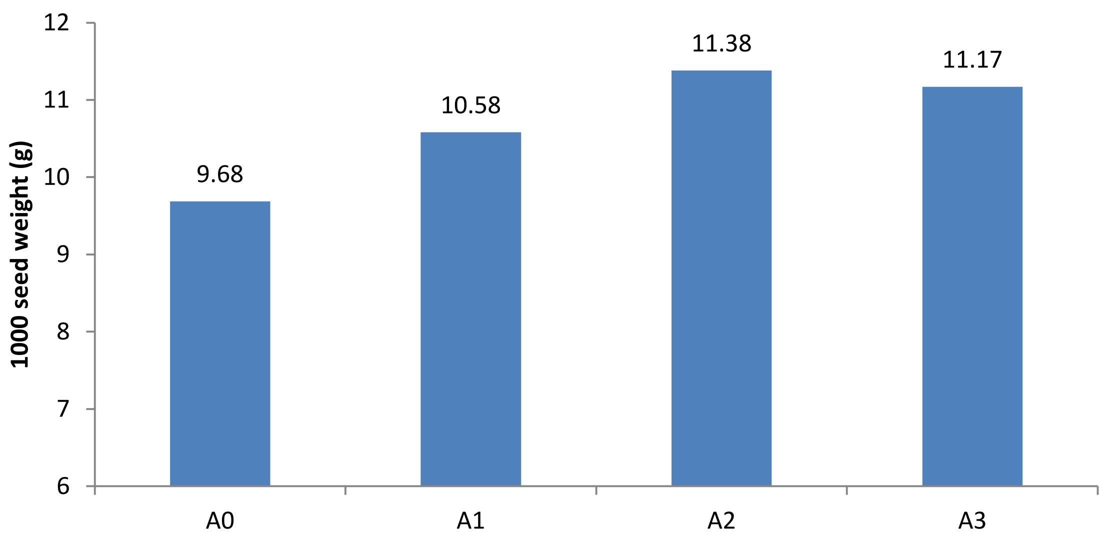
The Fig. 26 and App. VIII showed that NAA had significant influenced on the 1000 seed weight of sesame. The highest 1000 seed weight (11.38 g) was produced by A_2 which was statistically similar with A_3 (11.17 g) and A_0 produced the lowest 1000 seed weight (9.68 g). The results showed that application of NAA as foliar spray increased the 1000 seed weight (g) and the best result found from A_2 (50 ppm). Higher concentration of NAA on grass pea increased 1000 seed weight had reported by Rahman *et al*. (1989) and Sharma *et al*. (1999).

The combined interaction of different levels of nitrogen fertilizer and NAA doses showed significant variation on the 1000 seed weight (g) of sesame (Table 6 and Appendix VIII).The maximum 1000 seed weight (13.13 g) was recorded for the N_1A_2 (60 kg ha^{-1} and 50 ppm NAA) treatment combination and the lowest (9.16 g) was observed from N_0A_0 (control or without N and NAA) treatment combination which was statistically similar with N_0A_1 (9.76 g) treatment combination. The results of this study showed the increment of 1000 seed weight (g) and the highest 1000 seed weight (g) of sesame was obtained from N_1A_2 treatment combination (60 kg ha^{-1} nitrogen with 50 ppm of NAA) which was similar to the results found in seed weight $plant^{-1}$ (g) and seed weight $plot^{-1}$ (g) (Table 6).



