GERMINATION, VIGOR AND YIELD PERFORMANCE OF DIFFERENT SESAME (SESAMUM INDICUM L.) VARIETIES

Examination Roll No. MS- 050805

A Thesis
Submitted to the Agrotechnology Discipline in partial fulfillment of the requirement for the degree of Master of Science in Agronomy

Agrotechnology Discipline
Khulna University
Khulna-9208
Bangladesh

February, 2008

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A Thesis
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DEDICATED TO MY
BELOVED PARENTS AND HUSBAND

THESIS ABSTRACT

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By

Mst. Kanij Fatema

A laboratory experiment was conducted at the Agronomy Laboratory of Agrotechnology Discipline, Khulna University, Khulna and another was a field experiment was conducted at the Field Laboratory of the same Discipline during kharif-1 (March-June), 2006 to determine germination capacity, vigor and yielding ability of different sesame varieties. Seven varieties of sesame (V_1 = T-6, V_2 = BARI Til-2, V_3 = BARI Til-3, V_4 = BINA Til, V_5 = Khulna local Til, V_6 = Panchagarh Local Til-1 and V_7 = Panchagarh Local Til-2) were used as treatment variables in the experiments. The laboratory experiment was laid out in a Completely Randomized Design (CRD) while the field experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Germination test was done in the laboratory following Petri dish method. Germination was counted at an interval of 24 hours and continued for seven days. Seedling dry weight was recorded from 3rd day to 18th day at three day intervals. Plant height, number of branches plant^{-1}, number of leaves plant^{-1}, number of capsules plant^{-1}, length of capsule, number of seeds capsule^{-1}, 1000-seed weight, seed yield plant^{-1} and harvest index were recorded from each replicated plot in the field trial. There was wide variation in germination percentage among the varieties. BARI Til-3 had the highest germination percentage (99.33) followed by BINA Til (94.00%) while Panchagarh Local Til-1 exhibited the lowest germination percentage (30.00). T-6 was found superior attaining the maximum dry weight at every sampling dates. However, performance of other varieties was variable. All the yield attributes except 1000-seed weight were significantly affected by variety. All the yield parameters were found maximum in the variety T-6 except capsule length and seeds capsule^{-1}. Variety BINA Til possessed the longest capsules as well as more number of seeds capsule^{-1}. The performance of other varieties was not consistent. Seed yield was well correlated with plant height, leaf plant^{-1}, capsule number and harvest index.

ACKNOWLEDGEMENTS

First of all, the author is very much grateful to the Almighty Allah Who always helps for facing any difficulty and has enabled her to complete the research work and to prepare the thesis.

With a sense of devotion and duty, the author whole heartedly, expresses her profound sense of gratitude, sincere appreciation and immense indebtedness to her respected teacher and supervisor Dr. Md. Sarwar Jahan, Associate Professor, Agrotechnology Discipline, Khulna University, Khulna, for his sincere interest, intellectual guidance, scholastic supervision and extra ordinary kind concern during the study and the preparation of the thesis manuscript.

The author wishes to express her cordial thanks and indebtedness to respected co-supervisor, Dr. Sanjoy Kumar Adhikary, Professor, Agrotechnology Discipline, Khulna University, Khulna, for his kind co-operation and time to time encouragement during the development of the program of studies as well as research work and guidance for improving the thesis.

The author is grateful to Professor Dr. Md. Yasin Ali, Head of Agrotechnology Discipline, Khulna University, Khulna for providing all facilities to perform the research work. The author is also anticipated to all honorable teachers of Agrotechnology Discipline, Khulna University, Khulna, for their encouragement and valuable suggestions.

The author expresses her heartiest gratitude and indebtedness to the Section Officer (Lab.) Md. Shamsol Alam and the Skilled Farmer, Nivanon Kumar Roy, Agrotechnology

Discipline, Khulna University, Khulna, for their cooperation to complete the research work both in the field and in the laboratory.

The author expresses her gratefulness to her friend Nahida Islam for her cordial support. Thanks go to Nandita Roy for taking the analytical photographs. The author is also thankful to Sarbani Biswas for technical support.

The author expresses gratitude to her parents and husband Md. Enamul Haque for their immense patience, sacrifice, inspiration and all sorts of help during the study.

February, 2008 **The author**

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GENERAL INTRODUCTION

Oilseed is one of the major economically important group of crops in Bangladesh. Annually Bangladesh is producing about 0.16 million tonnes of edible oil as against the requirement of 0.5 million tonnes (Wahhab *et al.,* 2002). To meet the demand the country has to import oils and oilseeds to the tune of about 160 million US dollar every year (Anonymous, 2000). Therefore, it is an urgent need to take immediate actions for increasing the internal production to reduce the import to some extent.

In Bangladesh, sources of edible oils are rapeseed/mustard, sesame, groundnut, soybean, niger, linseed, sunflower and safflower. Of the total land used under oilseeds cultivation, 60% is used for mustard and rapeseed cultivation. But it is a fact that only by cultivating mustard and rapeseed our requirement of vegetable oil cannot be met up. In that case, importance has to be given on the cultivation of other oil crops including sesame. If the other oilseeds are cultivated using high yielding varieties and modern technologies, the shortage of edible oil in the country will be minimized to a great extent.

The climate of Bangladesh is suitable for cultivation of different edible oilseeds. However, the national average yield of oil crops is 739 kg ha^{-1} (Wahhab *et al.*, 2002), which is very low as compared to other oilseeds growing countries of the world. The main reasons of lower yield of our country are lack of good quality HYV seeds and inadequate adoption of improved production technologies developed by different institutes. High yielding oilcrop varieties developed by Bangladesh Agriculture Research Institute, Bangladesh Institute of

Nuclear Agriculture, Bangladesh Agricultural University and other organizations are not properly disseminated to the farmers.

It has been established that the rate of seedling emergence, uniformity of emergence and total emergence are critical determinants of crop establishment and yield (Bam *et al.*, 2006). A successful crop establishment therefore requires planting high quality seed which germinates promptly under a wide range of field conditions (Phill, 1995; Yamauchi and Winn, 1996; Mcdonald, 1998). However, loss of viability and vigor prior to sowing is a major problem in tropical and subtropical regions (Ellis, 1988) due to poor storage conditions, resulting in low field emergence (Khan *et al.*, 2003).

Germination energy is a direct measure of seed vigor. Mean germination time is a good measure of vigor of viable seeds (Shen and Oden, 2000). Prolonged germination time is therefore an indication of deterioration of seed quality (Dell'Aquila, 1987).
In Bangladesh, about 1.0 million hectare of arable lands are affected by varying degree of soil salinity (Karim *et al.*, 1990). Crop yields, cropping intensity, production levels and people's quality of livelihood are much lower in this region than other parts of the country, which have enjoyed the fruits of modern agricultural technologies based on high yielding varieties, improved fertilizer and water management and improved pest and disease control measures (BBS, 2001). It is noteworthy that sesame is the main and/or only crop during kharif season in saline areas including Khulna region (Jahan *et al.*, 2005). Jahan and Sultana (2007) reported that sesame cultivation is an integral part of the existing cropping patterns of this agriculturally problem area. However, the farmers of this region grow only

the local cultivars of sesame. It has been reported by the researchers that the traditional varieties show an average yield of 630 kg ha^{-1} whereas the high yielding varieties yield up to 1700 kg ha^{-1} (BINA, 2004). It is thus necessary to study the performance of high yielding varieties of sesame to incorporate in the existing cropping patterns. This effort will certainly increase the overall productivity of this region.

Keeping the above facts in mind the present study was undertaken

1. to determine germination capacity and vigor of different sesame varieties, and
2. to find out the yielding ability of different sesame varieties.

REVIEW OF LITERATURE

Sesame (*Sesamum indicum* L.) is the summer leading oil crop in Bangladesh . Investigation on sesame in its major growing countries like Bangladesh is limited and in developed countries it is a minor crop with little interest. As a result information on its germination, seedling vigor and yield performance is limited. However, information available in these aspects of sesame have been reviewed and presented in this section.

Varietal performance of different crops

Uddin and Mitra (1994) conducted an experiment with some genotypes of sesame and observed that significant variation was present among the genotypes in respect of all characters studied (seed yield plant^{-1}, branches plant^{-1}, capsule plant^{-1}, seeds capsule^{-1}, days to maturity and days to flowering) except 1000-seed weight.

Begum and coworkers (2001) carried out an experiment with variety T_6 and variety Lal Til and found that the varieties differed significantly for the studied characters except 1000-seed weight. T_6 performed better in terms of seed yield, capsule number plant^{-1} and plant height, whereas Lal Til variety was superior for branch and stalk production.

Balasubramaiyan (1996) conducted an experiment with variety TMV3 and variety VS350 of sesame and observed that pre-released culture VS350 yielded more (711 kg ha^{-1}) than variety TMV3 (636 kg ha^{-1}).

