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Title: Sowing Methods and Nitrogen Rates Affect Growth and Yield of Sesame in Saline Soil of Southwestern Coastal Bangladesh

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ABSTRACT

Salinity is a major limitation to crop production in the southwestern coastal region of Bangladesh, where sesame (*Sesamum indicum* L.), even with moderate salt tolerance, often experiences decreased harvest. This study aimed to judge the effects of different sowing methods and nitrogen rates on the growth and yield performance of sesame (BARI Til-6) under saline soil conditions. A field experiment was conducted at the Regional Inspection Centre (RIC), Bangladesh Meteorological Department, Gollamari. The experiment comprised three sowing methods (broadcasting, line sowing, and dibbling) and four nitrogen levels (0, 15, 30, and 45 kg N ha^{-1}), arranged in a Randomized Complete Block Design (RCBD) with three replications. Data were collected on plant height (cm), number of branches plant^{-1}, capsule length (cm), number of capsules plant^{-1}, number of seeds capsule^{-1}, 1000-seed weight (g), seed weight plant^{-1} (g), and harvest index (%). Line sowing produced the highest values for most growth and yield attributes, including, plant height (60.90 cm), number of branches plant^{-1} (2.36), number of capsules plant^{-1} (13.03), number of seeds capsule^{-1} (52), seed weight plant^{-1} (1.99 g), and harvest index (31.10%). Dibbling resulted in the lowest performance for most parameters. The application of 45 kg N ha^{-1} significantly enhanced plant growth and yield, with highest plant height (69.99 cm), number of branches plant^{-1} (2.91), capsule length (1.98 cm), number of capsules plant^{-1} (16.55), and number of seeds capsule^{-1} (59.15), seed weight plant^{-1} (2.81 g), and harvest index (33.60%). Interaction between sowing methods and nitrogen rates significantly influenced all growth and yield attributes except 1000-seed weight (g). The lowest results were found from combination of three sowing methods with control treatments. Based on the findings of this study, line sowing combined with 45 kg N ha^{-1} is recommended for the cultivation of sesame (BARI Til-6) in the saline soils of southwestern coastal Bangladesh.

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INTRODUCTION

Sesame (*Sesamum indicum* L.) as an ancient cultivated oilseed crops around the world, is popular for its oil, edible seeds as well as for providing health benefits. Sesame seeds are rich in fat, protein, minerals, vitamins, and fiber. Sesame oil is particularly high in unsaturated fatty acids, fat-soluble vitamins, and amino acids. According to the investigation of Wei et al., (2022), sesame seeds contain 21.90% protein, 61.70% fat, and are rich in minerals including Fe and Ca. Both the seeds and oil of sesame offer substantial pharmacological and physiological benefits to the whole body, mainly the liver, kidneys, spleen, and stomach. In addition to lubricating the intestinal track, sesame oil also nourishes the internal organs (Pathak et al., 2002).

Sesame is the third largest source of edible oil in Bangladesh, both in terms of area and production. In Bangladesh, the crop can be grown in both the *kharif* and early *rabi* seasons; however, about 70% of sesame is produced during the *kharif* season. The total area under sesame cultivation is 31770 ha, with a total production of 30714 metric tons, giving an average yield of 966 kg ha^{-1} (BBS, 2022). Compared to other sesame-producing countries, the yield of sesame in Bangladesh is low. This may be attributed to several factors, such as the unavailability of quality seeds of high-yielding varieties, improper fertilizer management practices, and disease and insect infestations (Salam et al., 2020). Sowing methods and fertilizer applications are critical for promoting crop development and yield, especially under rainfed conditions. Due to the ease of planting and the lack of appropriate planting equipment, the broadcast method of sowing is used by the majority of sesame growers. However, this method is limited by uneven seed distribution and seeds lying exposed on the surface, where they can be picked up by birds (Ndor and Nasir, 2019).

Nitrogen is an indispensable component in the structure of chlorophyll and proteins. Therefore an adequate supply of supply of nitrogen is advantageous for both carbohydrate and protein metabolism stimulating cell division and expansion. This results in increased foliage area and contributes to better seed and dry matter yields in sesame. Elevated nitrogen doses suggestively improve vital yield attributes like the number of capsules per plant, seeds per capsule, seed yield, biomass, 1000-seed weight, and harvest index (Ibrahim et al., 2014). Nitrogen also supports overall plant growth, seed formation, and oil quality in sesame (Hossain et al., 2007). Improved biomass buildup and increased branching leading to enhanced nutrient acquisition and vegetative growth, are firmly associated to better nitrogen availability (Venu et al., 2022; Abdalsalam and Al-Shebani, 2010). However, undue nitrogen use can delay crop maturity, lead to physiological disarrays, and finally diminish yield. Thus, applying nitrogen at optimum levels is critical for maximizing sesame growth and productivity (Obreza and Vavrina, 1993).