N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1} nitrogen applied as urea ,
N_2– 120 kg ha^{-1} nitrogen applied as urea

Fig. : 25. Effect of different levels of nitrogen on 1000 seed weight of sesame



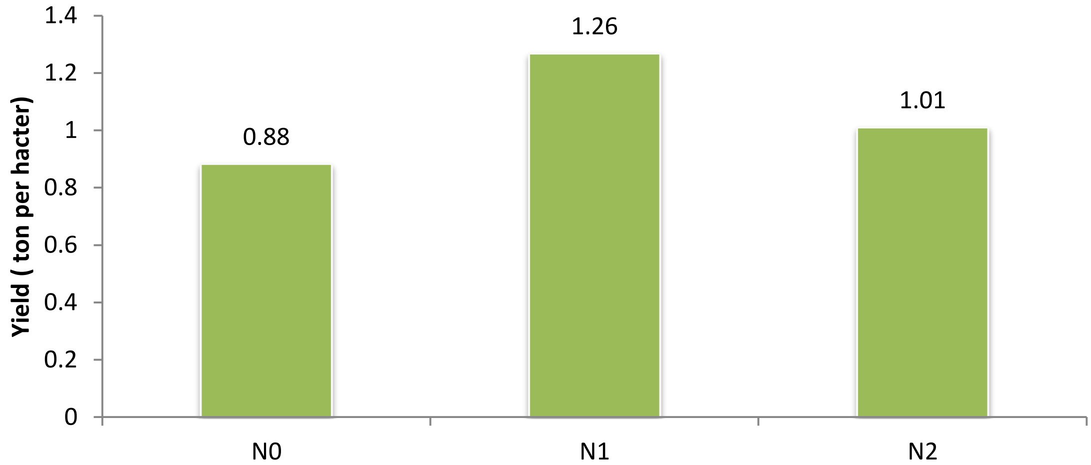
A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix

Fig. : 26. Effect of differents levels of NAA on the 1000 seed weight of sesame

4.14 Yield (t ha^{-1})

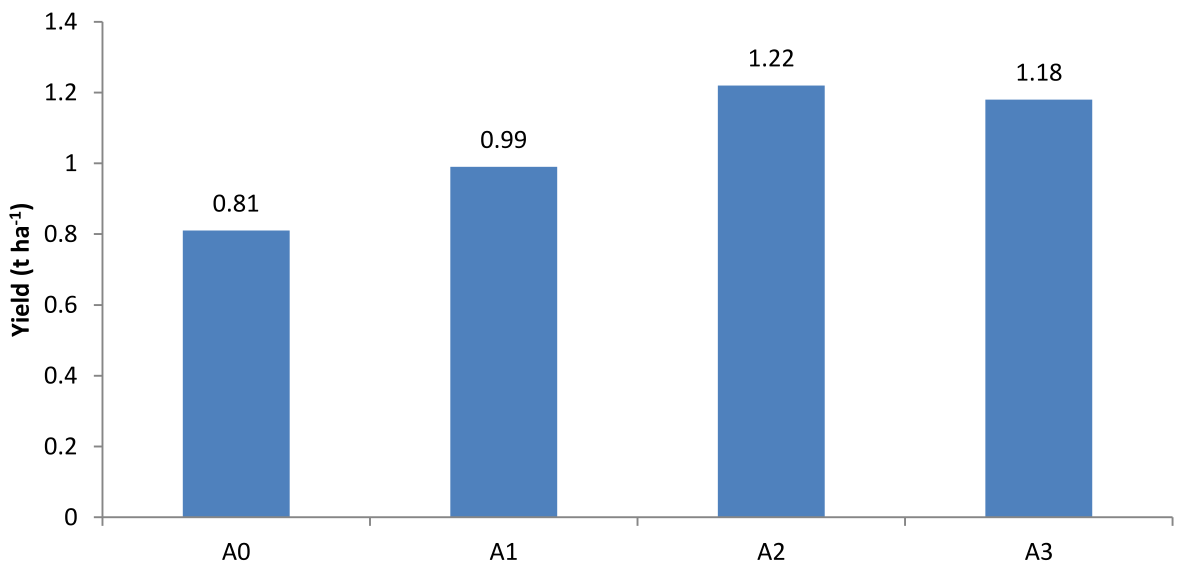
The seed yield of sesame $plot^{-1}$ (g) was converted into $hectare^{-1}$ and has been expressed in metric tons. The different levels of nitrogen had significant effect on the yield of seed ton (t) $hectare^{-1}$ as consistent with seed weight $plant^{-1}$ (g), seed weight $plot^{-1}$ (g) and 1000 seed weight (g) (Fig. 21, 23, 25 and 27). The maximum yield of seed $hectare^{-1}$(1.26 t) was obtained from N_1 (60 kg ha^{-1}) whereas the minimum yield of seed per hectare (0.88 t) was obtained from N_0 (control or without N). N_1 (60 kg ha^{-1}) gave the maximum yield than N_2 (120 kg ha^{-1}) this could be because of excessive nitrogen had been reported to reduce fruit number and yield for sesame but enhances plant growth (Aliyu *et al*., 1996). This finding corroborated those of Bonsu (2003), Fathy and Mohammed (2009).