Kadir and associates (1996) carried out an experiment on genetic parameters, character association and path analysis in sesame and observed that days to 50% flowering, branches plant^{-1}, capsule plant^{-1}, seeds capsule^{-1} and 1000-seed weight had the positive and significant association with seed yield both at phenotypic and genotypic levels.

Suddihiyam and colleagues (2001) conducted an experiment to observe the response of sesame to temperature and photoperiod and found that there were significant interactions of temperature and photoperiod on the rate of flowering of sesame. They also found that temperature affects both vegetative development and the rate of floral induction in some varieties.

Ramiraz and coworkers (2005) conducted an experiment with salt tolerance of sesame genotypes and suggested that sesame tolerance to $CaCl_2$ salinity improved through the growing season and may be genetically controlled.

Venkatesan and fellows (1985) found highest yield of sesame in the summer season as compared to monsoon season applying similar dose of nitrogen in both rabi and kharif seasons.

Mohammad (1989) found that among varieties of mustard there was significant difference in height at vegetative stage.

Mondal (1983) conducted an experiment with exotic and indigenous strains of safflower and observed that significant differences were present in seed yield ha^{-1}, seed yield $plant^{-1}$, plant height, number of primary branches $plant^{-1}$, number of heads $plant^{-1}$, days to maturity and oil content between the exotic and indigenous strains of safflower.

Alam and Wahhab (1981) demonstrated between two different varieties of mustard that a selected variety 9002 matured earlier and gave 37% higher yield than the recommended variety Rai-5.

Dubey and coworkers (1995) observed that there was significant variation in the yield contributing characters as well as seed yield among different genotypes of soybean.

Patrick (1988) reported that seed yield is mostly governed by varietal characteristics and environment the crop experiences during its development.

Desai and colleagues (1984) indicated that capsule number had the maximum direct influence on seed yield of sesame varieties.

Variation in seed and seedling vigor

Vigor is the sum of those properties of the seed which determine the level of activity and performance of the seed or seed lot during seed germination and seedling emergence (ISTA, 2006). Maximum viability is attained earlier than maximum vigor but both are assumed to be at maximum at physiological maturity (Harrington, 1972). After physiological maturity, seed vigor declines earlier than viability (Dornbos, 1995). Germination and stand establishment depends on some factors like seed vigor and field condition. The seeds having low vigor values cannot germinate well under adverse field conditions.

Khandakar and Bradbeer (1983) reported a wide gap between laboratory test and field germination. Low vigor in seed may be due to genetic, physiological, morphological, cytological, mechanical and microbial factors (Heydecker, 1972). Mechanical damage during harvesting, processing and transportation is one of the real causes of low vigor in seeds (Roberts, 1972).

Tekrony and associates (1980) observed a significant decline in seed vigor after harvest maturity which has closely related to air temperature, relative humidity and precipitation per day. In other experiment, Siddique and Goodwin (1980) found that high temperature (33^0C) during seed growth reduced seed quality of bean. Soybean plants that matured during hot and dry weather produced seed with low laboratory germination and field emergence. The highest quality soybean seeds were produced that matured before hot and dry weather. Environmental stress like high day and night temperature during reproductive growth of soybean reduce seed germination and seedling vigor (Gibson and Mullen, 1996). On the other hand, Zito and colleagues (1995) found better germination in seeds developed in good weather condition.

Seed vigor determines the potential for rapid, uniform emergence and development of normal seedlings under wide range of field conditions (ISTA, 1976). Seed germination and early seedling growth are considered critical for raising crops successfully as they indirectly determine the crop stand density and consequently the yield of crop (Gelmond, 1978). Vigor measures can be used for predicting the potential field performance of seedlings.

Tekrony and Egli (1977) used standard germination, 4 days germination and accelerated aging germination to construct vigor indices. These indices were better predictors to field emergence than individual tests. Multiple regression techniques have also been used to relate several laboratory tests to field emergence.

Loeffer (1981) and Yaklieh and Kulik (1979) developed equations with coefficients of determination (R^2) ranging from 0.68 to 0.91 but they did not evaluate their ability independently to predict emergence.

Leudders and Burris (1979) used their multiple regression equation to predict emergence and found that it was not better than individual laboratory tests.

Since sesame is sown from seed, one of the reasons for low yield may be use of poor quality seeds resulting in low seedling vigor and field stand. Seed deterioration can render seed worthless for planting purposes, although its germination percentage may remain relatively high (Christiansen and Presley, 1967). No laboratory test can predict the absolute values of field emergence because of great soil environmental variability.

Burris (1985) found a positive correlation between rolled towel germination values with field emergence in soybeans; but concluded that such correlation depends on field environment.

Bird and Reyes (1967) found that germination of unconditioned cottonseed tended to increase until seed reached the conditioned stage.

Most early studies evaluated seed quality by comparing laboratory germination tests to actual field emergence. Seed viability and potential vigor directly affect the performance of field planted seeds. Tekrony and Egli (1991) extensively reviewed the relationship of seed vigor to crop yield and concluded that high vigor seeds ensure adequate plant population under a wide range of field conditions that affect vegetative growth and ultimately yield in crops (such as lettuce, broccoli etc.) that are harvested vegetative. The general relationships between seed vigor or viability and crop yield have also been discussed by Bishnoi and Delouche (1980).

The rapid and uniform emergence of the seedlings of legumes in the field is conducive to higher yields (Hopper *et al.*, 1979). Similar result was also found by Gan and coworkers (1992) in case of wheat, they reported that grain yield plant^{-1} decreased for progressively latter emerged plants.

Zhang and Mann (1990), and Shieh and McDonald (1982) had similar observations in *Agropyron* and sunflower.

Varietal differences in seed germination in response to environmental variation determine cultivar adaptability (Takahashi, 1984). Usually laboratory germination tests are used to obtain a general indication of the capacity of seeds to produce plants in the field. High germination percentage may not necessarily result in good stand and establishment rather high germination percentage raises high expectation of field emergence. Seed vigor tests often give better predictability of field performance (Marshal and Naylor, 1984). Seed vigor is the sum total of genetic properties (Perry, 1972), which determine the potential for rapid, uniform emergence, and development of normal seedling under a wide range of field conditions (McDonald, 1980). Several tests are available for estimating seed vigor (ISTA, 1989). Electrical conductivity test has been used by many researchers to indicate seed vigor (Normah and Chin, 1991). The objective of the present study was to see the variations in germination capacity and seedling vigor of seven sesame varieties of Bangladesh.

MATERIALS AND METHODS

The experiment was conducted in the Agronomy Laboratory of Agrotechnology Discipline, Khulna University, Khulna from the month from June to July, 2007. The experiment was laid out in a Completely Randomized Design (CRD) with seven varieties and three replications. Data on germination and seedling vigor were subjected to analysis of variance (ANOVA). All the recorded data were analyzed with the computer package MSTAT-C and differences among treatment means were adjudged by Duncan's Multiple Range Test (DMRT).

Germination test: Healthy and uniform seeds of T-6, BARI Til-2, BARI Til-3, BINA Til, Khulna local Til, Panchagarh local Til-1, Panchagarh local Til-2 were used in the study. For each variety three replications of Petri dishes were used. Two blotters or filter papers were placed on the bottom of the Petri dish and they were soaked with distilled water. Fifty seeds were placed on the surface of water-soaked blotters in each Petri dish. The kind of seed, date and time of seed soaking were written on the lid of Petri dish with the help of a glass marker. Germination was counted at an interval of 24 hours for seven days. A seed was considered to be germinated as seed coat ruptured, plumule and radicle came out and were >2 mm long. Germination count was expressed in percentage. The rate/speed of germination was calculated using the following formula (Krisnasamy and Seshu, 1990).

Germination (%) was calculated by using the following formula:

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds set for test}} \times 100$$

Speed of germination was calculated using the following formula (Maguire, 1962):

$$\text{Speed of Germination (\%)} = \frac{\text{Number of seeds germinated at 72 h}}{\text{Number of seeds germinated at 168 h}} \times 100$$

Mean germination time (MGT) was calculated using the following formula (Scott *et al.*, 1984):

$$MGT = \frac{\Sigma\, T_iN_i}{\Sigma\, N_i}$$

Where, N_i is the number of newly germinated seeds at time T_i

Vigor tests: Beginning third day after germination five plant samples from each Petri dish was harvested daily. The plant sample was dried at 70^0 C for 72 hours and dry matter was recorded. Seedling dry weight was recorded in third day to eighteenth day at three days interval.

RESULTS AND DISCUSSION

Germination count was made daily beginning from third day of emergence of the seeds. There was wide variation in germination percentage among the varieties. Germination percentage ranged between 30 to 99. Varieties differed appreciably in the rate on germination as well.