The method of planting is another essential factor in crop production. An appropriate planting technique not only ensures proper crop establishment and optimal plant density in the field, but also permits more efficient and effective use of land and additional inputs for plant growth and yield. In line sowing, plant spacing becomes more uniform, which has a considerable impact on resource use efficiency- including water, nitrogen, and phosphorus utilization- as well as energy conservation and reduced soil compaction (Troedson et al., 1989). Conversely, broadcasting often results in uneven plant spacing, with some plants too close and others too far apart. According to Jan et al. (2015), the sowing method influences canopy architecture, disturbing the crop through light capture and distribution, as well as associated physiological and morphological changes. Uniform plant stands achieved through line sowing offer a significant yield advantage over the unequal spacing linked to broadcasting. Sesame yield can be considerably increased by adopting improved planting methods. In Bangladesh, the broadcast method is the most commonly used technique for growing sesame, as it involves minimal expense and simple agronomic practices (Miah et al., 2015).

Although sesame is an important oilseed crop in Bangladesh, limited research has focused specifically on the combined effects of sowing methods and nitrogen application rates on the growth and yield of BARI Til-6, an improved sesame variety released recently. While some studies have investigated either nitrogen fertilization or sowing techniques individually, integrated research examining the interaction between these two factors- particularly under the unique agro-ecological conditions of the southwestern coastal region of Bangladesh- is scarce. This coastal zone is characterized by distinct soil properties, salinity levels, and climatic conditions that may influence crop responses differently from other regions. To address this gap, the present study was undertaken to evaluate the effects of different sowing methods and nitrogen application rates on the growth and yield performance of BARI Til-6. Specifically, the study aims to assess how these factors influence the crop’s development and productivity, and to determine the proper combination of sowing method and nitrogen rate for improving sesame yield in the southwestern coastal region of Bangladesh.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out at the Regional Inspection Center (RIC), Bangladesh Meteorological Department, Gollamari, Khulna.

Climate

The experimental location has a subtropical climate, characterized by high temperatures and humidity, as well as heavy rainfall accompanied by irregular gusty winds during the *kharif-1* season (March-July), whereas in the *rabi* season temperatures are comparatively low.

Soil

The experimental site is located in the Ganges Tidal Floodplain in southwestern Bangladesh, characterized by smooth terrain and elevated salinity. The top soil is acidic, while the sub-soils ranges from neutral to slightly alkaline. The soil fertility is relatively high, with medium to high organic matter content. Soil samples (0 - 15 cm depth) were analyzed at the Soil Resource Development Institute (SRDI), Khulna and the results are presented in Table 1.

Planting Material

Sesame variety BARI Til-6 was used as the planting material.

Experimental Design

The experiment was conducted using a Randomized Complete Block Design (RCBD) with two factors and three replications. Factor A consisted of three planting methods i.e. broadcasting (S_1), line sowing (S_2) and dibbling (S_3); while factor B composed of four nitrogen levels viz. 0 (N_0), 15 (N_1), 30 (N_2) and 45 (N_3) kg N ha^{-1} applied as urea (BARI recommendation is about 40 kg N ha^{-1}). In total there were 36 plots, maintaining individual plot size of 4 m^2.

Land Preparation

The land was initially ploughed by a tractor. The soil was then brought to a suitable tilth by ploughing and harrowing several times using a country plough and ladder. The weeds and stubbles were then removed. The total experimental land was divided into unit plots based on the experimental design. Before planting, the basal dose of fertilizers was applied properly.

Fertilizer Application

Phosphorus, potassium, sulphur, and boron were applied at the rate of 30, 20, 20 and 10 kg ha^{-1}, respectively, as recommended by BARI with minor modification. Urea was applied according to treatment doses. Half of the urea and full dose of TSP, MoP, gypsum, and boric acid was applied during final land preparation. Rest of the urea was applied in split at 30 days after sowing (DAS).

Table 1. Characteristics of the Experimental Soil (0-15 cm depth)

Properties	**Value**	**Class**
pH	8.20	Slightly alkaline
Salinity (dS/m)	7.50	Moderately Saline
Organic matter (%)	1.67	Low
Nitrogen (%)	0.18	Low
Phosphorus (µg/g of soil)	46.27	Very high
Potassium (µg/g of soil)	0.25	Moderate
Sulfur (µg/g of soil)	52. 15	Very high
Zinc (µg/g of soil)	0.62	Low
Boron (µg/g of soil)	1. 12	Very high

Source: SRDI, Khulna, Bangladesh

Seed Sowing

Seeds of sesame were sown on 20 February, 2024 following the layout of the investigation. For line sowing, line to line distance was kept 30 cm. Broadcasting was done by blending the sesame seeds with sands. Dibbling was completed by placing sesame seeds in small holes and then covered with loose soil. The seed rate followed was 8 kg ha^{-1}.