In this study the seed yield of sesame $plot^{-1}$ (g) was converted into $hectare^{-1}$and has been expressed in metric tons (Fig. 28 and Appendix VIII). The different concentrations of 1-napthaleneacetic acid (NAA) had significant effect on the seed yield of sesame ton $hectare^{-1}$ as similar to seed weight $plant^{-1}$ (g), seed weight $plot^{-1}$ (g) and 1000 seed weight (g) (Fig. 22, 24, 26, 28). The highest yield of seed $hectare^{-1}$(1.22 t) was obtained from A_2 (50 ppm) which was statistically similar with A_3 (1.18 t) and the minimum yield of seed per hectare (0.81 t) was obtained from A_0 (control or 0 ppm NAA). These results showed that the foliar application of NAA increased the yield of sesame. The similar findings had stated by Rao (1971). Nawalagatti *et al.* (1991), Segare and Naphade (1987), Venkaten *et al.* (1984) and Subrahmaniyan *et al.* (1999) had observed that foliar spray of NAA in different concentration at different days of interval significantly increased the yield. Application of growth regulators had significantly increased the yield of plant had also reported by Witgenberger *et al.* (1985), Bharud *et al.* (1986), Gundalia *et al.* (1990) and Devasenapathy *et al.* (1987).



N_0 – No nitrogen applied, N_1 – 60 kg ha^{-1} nitrogen applied as urea ,
N_2– 120 kg ha^{-1} nitrogen applied as urea

Fig. : 27. Effect of different levels of nitrogen on the yield of sesame



A_0 – 0 ppm NAA applied as Planofix, A_1 – 25 ppm NAA applied as Planofix
A_2 – 50 ppm NAA applied as Planofix, A_3 – 75 ppm NAA applied as Planofix

Fig. : 28. Effect of differents levels of NAA on the yield of sesame

There was a significant combined effect of different levels of nitrogen fertilizer and NAA concentrations and showed significant variation on the yield of sesame (Table 6 and Appendix VIII). The maximum seed yield (1.49 t) was recorded for the N_1A_2 (60 kg N $ha^{-1}$and 50 ppm NAA) treatment combination and the minimum (0.54 t) was observed from N_0A_0 (0 kg N ha^{-1} and 0 ppm NAA) treatment combination. The total yield of sesame increased by the application of different levels of N fertilizer and NAA concentrations and the best result from the combination of N_1A_2 (60 kg ha^{-1} N and 50 ppm NAA) had found from this experiment. Previous results like pod number $plant^{-1}$, pod diameter (mm), pod length (mm), seed weight $plant^{-1}$ (g), seed weight $plot^{-1}$ (g) and 1000 seed weight (g) (Table 5, 6) had similarity with these results. Katwala and Saraf, (1990) observed that as application of one percent urea as nitrogen fertilizer (N) with 1-napthaleneacetic acid (NAA) at 40 ppm significantly increased the yield of sesame.