Table 1. Differences in germination among different sesame varieties

Variety	Germination (%)	Germination speed (%)	Mean germination time (days)
T-6	60.67c	38.05d	2.38b
BARI Til-2	83.33ab	75.54b	1.29d
BARI Til-3	99.33a	86.06a	1.38d
BINA Til	94.00a	80.49ab	1.50d
Khulna local Til	60.00c	24.65e	2.86a
Panchagarh local Til-1	30.00d	16.69e	2.50b
Panchagarh local Til-2	65.33c	47.20c	2.09c
CV (%)	13.41	9.43	6.93

Among the seven varieties, BARI Til-3 showed the highest percentage (99.33%) of germination, which was statistically similar to BINA Til (94.00%) and BARI Til-2 (83.33%) respectively. The lowest percentage of germination was recorded in Panchagarh local Til-1 (30.00%) which was different from other varieties. T-6, Khulna local Til and Panchagarh local Til-2 were statistically similar with each other (60.67%, 60.00% and 65.33%, respectively) regarding germination. The highest germination speed was observed in BARI Til-3 (86.06%) which was statistically similar to BINA Til (80.49%). The lowest germination speed was observed in variety Panchagarh local Til-1 (16.69%) which was statistically similar with Khulna local Til (24.65%). The highest mean germination time was observed in Khulna local Til (2.86 days) and the lowest in BARI Til-2 (1.29 days) which was statistically similar with BARI Til-3 (1.38 days) and BINA Til (2.50 days) respectively.

Table 2. Seedling dry weight (mg five plants^{-1}) among different sesame varieties over time.

Variety	Seedling dry weight (mg five plant^{-1}) at different harvesting dates					
	1st	2nd	3rd	4th	5th	6th
T-6	14.00a	16.00a	18.00a	23.00a	27.47a	30.50a
BARI Til-2	12.00b	13.47bc	16.33b	18.23cd	24.73b	29.50ab
BARI Til-3	10.00c	10.67d	15.33bc	16.07d	21.80c	27.00c
BINA Til	11.00bc	13.47bc	14.73c	19.37bc	24.90b	26.10c
Khulna local Til	12.00b	11.87cd	16.00bc	21.00ab	23.80b	27.50bc
Panchagarh local Til-1	10.00c	11.77cd	14.93bc	16.00d	16.40e	17.50e
Panchagarh local Til -2	10.00c	14.50ab	16.10bc	18.20cd	19.63d	22.80d
CV (%)	9.57	9.29	5.58	6.75	4.79	5.03

Among the varieties, in the first sampling date, the highest dry weight was found in T-6 (14.00 mg 5 plants^{-1}) and the lowest dry weight was found in Panchagarh local Til-1, Panchagarh local Til-2 and BARI Til-3 (10 mg 5 plants^{-1}). In 2nd, 3rd, 4th, 5th and 6th date of sampling the highest seedling dry weight was found in T-6 (16.00, 18.00, 23.00, 27.47 and 30.50 mg 5 plants^{-1} respectively). The lowest were BARI Til-3, BINA Til in 2nd and 3rd

sampling date respectively. Panchagarh local-1 got the lowest weight in case of 4th, 5th and 6th day (16.00, 16.40 and 17.50 mg 5 plants^{-1}, respectively). Irrespective of varieties, seedling dry weight increased from emergence to eighteenth day and the highest increment in dry weight was observed in BARI Til-2 (16.5 mg 5 plants^{-1}).

Plate1. Seedlings of the variety T-6 at 10 days after germination (DAG)

Plate 2. Seedlings of the variety BARI Til-2 at 10 DAG

Plate 3. Seedlings of the variety BARI Til-3 at 10 DAG

Plate 4. Seedlings of the variety BINA Til at 10 DAG

Plate 5. Seedlings of the variety Khulna local Til at 10 DAG

Plate 6. Seedlings of the variety Panchagarh local Til-1 at 10 DAG

Plate 7. Seedlings of the variety Panchagarh local Til-2 at 10 DAG

PART II

YIELD PERFORMANCE OF DIFFERENT SESAME VARIETIES

INTRODUCTION

Three basic food elements i.e. carbohydrate, protein and fat or oil are required daily to provide necessary inputs and energy for normal growth and development of human beings. Oilseed crops play a vital role in human diet as well as in the economy of Bangladesh. They constitute the second most important group of the crop next to cereals (Anonymous, 2000).

Sesame (*Sesamum indicum* L.) is an important oil seed crop belonging to the family Pedaliaceae. The total area under sesame cultivation is 280000 hectares and production is 21000 metrictonnes (BBS, 2004). Despite of its versatile use, the crop is still neglected both in the research and farmers levels. The present average seed yield of sesame in Bangladesh is 900 kg ha^{-1} at demonstration trial but the national average yield is only 628 kg ha^{-1} (Wahhab *et al.*, 2002) which is quite low compared to other sesame growing countries (Khaleque and Begum, 1991). The low average yield of the crop might be due to cultivation of low yielding traditional varieties and poor management practices (Ali *et al.*, 1997). The yield potential of the crop can be explored through agronomic and genetic manipulations. It has been reported that the variability in cultural practices such as irrigation types and intervals, sowing interval and varietial properties etc. (Avila *et al.*, 1992; Majumdar and Roy, 1992) are important factors affecting sesame yield. Therefore, research on cultivation of superior cultivars under improved management conditions is utmost importance.

The climatic conditions of Bangladesh is quite suitable for the cultivation of sesame (Begum *et al.*, 2001). Among the oil crops cultivated in the country, sesame draws the special attention of the researchers as it can be grown in early Kharif season when most of the land remain fallow (Sarder and Rosario, 1993).

The average yield of sesame in Bangladesh can be improved through cultivation of superior varieties which needs screening of existing cultivars. Therefore, the present study was undertaken to examine the yield performance of seven sesame varieties of Bangladesh in Khulna region.

MATERIALS AND METHODS

Experimental site and climate

The experiment was conducted in experimental field of the Agrotechnology Discipline of Khulna University, during Kharif-1 (March-June) 2006.

Treatments

Seven varieties of sesame were used in the experiment as treatment variables. These were

V_1 = T-6

V_2 = BARI Til-2

V_3 = BARI Til-3

V_4 = BINA Til

V_5 =Khulna local Til

V_6 =Panchagarh local Til-1

V_7 =Panchagarh local Til-2

Design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 5 m × 4 m. Row and plant spacing was 30 cm ×10 cm. The adjacent blocks and the adjacent plots were separated from one another by 1 m and 0.5 m, respectively.

Land preparation

The land was initially ploughed with a bullock drawn country plough. All uprooted weeds and stubbles of the previous crop were removed from the experimental field. The land was finally prepared with power tiller to ensure a good land preparation. Bullock drawn leveler was used to level the land.

Fertilizer application

A dose of 110 kg N, 140 kg P_2O_5, 45 kg K_2O, 105 kg S, 5 kg Zn, and 10 kg B ha^{-1} was applied in the form of urea, triple super phosphate (TSP), muriate of potash (MP), zinc sulfate and boric acid, respectively. All fertilizer materials except urea were applied during final land preparation. Urea was applied in two equal splits; first half was applied as basal dose and the second half was top dressed after 30 days of sowing.

Seed sowing and crop establishment

The seeds of the variety T-6, BARI Til-2, BARI Til-3 were colleted from the Bangladesh Agricultural Research Institute (BARI), Gazipur; BINA Til was collected from Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh; Khulna local Til was collected from the farmers of Batiaghata, Khulna, Panchagarh local Til-1 and Panchagarh local Til-2 were collected from the farmers of Panchagarh. Seeds were treated with Vitavax-200 at the rate of 2 g kg^{-1} of seeds before sowing. Sowing was done manually in lines on March 01, 2006 in 2-2.5 cm deep furrows made by hand iron tine maintaining a line to line distance of 30 cm at the rate of 5.5 to 6.5 kg ha^{-1}. Immediately after sowing the plots were lightly irrigated to ensure moisture for uniform emergence. The seedlings emerged out within seven days after sowing. Fifteen days after emergence the crop was thinned to a desirable plant population keeping a plant to plant distance of about 10 cm. Weeding, irrigation and mulching were done as per requirements.

Data recording

The following data were recorded from each replicated plot during and after harvest. Five sample plants were collected from each plot and the means were calculated.

Plant height

Plant height was measured from the base to the tip of the plants and the means were calculated.

Number of branches plant^{-1}

The number of primary and secondary as well as total branches plant^{-1} was counted from five sampled plants and then averaged.

Number of leaves plant^{-1}

The number of leaves plant^{-1} was counted from total branches of five sampled plants and then averaged.

Number of capsules plant^{-1}

All the capsules borne on all the five sample plants of each unit plot were counted to determine the average number of capsule plant^{-1}.

Length of capsule (cm)

Five capsules were randomly selected from each sample plant of the five sample plants of each unit plot. The length of each capsules were measured using a measuring scale and finally plot wise average capsule length was calculated.

Number of seeds capsule^{-1}

Five capsules were randomly selected from each sample plant of the five sample plants of each unit plot. The capsules were split to count the seeds per capsule.

1000- seed weight (g)

One thousand oven-dried seeds were counted and then weight was recorded by means of an electric balance. Then the weight was converted to 14% moisture level.

Seed yield plant^{-1}

The crop was harvested at full maturity, seeds were separated out from the capsule, cleaned and dried in the sun to bring them safely moisture content of seed and thereafter the weight was taken. The weight of the seed was then converted to 14% moisture level by using the following formula.

$$X \times (1 + 0.14)$$

X = Weight of the seed at 0% moisture level.

Harvest index (%)

Harvest index (HI), the ratio of economic (seed) yield to biological yield was estimated and expressed as percentage using the following formula.

$$HI\ (\%)) = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

Biological yield = Seed yield + Straw yield

Statistical analysis

Data on plant characters, yield and yield attributes were subjected to analysis of variance (ANOVA). All the recorded data were analyzed with the computer package MSTAT-C and differences among treatment means were compared by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984). Functional relationships between yield parameters and plant growth characters were determined using simple correlation and regression analysis.

RESULTS AND DISCUSSION

The results obtained from the experiment in respect of variety on growth and yield of sesame are presented and discussed in this chapter. The parameters studied were plant height, number of branches plant^{-1}, capsules plant^{-1}, capsule length, seeds capsule^{-1}, 1000-seed weight, seed yield and harvest index. The results have been presented and discussed parameter-wise below.

Plant Growth Characters

Plant height (cm)

Plant height is an important morphological character that acts as a potent indicator of availability of growth resources in its vicinity. The height of plants depends on nutrient (Ferdous, 2001). Plant height at maturity varied significantly among different varieties in this study (Table 3). The highest plant height (102.50 cm) was observed in variety BARI Til-2 which was statistically similar with variety T-6. Hoque (1998) also found 102.60 cm tall plants in BARI Til-2. The lowest plant height (74.73 cm) was observed in variety Panchagarh local Til-2. Both varieties BINA Til and Khulna local Til showed statistically similar plant height (92.05 cm and 90.73 cm, respectively). Plant height of 83.53 cm was observed in variety BARI Til-3 which was similar statistically with variety Panchagarh local-1. Subrahmaniyan *et al.,* (1999) also reported that plant height may vary according to variety. Plotting plant height against yield showed a positive relationship (Fig. 1) indicating that the tallest plants produced more yield compared to smaller ones.

Table 3. Plant height (cm) and number of leaf plant^{-1} in different sesame varieties

Variety	Plant height (cm)	Leaf plant^{-1}
T-6	100.67a	344.87a
BARI Til-2	102.50a	259.30b
BARI Til-3	83.53c	94.87c
BINA Til	92.05b	39.90d
Khulna local Til	90.73b	60.83d
Panchagarh local Til-1	82.00c	39.80d
Panchagarh local Til-2	74.73d	47.67d
CV (%)	4.38	10.01

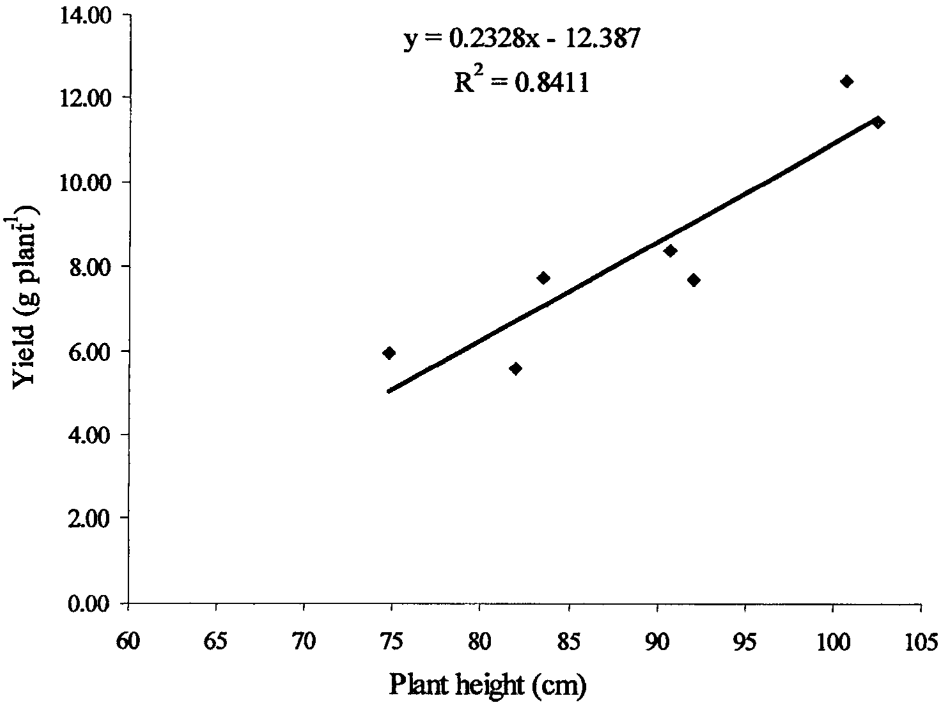

Fig. 1. Functional relationship between yield plant^{-1} and plant height in sesame varieties

Leaf Plant^{-1}

Biomass production of a crop plant depends almost wholly on the amount and pattern of photoactive radiation (PhAR) intercepted and absorbed by the crop and the efficiency of the crop to use the absorbed radiation. The interception of PhAR by a crop surface is the function of leaf area and the posture of the leaves on the plant (Jahan and Hamid, 2006). Both leaf area and leaf posture are dependent on number of leaf plant^{-}1. There was significant variation in number of leaf plant^{-1} among the varieties tested (Table 3). Among the varieties, T-6 produced the highest leaf plant^{-1} (344.87) followed by BARI

Til-2 (259.30). Panchagarh local Til-1 produced the lowest (39.80) leaf plant^{-1}. BINA Til, Khulna local Til, Panchagarh local Til-1and Panchagarh local Til-2 produced statistically similar leaf plant^{-1} (39.90, 60.83, 39.80 and 47.67, respectively). Plotting yield as a dependent variable against leaf plant^{-1} as independent variable yielded a straight line (Fig. 2). This result indicates that seed yield is dependent on leaf plant^{-1} and over 85% of the variation in yield could be satisfied by the variation in leaf plant^{-1}.

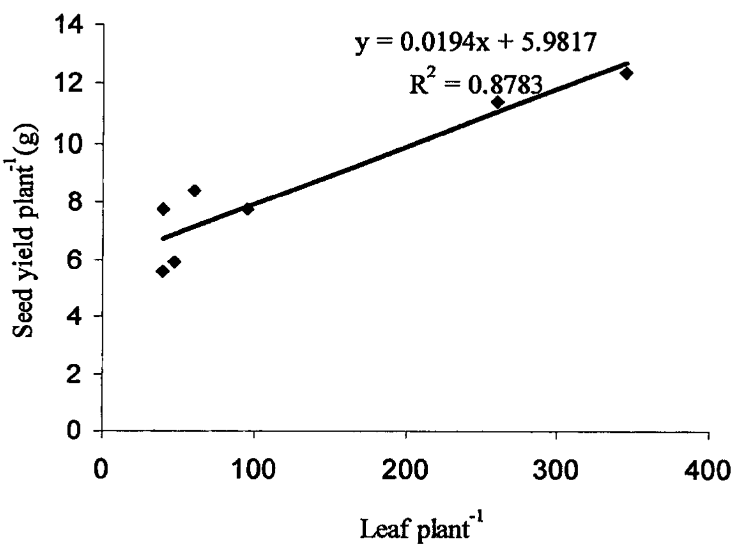

Fig. 2. Functional relationship between seed yield plant^{-1} and leaf plant^{-1} in sesame varieties

Table 4. Differences in branches plant^{-1} among sesame varieties

Variety	Branches plant^{-1}		
	Primary	Secondary	Total
T-6	6.33a	7.20a	13.53a
BARI Til-2	6.10a	4.70b	10.80b
BARI Til-3	4.73b	1.33c	6.07c
BINA Til	0.70e	0.00e	0.70f
Khulna local Til	4.20c	0.47d	4.67d
Panchagarh local Til-1	3.13d	0.20de	3.33e
Panchagarh local Til-2	3.27d	0.20de	3.47e
CV (%)	7.22	11.91	7.08

Branches Plant^{-1}

Primary, secondary and total branches plant^{-1} were recorded (Table 4). The highest number of primary branches plant^{-1} was observed in variety T-6 that was statistically similar to BARI Til-2 (6.33 and 6.10, respectively). The lowest primary branch plant^{-1} was observed in variety BINA Til (0.70). Both the varieties Panchagarh local Til-1 and Panchagarh local Til-2 showed statistically similar branches plant^{-1} (3.13 and 3.27, respectively). In case of secondary branch, the highest number was observed in variety T-6 (7.20). There were no secondary branches in the variety BINA Til. Varieties Khulna local Til, Panchagarh local Til-1 and Panchagarh local Til-2 produced statistically similar secondary branches plant^{-1} (0.47, 0.20 and 0.20, respectively). Similarly, the highest number of total branches plant^{-1} was observed in variety T-6 (13.53) which was statistically different from other varieties. BINA Til (0.70) produced the lowest total branches plant^{-1}. Begum and assosiates (2001) also reported variability in branches number plant^{-1} in two sesame varieties viz. T-6 and Lal Til of Bangladesh.