Chapter V
SUMMARY AND CONCLUSIONS

The experiment was undertaken during Kharif 1 season, April 2013 to July 2013 to examine the response to different levels of nitrogen (N) and 1-napthaleneacitic acid (NAA) on morphology, yield and yield attributes of sesame variety BARI Til 4. In this experiment, the treatment consisted of three different N levels viz. N_0 = 0 kg N ha^{-1}, N_1 = 60 kg N ha^{-1}, and N_2 = kg N ha^{-1}, and four different level of NAA viz. A_0 = 0 ppm, A_1 = 25 ppm, A_2 = 50 ppm and A_3 = 75 ppm. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. The amount of fertilizers in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc oxide and boric acid as a source of N, P, K, S, Zn and B respectively were applied according to treatment and area of experimental unit plot. The collected data were statistically analyzed for evaluation of the treatment effect. Results showed that a significant variation among the treatments in respect majority of the observed parameters.

There was significant difference among the different levels of N in respect of almost all parameters. The tallest plant height (61.31, 90.47 and 121.3 cm at 30, 40 and 50 DAS respectively) was recorded with $N_{1,}$ 60 kg N ha^{-1}. The maximum number of leaves per plant (15.42, 18.25 and 37.67 at 30, 40 and 50 DAS, respectively) was produced by 60 kg N ha^{-1}. The number of branches $plant^{-1}$ showed significant variation during 30 DAS and the maximum number of branches $plant^{-1}$ (6.58) was produced by 60 kg N ha^{-1} whereas no significant variation was found at 40 and 50 DAS in case of number of branches $plant^{-1}$. The highest fresh and dry shoot weight (49.17 g and 7.41 g, respectively) was obtained from 60 kg N ha^{-1}. The highest fresh and dry root weight (6.90 g and 1.75 g, respectively) was obtained from 60 kg N ha^{-1}. The maximum number of pod $plant^{-1}$ (49.08) was obtained in plots which received 60 kg N ha^{-1}. The highest fruit diameter and length (9.85 mm and 21.49 mm, respectively)) was obtained from N_1 (60 kg N ha^{-1}). The maximum seed weight per plant (27.41 g) was produced by N_1 treatment. The maximum seed yield per plot (380.4 g) was produced by $N_{1.}$ The maximum thousand seed weight (11.18 g) was produced by N_1. The maximum yield of seed per hectare (1.26 t) was obtained from $N_{1,}$ 60 kg N ha^{-1}, whereas the minimum yield of seed per hectare (0.88 t) was obtained from $N_{0,}$ without N.

Plant height showed significant difference in response of foliar application of 1-napthaleneacitic acid (NAA). The tallest plant height (60.98, 91.10 and 123.2 cm at 30, 40 and 50 DAS, respectively) was produced with the A_2 (50 ppm NAA). The results showed that number of leaves plant^{-1} were statistically insignificant hence was not influenced by different NAA concentrations. There was no significant variation observed in the number of branch plant^{-1} at 30 and 40 DAS hence not affected by different NAA doses whereas significant effect at 50 DAS and the maximum number of branches plant^{-1} 14.00 was produced by A_2 (50 ppm NAA). The highest fresh and dry shoot weight (47.51 g and 8.50 g, respectively) was obtained from 50 ppm NAA. The highest fresh and dry root weight (6.75 g and 2.16 g, respectively) was obtained from 50 ppm NAA. The maximum number of pod plant^{-1} (51.22) was obtained in plots which received 50 ppm NAA. The highest fruit diameter and length (9.15 mm and 23.63 mm, respectively)) was obtained from A_2 (50 ppm NAA). The maximum seed weight per plant (29.40 g) was produced by A_2 treatment. The maximum seed yield per plot (367.2 g) was produced by A_2 (50 ppm NAA). The maximum thousand seed weight (11.38 g) was produced by A_2. The maximum yield of seed per hectare (1.22 t) was obtained from A_2 (50 ppm NAA), whereas the minimum yield of seed per hectare (0.81 t) was obtained from $A_{0,}$ without NAA.