Table 5. Distribution of capsules plant^{-1} in different sesame varieties

Variety	Capsules plant^{-1}		
	Main stem	Primary branch	Secondary branch
T-6	30.40b	74.80a	32.13a
BARI Til-2	31.50b	49.60b	3.00b
BARI Til-3	23.33d	40.00bc	3.20b
BINA Til	50.00a	14.90e	0.00c
Khulna local Til	25.87c	33.40c	1.13c
Panchagarh local Til-1	22.00d	31.00cd	0.20c
Panchagarh local Til-2	18.80e	20.93de	0.02c
CV (%)	4.51	15.58	14.79

Distribution of capsules plant^{-1}

Variation in number of capsule plant^{-1} among different varieties is presented in Table 5. Capsules plant^{-1} was recorded in main stem, in primary branch and also in secondary branch. In the main stem, the highest number of capsules plant^{-1} was observed in the variety BINA Til (50.00) which was statistically different from other varieties. Both T-6 and BARI Til-2 produced statistically similar number of capsules plant^{-1} (30.40 and 31.50, respectively). Panchagarh local Til-2 produced the lowest capsules plant^{-1} (18.80). It was also observed that BARI Til-3 and Panchagarh local Til-1 produced statistically similar capsules plant^{-1} (23.33 and 22.00, respectively). In case of primary branch, variety

T-6 (74.80) produced highest capsules plant^{-1} which was not different from Panchagarh local Til-2. Variety BINA Til produced lowest capsules plant^{-1}. Both the variety BARI Til-2 and BARI Til-3 (49.60 and 40.00, respectively) and Khulna local Til and Panchagarh local Til-1 (33.40 and 31.00, respectively) produced statistically similar capsules plant^{-1}. In secondary branch, T-6 (32.13) produced highest capsules plant^{-1}. Both BARI Til-2 and BARI Til-3 (3.00 and 3.20, respectively) produced similar number of capsules. On the other hand, varieties BINA Til, Khulna local Til, Panchagarh local Til-1 and Panchagarh local Til-2 (0.00, 1.13, 0.20 and 0.02, respectively) produced statistically similar number of capsules plant^{-1} in the secondary branch.

Table 6. Differences in yield and yield attributes among different sesame varieties

Variety	Branches plant^{-1}	Capsules plant^{-1}	Capsule length (cm)	Seeds capsule^{-1}	1000-seed weight (g)	Seed yield plant^{-1} (g)	Harvest index (%)
T-6	137.33a	137.33a	2.47cd	74.13c	4.89 $^{(NS)}$	12.37a	32.86a
BARI Til-2	84.10b	84.10b	2.54cd	80.80b	4.30 $^{(NS)}$	11.39a	28.87ab
BARI Til-3	66.53c	66.53c	2.74bc	74.33c	4.53 $^{(NS)}$	7.72bc	26.08b
BINA Til	64.90cd	64.90cd	4.98a	91.60a	4.49 $^{(NS)}$	7.70bc	24.28bc
Khulna local Til	60.40cd	60.40cd	2.77bc	70.73c	4.37 $^{(NS)}$	8.36b	27.01b
Panchagarh local Til-1	53.20d	53.20d	3.04b	75.33c	4.67 $^{(NS)}$	5.60c	19.08d
Panchagarh local Til-2	39.75e	39.75e	2.30d	60.53d	4.39 $^{(NS)}$	5.96c	20.56cd
CV (%)	7.08	8.83	5.70	3.29	4.71	13.52	9.92

Yield and yield attributes

Capsules plant^{-1}

Number of capsules plant^{-1} ranged from 39.75 to 137.33 (Table 6). The highest number of capsules plant^{-1} was observed in variety T-6 (137.33). Variety Panchagarh local Til-2 (39.75) produced the lowest capsules plant^{-1}. The varieties BINA Til and Khulna local Til had statistically similar (64.90 and 60.40, respectively) capsules plant^{-1}. These results are in agreement with that of Kathiresan (2002) and Subrahmaniyan *et al.* (1999), Tiwari *et al.* (2000). They reported that the number of capsules plant^{-1} varied significantly in different cultivars. Capsules plant^{-1} when plotted against total branches plant^{-1} yielded a straight line. This suggests that capsules plant^{-1} is dependent on branches plant^{-1} and more than 70% (R^2 = 0.7277) of the variation in capsules plant^{-1} defined by variation in branch number plant^{-1} (Fig. 3)

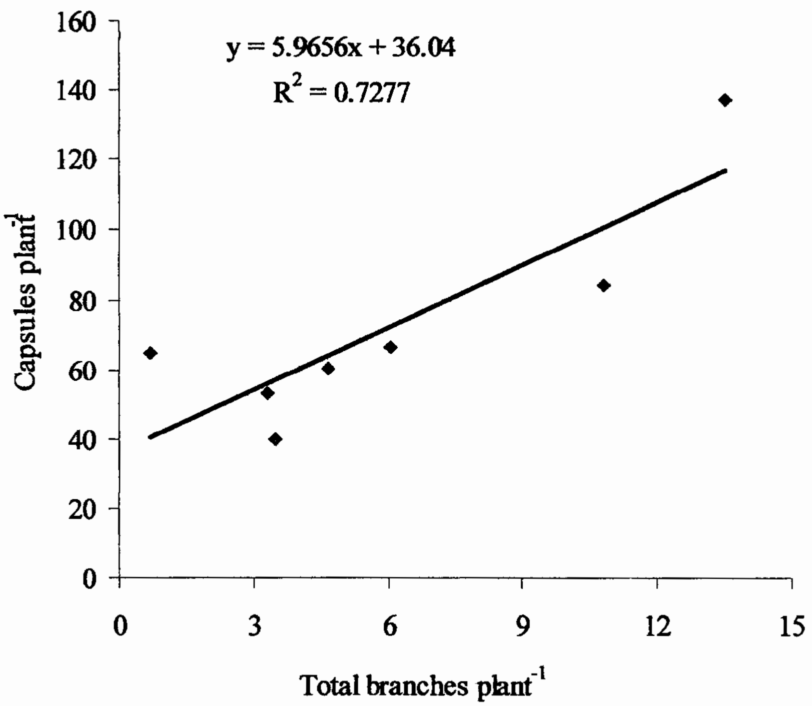

Fig. 3. Functional relationship between capsule plant^{-1} and total branches plant^{-1} in sesame varieties

Length of capsule (cm)

The difference among the varieties in respect of capsule length was found to be statistically significant (Table 6). Capsule length varied from 2.30 cm to 4.98 cm among the different sesame varieties tested. Maximum length of capsule was found in BINA Til (4.98 cm) while the minimum in Panchagarh local Til-2. Varieties T-6, BARI Til-3, BARI Til-3 and Khulna local Til produced statistically similar capsule length. Capsule length of BARI Til-3, Khulna local Til and Panchagarh local Til-1 was also statistically similar. Rahman and coworkers (1995) also found variation in capsule length in two sesame varieties grown during kharif season.

Seeds capsule^{-1}

Number of seeds capsule^{-1} is an important seed yield component which may vary for the genetic make up of the varieties. The difference among the varieties in respect of seeds capsule^{-1} was found to be statistically significant (Table 4). Seeds capsule^{-1} in the studied cultivars varied between 60.53 to 91.60. The highest seeds capsule^{-1} was found in BINA Til (91.60). The lowest number of seeds capsule^{-1} was recorded in the variety Panchagarh local Til-2 (60.53) Varieties T-6, BARI Til-3, Khulna local Til and Panchagarh local Til-1 had statistically similar seeds capsule^{-1}. These findings corroborated with those reported by Kathiresan (2002).

1000- seed weight

Weight of 1000 seeds varied from 4.30 g to 4.89 g among the sesame cultivars tested (Table 6). Numerically, the minimum weight of 1000-seed (4.30 g) was found in the variety BARI Til-3 while the maximum in T-6 (4.89 g). However, there was no significant difference among the varieties regarding 1000-seed weight (Table 6). Similar result was also found by different authors such as Tiwari and coworkers (2000), Sharma and Kakati (1993) and Begum and coworkers (2001).

Seed yield

Seed yield in sesame is a function of branches plant^{-1}, capsule length, capsule plant^{-1} and seeds capsule^{-1} (Hunsigi and Krishna, 1998; Rahman *et al.*, 1995). It was observed that there was significant difference in seed yield (g plant^{-1}) among the varieties tested (Table 4). T-6 (12.37) produced the highest seed yield which was statistically similar with BARI

Til-2 (11.39g). Varieties BARI Til-3, BINA Til and Khulna local Til produced statistically similar seed yield (7.72 and 7.70 and 8.36g plant^{-1}, respectively). Varieties Panchagarh local Til-1 and Panchagarh local Til-2 produced statistically similar seed yield (5.60 and 5.96 g plant^{-1}, respectively). The higher seed yield in T-6 was attributed due to more number of branches plant^{-1}, higher number of capsules plant^{-1} and higher harvest index (Table 6). On the other hand, more seed yield plant^{-1} (g) in BARI Til-2 was due mainly to higher seeds capsule^{-1} and higher harvest index (Table 6). Rahman and coworkers (1995) also reported higher seed yield in T-6 due to more number of capsules, increased capsule size (length) and higher seed weight capsule^{-1}. Seed yield (g plant^{-1}) showed a positive and linear relationship with capsules plant^{-1} (Fig. 4). The higher value of R^2 (R^2 =0.8002) suggests that 80% of the variations in yield could be explained by the variation in capsule number plant^{-1}.

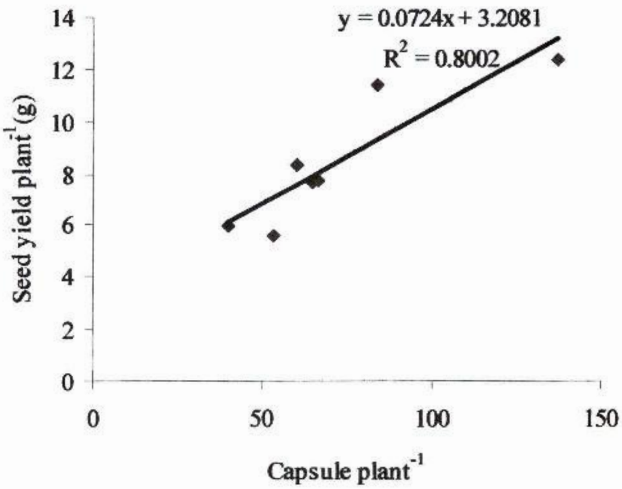

Fig. 4. Functional relationship between seed yield plant^{-1} and capsule plant^{-1} in sesame varieties

Harvest index

There was significant differences in harvest index among the sesame varieties (Table 6). Harvest indices in the tested varieties ranged from 19.08 (Panchagarh local Til-1) to 32.86 (T-6). Rahman and associates (1995) reported HI of 0.21 – 0.31 in two sesame cultivars grown in both rabi and Kharif seasons. T-6 produced highest harvest index (32.86) which was statistically similar to BARI Til-2 (28.87). Panchagarh local Til-1 (19.08) produced lowest harvest index which was statistically similar to Panchagarh local Til-2 (20.56). Varieties BARI Til-3, Khulna local Til, BARI Til-2 and BINA Til showed statistically similar harvest index (26.08, 27.01, 28.87 and 24.28, respectively). Plotting yield plant^{-1} (g) against HI suggested that the seed yield was highly dependent on harvest index and over 80% variation in yield could be explained from the variation in HI (Fig. 5). Jahan and

Hamid (2004) also reported a significant and positive relationship between yield and HI in mungbean.

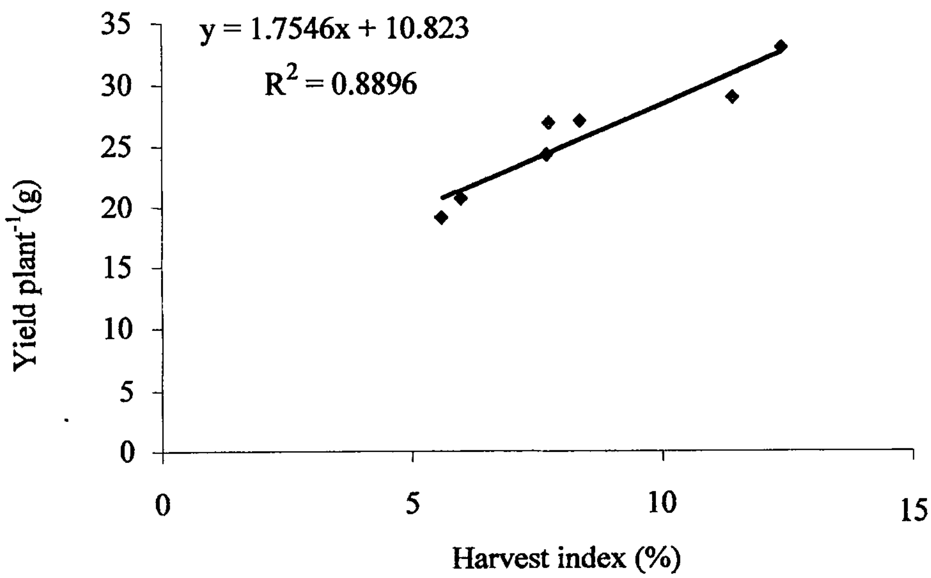

Fig 5. Functional relationship between yield plant^{-1} and harvest index in sesame varieties

Table 7. Correlation coefficients among different plant characters in sesame

Correlations (R)

Characters	Branches plant^{-1}	Leaf plant^{-1}	Capsules plant^{-1}	Capsule length (cm)	Seeds capsule^{-1}	1000-seed weight.	Seed yield plant^{-1} (g)	Harvest index (%)
Plant height (cm)	0.686	0.783*	0.784*	0.080	0.555	0.142	0.917**	0.843*
Branches plant^{-1}		0.968**	0.853*	-0.592	-0.099	0.365	0.884**	0.819*
Leaf plant^{-1}			0.918**	-0.402	0.079	0.404	0.937**	0.848*
Capsules plant^{-1}				-0.163	0.227	0.641	0.895**	0.875**
Capsule length (cm)					0.809*	-0.023	0.219	-0.198
Seeds capsule^{-1}						0.041	0.255	0.205
1000-seed weight							0.233	0.255
Harvest index (%)							0.955**	

*Correlation is significant at the 0.05 level

**Correlation is significant at the 0.01 level

The positive correlation of leaf number and capsule number with plant height and branches number indicate that tallest and branched varieties produced more leaves and capsules. Similarly, most of yield contributing characters i.e plant height, branches plant^{-1}, leaves plant^{-1}, capsules plant^{-1} influenced the economic yield or seed yield (Table 7)

SUMMARY AND CONCLUSION

Two trials were conducted with seven varieties of sesame to examine the varietal differences in germination, seedling vigor and yield performance. The laboratory experiment was laid out in a Completely Randomized Design (CRD) while the field experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Germination test was performed following the Petri dish method. Two blotters or filter papers were placed on the bottom of the Petri dish and they were soaked with distilled water. Fifty seeds were placed on the surface of water-soaked blotters in each Petri dish. Germination was counted at an interval of 24 hour and continued for seven days and was expressed in percentage. There was wide variation in germination performance among the varieties. Among the seven varieties, BARI Til-3 showed the highest percentage (99.33%) which was statistically similar to BINA Til (94.00%) and BARI Til-2. Panchagarh Local Til-1 exhibited the lowest performance in germination (30.00%) which was statistically different from other treatments. T-6, Khulna Local Til and Panchagarh Local Til-2 possessed statistically similar germination percentage. Germination speed of BARI Til-3 (86.06%) and BINA Til (80.49%) were statistically similar while, that of Khulna Local Til (24.65%) and Panchagarh Local Til-1 (16.69%) were also identical. Mean germination period was the maximum in Khulna Local Til (2.86 days) which was statistically different from other varieties. The lowest mean period for germination was noted in the variety BARI Til-2 (1.29 days) which was statistically similar to mean germination period of BARI Til-3 (1.38 days) and BINA Til (1.50 days). Seedling dry weight was recorded in third day to eighteenth day at three day intervals. Seedling dry weight increased gradually from emergence reaching the maximum at 18th day of emergence irrespective of varieties. Except 18^{th} day T-6 was statistically superior in gaining dry weight at all the sampling dates. However, variable performance was noticed for other six cultivars in obtaining weight of seedlings. Plant height, number of branches $plant^{-1}$, number of leaves $plant^{-1}$, number of capsules $plant^{-1}$, length of capsule, number of seeds $capsule^{-1}$, 1000-seed weight, seed yield $plant^{-1}$ and harvest index were recorded from each replicated plot at maturity in the field experiment. All the growth and yield parameters of sesame were markedly influenced due to varieties except 1000-seed weight. T-6 had the longest plant that was statistically similar to the plant heights of BARI Til-2. Panchagarh Local Til-1 had the shortest plant which did not vary statistically from plants obtained in Panchagarh Local Til-2. T-6 possessed the maximum number of photosynthetic organs (leaves) which was statistically different from other varieties. BINA Til, Khulna Local Til, Panchagarh Local Til-1 and Panchagarh Local Til-2 possessed statistically similar leaves $plant^{-1}$. The variety T-6 was found superior to other varieties for all the yield contributing characters except capsule length and seeds $capsule^{-1}$. However, seed yield $plant^{-1}$ and HI of BARI Til-2 were statistically similar to that of T-6. Capsule length as well as seeds $capsule^{-1}$ were recorded maximum in the variety BINA Til. Other varieties performed variably in respect of yield and yield attributes of sesame. Seed yield (g $plant^{-1}$) showed positive and linear relationship with plant height, leaf $plant^{-1}$, capsule $plant^{-1}$ and HI.