The combinations of N and NAA had significant effect on almost all parameter. The tallest plant height (67.73, 94.23 and 124.4 cm at 30, 40 and 50 DAS, respectively)) was found in N_1A_2 treatment combination. The results showed significant differences on number of leaves plant^{-1} and number of branches plant^{-1} of sesame at 30 DAS whereas statistically insignificant at 40 DAS and 50 DAS. The maximum number of leaves plant^{-1} and number of branches plant^{-1} (19.23 and 8.00, respectively) at 30 DAS was found in N_1A_2 treatment combination (60 kg N ha^{-1} and 50 ppm NAA). The highest fresh and dry shoot weight (58.30 g and 10.10 g, respectively) and highest fresh and dry root weight (9.53 g and 3.43 g, respectively) was obtained from N_1A_2 treatment combination. The maximum number of pod per plant (59.67), pod diameter (11.59 mm) and pod length (23.63 mm) was found in N_1A_2 treatment combination. The maximum seed weight per plant (34.67 g), seed weight per plot (447.1 g), thousand seed weight (13.13 g) was found in N_1A_2 treatment combination (60 kg N ha^{-1} and 50 ppm NAA). The highest yield of seed per hectare (1.49 tones) was obtained from N_1A_2 treatment combination (60 kg N ha^{-1} and 50 ppm NAA). The lowest yield of seed per hectare (0.54 tones) was obtained from N_0A_0 treatment combination without nitrogen and 1-napthaleneacitic acid.

Considering the above results, it may be summarized that morphological parameters, seed yield and yield contributing parameters of sesame are consistent with N and NAA application. Therefore, the present experimental results suggest that the combined use of 60 kg N ha^{-1} and 50 ppm NAA along with recommended doses of other fertilizer would be beneficial to increase the seed yield of sesame variety BARI Til 4 under the climatic and edaphic condition of Sher-e-Bangla Agricultural University, Dhaka.

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

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for analogy the accuracy of the experiment.
2. It needs to conduct more experiments with N and NAA whether can regulate the morphophygiology, yield and seed quality of sesame BARI Til 4.
3. It needs to conduct related experiment with other varieties of sesame.
4. Scope to conduct advance experiments how N and NAA physiologically increase seed yield and improve seed quality of sesame.

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APPENDICES

Appendix I: Physical and chemical characteristics of initial soil (0-15 cm depth)

A. Physical composition of soil

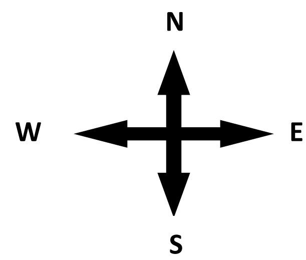
Soil separates	(%)	Methods employed
Sand	36.90	Hydrometer method (Day, 1995)
Silt	26.40	-do-
Clay	36.66	-do-
Texure class	Clay loam	-do-

(SAU Farm, Dhaka)