REFERENCES

Agrawal , R.L. 1991. *Seed Technology.* 7th edition, Laxmi Nagar, Delhi, India. 449 pp.

Ahmed, A.; Hussain, A.; Akhtar, M.; Ehsanullah and Musaddique, M. 2001. Yield and quality of two sesame varieties as affected by different rates of nitrogen and phosphorus. *Pakistan Journal of Agricultural Sciences,* 38: 4-7.

Alam, M.S. and Wahab, M.A. 1981. Response to selection of some varietes/ strains of mustard. *Bangladesh Journal of Agricultural Research,* 6: 13-19.

Ali, M.H.; Ullah, M.J.; Bhuiyan, M.S.V. and Amin, A.K.M.R. 1997. Effect of nitrogen and phosphorus on the yield attributes and yield of sesame (*Sesamum indicum*). *Bangladesh Journal of Agricultural Sciences*, 24: 27-32.

Anonymous, 2000. In: Daily Janakantha of 23.01.2000, Dhaka, Bangladesh.

Anonymous, 2000.Annual Research Report. On Farm Research Division, Bangladesh Agricultural Research Institute, Gazipur.

Avila, J.; Hernandez, J. and Aceredo, T. 1992. Effect of sowing distance between rows on performance of four sesame (*Sesamum indicum*) cultivars. *Agronomia Tropical Maracay*, 42: 307-320.

Balasubramaniyan, P. 1996. Influence of plant population and nitrogen level on yield and nutrient response of sesame (*Sesamum indicum*). *Indian Journal of Agronomy,* 41: 448-450.

Bam, R.K.; Kumaga, F.K.; Ufori, K. and Asiedu, E.A. 2006. Germination, vigor and dehydrogenase activity of naturally aged rice (*Oryza sativa* L.) seeds soaked in potassium and phosphorus salts. *Asian Journal of Plant Sciences,* 5: 948-955.

BBS (Bangladesh Bureau of Statistics). 2001. Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning, Government of People's Republic of Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2004. Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning, Government of People's Republic of Bangladesh.

Begum, R.; Samad, M.A.; Amin, M.R.; Pandit, D.B. and Jahan, M.A.H.S. 2001. Effect of row spacing and population density on the growth and yield of sesame. *Bangladesh Journal of Agricultural Sciences,* 28: 311-316.

BINA (Bangladesh Institute of Nuclear Agriculture) 2004. *Tiler Unnatajat- BINA TiL-1.* Bangladesh Agricultural Research Institute,Gazipur.

Bird, L.S. and Reyes, A.A.1967. Effects of cotton seed quality on seed and seedling characteristics. pp. 189-192. *National Cotton Council,* Memphis, Tennessee.

Bishnoi, U.R. and Delouche, J.C. 1980. Relationship of vigor tests and seed lots to cotton seedling establishment. *Seed Sciences and Technology,* 22: 637-640.

Burris, J.S. 1985. Soybean seedling growth and vigor. pp. 833-840. In: Shibles, R.M. (ed.) Proceedings World Soybean Research Conference III, 12-17 August, 1984. Westview Press, Boulder, Colorado, USA.

Christiansen, M.N. and Presley, J.T. 1967. Pathological and physiological aspects of seed quality. pp.189-192. In Proceedings Beltwide Cotton Production Research Conference, National Cotton Council, Memphis, Tennessee,USA.

Dell'Aquila, A. 1987. Mean germination time as a monitor of seed agency. *Plant Physiology and Biochemistry,* 25: 761-768.

Desai, N.M.; Slah, R.M. and Kukadia, 1984. Genetic parameters interrelationship and path coefficient analysis in sesame. *Journal of Oil Seeds*, 12: 33-38.

Dornbos, D.L. 1995. Production environment and seed quality. pp. 119-145. In: Barsa, A.S. (ed.), *Seed Quality, Basic Mechanisms and Agricultural Implications*. Food Products Press, London.

Dubey, O.P.; Dixit, J.P.; Tiwari, K.P. and Khan, R. A. 1995. Influence of irrigation on growth, yield and water use efficiency of spring soybean (*Glycine max*) genotypes. *Indian Journal of Agronomy*, 40: 616-619.

Ellis, R.H. 1998. The variability equation, seed viability monographs and practical advice in seed storage. *Seed Science and Technology*, 16: 29-50.

Ferdous, A.K.M. 2001. Effects of nitrogen and phosphorus fertilizers on nutrient uptake and productivity of edible podded pea. M.S. Thesis, Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur.

Gan, Y., Stobbe, E.H. and Moes, J. 1992. Relative date of wheat seedling emergence and its impact on grain yield. Crop Sciences, 32: 1275-1281.

Gelmond, H. 1978. Problems in crop seed germination, pp. 1-78. In: Gupta, U.S. (ed.), *Crop Physiology*. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, India.

Gibson, L.R. and L.E. Mullen. 1996. Influence of day and night temperature on soybean seed yield. *Crop Science*, 36: 98-104.

Gomez, A.K. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research*. 2nd ed. IRRI, Los Banos, Philippines. pp. 207-215.

Harrington, J.F. 1972. Seed storage and longevity. pp. 145- 245. In: Kozolowski, T.T. (ed.), *Seed Biology,* Vol. III. Academic Press, NewYork.

Heydecker, W. 1972. Vigor. pp. 209-252. In: Roberts, E.H. (ed.) *Viability of seed,* Syracuse Unversity Press.

Hopper, N.W.; Overhholt, and Martin, J.R. 1979. Effect of cultivar, temperature and seed size on the germination and emergence of soybeans (*Glycine max* L. Merr.). *Annals of Botany,* 44: 301-308.

Hoque, M. 1998. Effect of variety, nitrogen and sulphur application on seed yield, oil content and protein content of sesame. M.S. Thesis, Department of Agronomy, Bangladesh Agricultural University (BAU) Mymensingh.

Hunsigi, G. and Krishna, K.R. 1998. In Science of Field Crop Production. Oxford and Bij Publishing Co. Pvt. Ltd., New Delhi, India. 433p.

ISTA. 1976. Proceedings. International Seed Testing Association.31: 1-5.

ISTA. 1989. Handbook of Vigor Test Methods, Zurich, Switzerland.

ISTA. 2006. International rules for seed testing. *Seed Science and Technology,* 13: 365-513.

Jahan, E. and Sultana, S. 2007. Response of sesame varieties to irrigation. Undergraduate thesis, Agrotechnology Discipline, Khulna University, Khulna.

Jahan, M.S. and Hamid, A. 2004. Effect of population density and planting configuration on dry matter allocation and yield in mungbean (*Vigna radiata* (L.) Wilczek). *Pakistan Journal of Biological Sciences,* 7: 1493-1498.

Jahan, M.S; Hasan, M.A. and Islam, A.K.M.N. 2005. A study on the existing cropping patterns of Batiaghata upazila under Khulna district of Bangladesh. *Journal of Subtropical Agricultural Research and Development,* 3: 88-92.

Jahan, M.S. and Hamid, A. 2006. Effect of population density and planting configuration on canopy development and reproductive effort in mungbean (*Vigna radiata* (L.) Wilczek). *Research Journal of Agriculture and Biological Sciences,* 2:122-126.

Kadir, M.; Biswas, B.K.; Podder, P.; Alam, M.S. and Adhikary, S.K. 1996. Genetic parameters, character association and path analysis in sesame. *Bangladesh Journal of Agricultural Research,* 21: 37-43.

Karim, Z., Hussain, S.G. and Ahmed, M. 1990. Salinity Problems and Crop Intensification in the Coastal Regions of Bangladesh. Soils Publication No. 33. Soils and Irrigation Divition, BARC, Farmgate, Dhaka, Bangladesh, pp. 1-20.

Kathiresan, G. 2002. Response of sesame (*Sesamum indicum*) genotypes to levels of nutrients and spacing under different seasons. *Indian Journal of Agronomy,* 47: 537-540

Khaleque, M.A. and Begume, D. 1991. pp. 28. In: *Area and Production of Oilseed Crops in Bangladesh. Fifteen Years of Oilseed Research and Development in Bangladesh.* AST/CIDA.

Khan, M.M.; Quasim, M.; Iqbal, M.J.; Naeem, F. and Abbas, M. 2003. Effect of humidification on germinatibility, vigor and leakage in cockscomb (*Celosia argentia* var. *cristata* L.). *International Journal of Agriculture and Biology,* 5: 449-503.

Khandakar, A. L. and Bradbeer, J.W. 1983. pp. 1-92. In: Jute Seed Quality. Agricultural Economics and Social Sciences Program., Bangladesh Agricultural Research Council, Dhaka, Bangladesh.

Kitamura K. and Kaizuma, N. 1981. Mutant strains with low level of subunits of 7S globulin in soybean (*Glycine max* Merr.) seed. *Japanese Journal of Breeding*. 31: 353-359.

Krishnasamy, V., and Seshu, D.V. 1990. Germination after accelerated aging and associated characters in rice varieties. *Seed Science and Technology,* 18: 147-156.

Leudders, V.D. and Burris, J.S. 1979. Effects of broken seed coats on field emergence of soybeans. *Agronomy Journal,* 71: 877-879.

Loeffler, T.M. 1981. The bulk conductivity test as an indicator of soybean seed quality. M.S. Thesis, *University of Kentuky,* Lexington, Newyork, USA.

Maguire,. D. 1962. Speed of germination-aid in selection and calculation of seedling emergence and vigor. *Crop Science,* 2: 176-177.

Majumdar, D.K. and Roy, S.K. 1992. Response of summer sesame (*Sesamum indicum*) to irrigation, row spacing and plant population. *Indian Journal of Agronomy,* 37: 758-762.

Marshall, A.H., and Naylor, R.E.L. 1984. Reasons for the poor establishment of direct seeded grass. Annals of Applied Biology, 105: 87-96.

McDonald, M.B. 1980. Assessment of seed quality. *Horticultural Science,* 15: 784-788.

Mcdonald, M.B. 1998. Seed quality assessment. *Seed Science Research,* 8: 265-295.

Mohammed, F. 1989. Morphophysiology of mustard varieties in relation to three sowing dates. *Bangladesh Journal of Agricultural Research,* 14: 66-71.

Mondal, M.R.I. 1983. Performance of some exotic and indegenous strains of safflower. *Bangladesh Journal of Agricultural Research,* 8 : 23-26.

Normah, M.N., and Chin, H.F. 1991. Changes in germination, respiration and leachate conductivity during storage of *Hevea* seeds. *Pertanika,* 14: 1-6.

Om, P.; Singh, B.P.; Singh, P.K. and Prakash, O. 2001. Effect of weed control measures and nitrogen fertilization on yield and attributes of sesame (*Sesamum indicum)* under rainfed condition. *Indian Journal of Agricultural Sciences,* 71: 610-612.

Pattrick, J.W. 1988. Assimilate partioning in relation to crop productivity. *Horticultural Science,* 7: 171-175.

Perry, D.A. 1972. Seed and seedling vigor. pp. 313-387, In: Kozlowski, T.T. (ed.). *Seed Biology.* Vol. I. Academic Press, New York.

Phill, W.G. 1995. Low water potential and presowing germination treatments to improve seed quality. pp. 319-360. *In*: Basra, A.S. (ed.), *Seed quality, basic mechanisms and agricultural implications,* New York Food Products Press.

Rahman, M.M.; Hossen, T.S., Muhsi, A.A.A.; Quadir, M.A. and Haider, J. 1995. Seasonal variations in some physiological characters of sesame (*Sesamum indicum* L.). *Bangladesh Journal of Botany,* 24: 47-51.

Roberts, E.H. 1972. Storage environment and the control of viability. Viability of seeds. *Syracuse Univ. Press.* Syracuse, N.Y. p. 20.

Ramiraz, R.; Gutierrez, D.; Villafarie, R. and Lizaso, J. 2005. Salt tolerance of sesame genotypes at germination, vegetative and maturity stages. British Journal of Agriculture and Forest Science, 36: 17-18.

Roy, D.K.S.; Hamid, A.; MiaH, M. G. and Hashem, A. 1996. Seed size variation effect on germination and seedling size. *Journal of Agronomy and Crop Science,* 176: 79-82.

Sarder, N.A. and Rosario, E. L. 1993. Effect of tillage methods and N management on the establishment of sesame grown after wetland rice. *Bangladesh Journal of Agricultural Research,* 18: 172-179.

Scott, S.J., R.A. Jones and W.a. Williums 1984. Review of data analysis method for seed germination. *Crop Science,* 24: 1192-1199.

Sharma, N. N. 1994. Response of sesame (*Sesamum indicum*) varieties to levels of nitrogen and spacing. *Annals of Agricultural Research,* 15: 107-109.

Sharma, N. N. and Kakati, N. N. 1993. Response of summer sesame (*Sesamum indicum*) to levels of nitrogen and spacings. *Indian Journal of Agronomy.* 38: 659-661.

Shieh, W.J., and McDonald, M.B. 1982. The influence of seed size, shape and treatment on inbred seed corn quality. *Seed Science and Technology,* 10: 307-313.

Shen, T.Y. and Oden, P.C. 2000. Fumarase activity as a quick vigor test scots Pre (*Pinus sylvestris* L.) seeds. *Seed Science and Technology,* 28: 825-835

Siddique, M.A., and Goodwin, P.B. 1980. Seed vigor in bean (*Phaseolum vulgaris* L. cv Apollo) as influenced by temperature and water regime during development and maturation. *Experimental Botany,* 31: 313-323.

Subrahmaniyan, K.; Sridhar, P. and Arulmozhi, N. 1999. Response of sesame (*Sesamum indicum*) to plant population and micronutrients with and without farmyard manure under irrigated condition. *Indian Journal of Agronomy,* 44: 826-829.

Suddihiyam, P.; Steer, B.T. and Turner, D.W. 2001. The flowering of sesame (*Sesamum indicum* L.) in response to temperature and photoperiod. Canadian J. Commun. in Soil Science and Plant Anal. 30: 85.

Takahashi, N. 1984. Seed germination and seedling growth. pp. 71-88. *In*: Tsunoda, S. and Takahashi, N. (eds.), *Biology of rice* Japanese Scientific Society Press, Tokyo.

Tekrony, D.M. and Egli, D.B. 1977. Relationship between laboratory indices of soybean seed vigor and field emergence. *Crop Science,* 17: 573-577.

Tekrony, D.M; and.Egli, D.B. 1991. Relationship of seed vigor to crop yield. A review. *Crop Science,* 31: 816-822.

Tekrony, D.M; Egli, D.B. and Phillips, A.D. 1980. Effect of field weathering on the viability and vigor of soybean seed. *Agronomy Journal,* 71: 914-918.

Thornley, J. H. M. 1986. A germination model: Responses to time and temperature. *Journal of Theoretical Biology,* 123: 481-492.

Throve, S. B.; Pathan, S. B.; Pathan, S. H. and Pol, P.S. 1997. Performance of sesame cultivar at different fertility levels under rainfed condition. Journal of *Oilseeds Research,* 14: 107-108.

Tiwari, K.P.; Namdeo, K.P; Namdeo, K. N.; Girish, J. and Jha, G. 2000. Effect of nitrogen and sulphur on growth, yield and quality of sesame *(Sesamum indicum*) varieties. *Research on Crops,* 1: 163-167.

Uddin, M.J. and Mitra, B.N. 1994. Variability of some qualitative characters in sesame (*Sesamum indicum*). *Bangladesh Journal of Agriculture,* 19: 17-22.

Venkatesan, G., Elango, R. and Arunachalam, M.L. 1985. Influence of spacing and nitrogen on the yield of sesame. *Madras Agricuitural Journal,* 70: 468-470.

Wahhab, M.A.; Mondal, M.R.I.; Akbar, M.A.; Alam, M.S.; Ahmed, M. and Begum, E. 2002. *Status of Oil Crop Production in Bangladesh*. Oilseed Research Centre, Bangladesh Agricultural Research Institute (BARI), Gazipur, Dhaka. 85p.

Wright, N. 1980. Germination rate and growth characteristics of blue panic grass. *Crop Science,* 20: 42-44.

Yaklieh, R.W. and Kulik, M.M. 1979. Evaluation of vigor test in soybean seeds. Relationship of the standard germination test, seedling vigor classification, seedling length and tetrazolium staining to field performance. *Crop Science,* 19: 247-252.

Yamauchi, M. and Winn, T. 1996. Rice seed vigor and seedling establishment in anaerobic soil. *Crop Science,* 36: 680-686.

Zhang, J. and Mann, M.A.; 1990. Seed size variation and its effects on seedling growth in *Agropyron psammophilum*. *Botanical Gazettee,* 151: 106-113.

Zito, R.K.; Sediyama, C.S., Rocha, V.S.; Moreira, M.A., Reis, M.S. and Barros, E.G., 1995. Electrophoretic patterns of soybean seed and their physiological quality. *Revista-Ceres,* 239: 98-109.