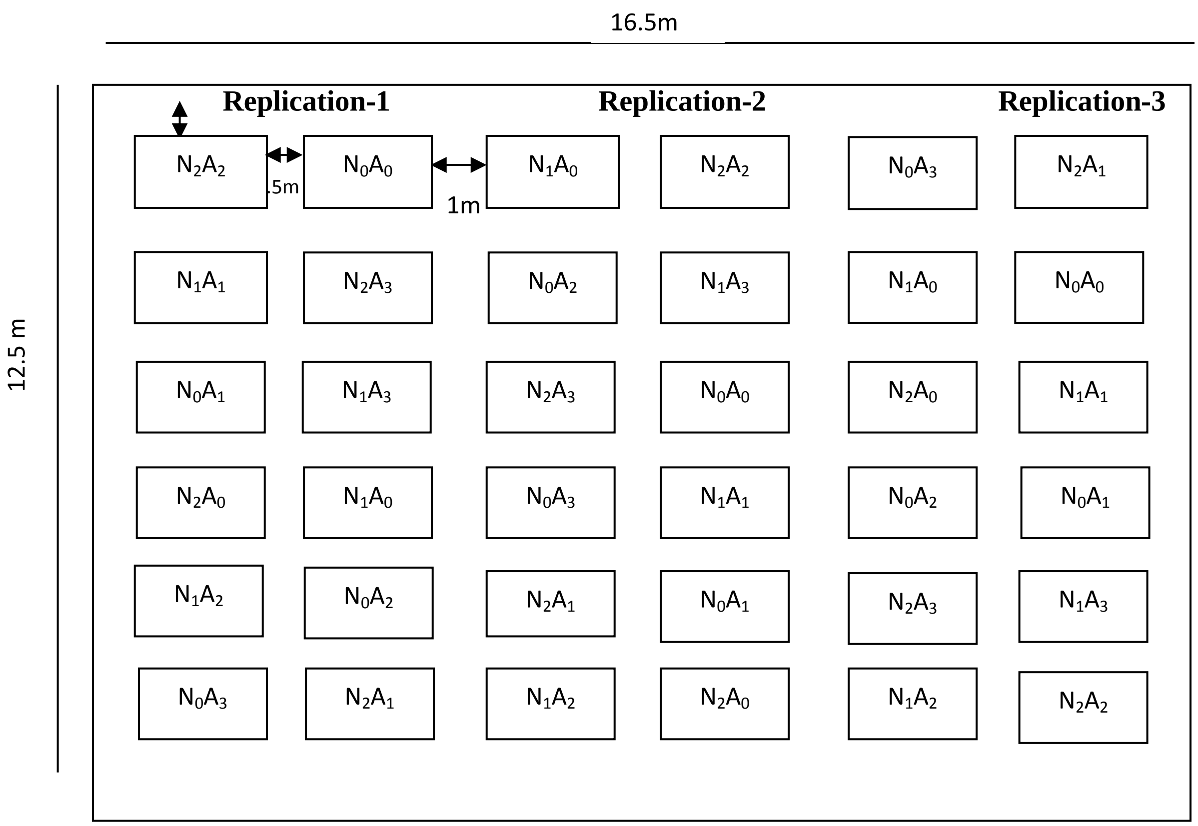
B. Chemical composition of soil

SI.	Soil characteristics	Analytical data	Methods employed
1	Organic carbon (%)	0.82	Walkley and Black, 1947
2	Total N (kg ha^{-1})	1790.00	Bremner and Mulvaney, 1965
3	Total S (ppm)	225.00	Bardsley and Lancster, 1965
4	Total P (ppm)	840.00	Olsen and Sommers, 1982
5	Available N (kg ha^{-1})	54.00	Bremner and Mulvaney, 1965
6	Available P (kg ha^{-1})	69.00	Olsen and Dean, 1965
7	Exchangeable K (kg ha^{-1})	89.50	Pratt, 1965
8	Available S (ppm)	16.00	Hunter, 1984
9	P^H (1 : 2.5 soil to water)	5.55	Jackson,1958
10	CEC	11.23	Chapman, 1965

(SAU Farm, Dhaka)



Appendix II. Layout of the experimental plot



Unit plot size:

2 m x 1.5 m

N = Nitrogen

NAA = 1-napthaleneacetic acid

Factor A: Nitrogen

N_0= without nitrogen

N_1= 60 kg N ha^{-1}

N_2= 120 kg N ha^{-1}

Factor B: NAA

A_0= without NAA

A_1= 25 ppm NAA

A_2= 50 ppm NAA

A_3= 75 ppm NAA

Appendix III: Analysis of variance of the data on plant height of sesame as influenced by different levels of nitrogen and 1-naphthaleneacetic acid

Sources of variation	Degree of freedom	Mean square		
		Plant height		
		30 DAS	40 DAS	50 DAS
Replication	2	96.74	103.30	106.73
Factor A (N)	2	172.33**	57.25**	56.03*
Factor B (NAA)	3	25.71NS	31.47**	38.00*
A X B	6	31.19*	22.16*	29.56*
Error	22	9.24	6.32	9.79

** significant at 1% level of probability,
* significant at 5% level of probability,
NS- Non significant

Appendix IV: Analysis of variance of the data on number of leaves plant^{-1} of sesame as influenced by different levels of nitrogen and 1-naphthaleneacetic acid

Sources of variation	Degree of freedom	Mean square		
		Number of leaf per plant		
		30 DAS	40 DAS	50 DAS
Replication	2	57.02	43.58	34.11
Factor A (N)	2	19.11*	34.33*	274.52**
Factor B (NAA)	3	10.69NS	22.54NS	58.69NS
A X B	6	14.55*	17.96NS	40.97NS
Error	22	3.87	9.70	25.89

** significant at 1% level of probability,
* significant at 5% level of probability, NS- Non significant

Appendix V: Analysis of variance of the data on number of branch plant^{-1} of sesame as influenced by different levels of nitrogen and 1-naphthaleneacetic acid

Sources of variation	Degree of freedom	Mean square		
		Number of branch per plant		
		30 DAS	40 DAS	50 DAS
Replication	2	1.02	1.58	1.75
Factor A (N)	2	10.52**	3.08NS	0.75NS
Factor B (NAA)	3	1.63NS	1.96NS	21.51**
A X B	6	3.71*	2.04NS	4.38NS
Error	22	0.99	0.97	2.32

** significant at 1% level of probability,
* significant at 5% level of probability,
NS- Non significant

Appendix VI: Analysis of variance of the data on fresh and dry weight (g) of shoot and root of sesame as influenced by different levels of nitrogen and 1-naphthaleneacetic acid

Sources of variation	Degree of freedom	Mean square			
		Shoot fresh weight (g)	Shoot dry weight (g)	Root fresh weight (g)	Root dry weight (g)
Replication	2	4.22	1.31	3.00	0.05
Factor A (N)	2	476.93**	8.84**	18.70**	0.12*
Factor B (NAA)	3	537.57**	16.42**	30.18**	5.56**
A X B	6	156.08**	13.77**	9.69**	2.59**
Error	22	5.64	0.428	0.58	0.02

** significant at 1% level of probability,
* significant at 5% level of probability,
NS- Non significant

Appendix VII: Analysis of variance of the data on Pod number per plant, Pod diameter and Pod length of sesame as influenced by different levels of nitrogen and 1-naphthaleneacetic acid

Sources of variation	Degree of freedom	Mean square		
		Number of pod per plant	Pod diameter (mm)	Pod length (mm)
Replication	2	23.69	2.18	0.74
Factor A (N)	2	263.34*	8.05**	24.97**
Factor B (NAA)	3	123.73*	13.19**	5.04*
A X B	6	201.38**	9.55**	2.71**
Error	22	50.58	1.19	2.76

** significant at 1% level of probability,
* significant at 5% level of probability,
NS- Non significant

Appendix VIII: Analysis of variance of the data on yield contributing characters of sesame as influenced by different levels of nitrogen and 1-naphthaleneacetic acid

Sources of variation	Degree of freedom	Mean square			
		Seed weight per plant (g)	Seed weight per plot (g)	1000 seed weight (g)	Yield (t ha^{-1})
Replication	2	0.93	479.52	0.13	0.01
Factor A (N)	2	206.18**	41451.69**	2.37*	0.46*
Factor B (NAA)	3	129.03*	28704.32**	5.14*	0.32*
A X B	6	59.31**	7968.10**	3.01**	0.08**
Error	22	3.39	447.28	0.16	0.01

** significant at 1% level of probability,
* significant at 5% level of probability,
NS- Non significant