Intercultural Operations

Weeding was done twice at 20 DAS and the second at 35 DAS. Thinning was performed in each experimental plot at 25 DAS. One pre-sowing irrigation was applied to ensure the uniform germination of sesame seeds. Proper drainage was to prevent waterlogging. To control cutworm infestation Dursban 20 EC was applied @ 2 ml/l during the time of infestation.

Harvesting and Threshing

The crop was harvested on May 15, 2024. The crop was collected plot-wise when approximately 80% of the capsules had matured. Five representative plants were collected from the central area of each plot, then tied firmly into bundles and taken to the threshing floor for seed separation. The bundles were then sun-dried for three days. The seeds were separated from the pods by beating with bamboo sticks, then cleaned, dried, and weighed. The weight of dry stover was also measured.

Data Collection

Data were collected regarding various sesame plant characteristics. Five plants were selected randomly from each plot, excluding the border plants outside the center 1 m^2 area. The sample plants were carefully uprooted using a *khurpi* to prevent seed loss then cleaned, dried. Data on the following crop attributes were collected from these samples.

i. Plant height (cm)
ii. Number of branches $plant^{-1}$
iii. Capsule length (cm)
iv. Number of capsules $plant^{-1}$
v. Number of seeds $capsule^{-1}$
vi. 1000 seed weight (g)
vii. Seed weight $plant^{-1}$ (g)
viii. Harvest index (%)

Harvest index was calculated with the following formula (Gardner et al., 1985).

Harvest index (%) = (Grain yield/Biological yield) × 100

Statistical Analyses

All the data collected were compiled and analyzed following analysis of variance (two-way ANOVA) using computer package 'Statistix-10'. The mean comparison among the treatment were performed by Tukey's HSD test at 95% confidence level. Simple linear regression analysis was done by MS-Excel to develop functional relationship between seed yield and harvest index as well as seed yield and stover yield of BARI Til-6.

RESULTS AND DISCUSSION

Plant height (cm)

The height of sesame plants increased over time gradually and reached the maximum at 75 DAS in all the sowing methods (Figure 1). The highest mean plant height (60.9 cm) was obtained from the line sowing method followed by dibbling (55 cm) and broadcasting (54.85 cm). The largest plant height produced in line sowing method may be owing to the fact that plant density is optimal for interplant competition to use space, light, and nutrients, which may contribute to the highest plant height. In line sowing, the spacing between plants became more equal, allowing each plant to have enough area for light interception, whereas with broadcast planting, the distance between two plants might be either close or quite distant due to even distribution (Caliskan et al., 2004). While our findings align with Caliskan et al. (2004) and Alam (2002), who reported improved growth with uniform spacing, other studies (Imoloame et al., 2007; Mohammad et al., 2023; Islam et al., 2008) reported varied or no significant effects of sowing method on plant height.

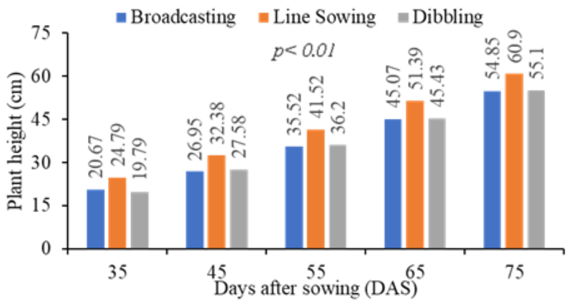

Figure 1. Plant height of sesame (cm) *cv*. BARI Til-6 at different days after sowing (DAS).

Plant height was significantly influenced by nitrogen levels (Figure 2). The tallest plants (67.99 cm) were observed at 45 kg N ha^{-1}, followed by 30 kg N ha^{-1} (62.92 cm), while the shortest (42.67 cm) were recorded in the control. Similar findings were reported by Pathak et al. (2002) and Fatima (2007), who observed increased plant height with higher nitrogen doses. Enhanced nitrogen availability promotes cell division and chlorophyll synthesis, thereby improving photosynthesis and assimilate production, which in turn supports greater vegetative growth (Dhaka et al., 2014).

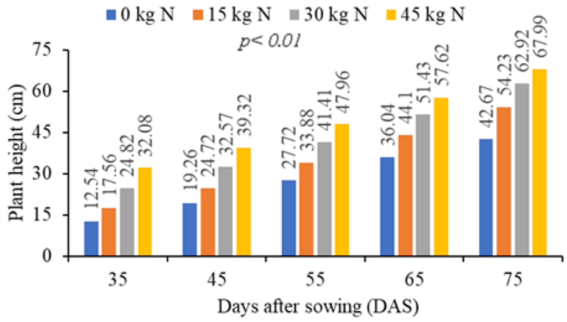

Figure 2. Plant height of sesame (cm) *cv*. BARI Til-6 under various doses of nitrogen (kg ha^{-1}).

The interaction effect of sowing method and nitrogen rates showed significant influence in plant height as shown in Table 4. Plant height was observed highest in combination with line sowing and 45 kg N ha^{-1} (72.18 cm) followed by dibbling and 45 kg N ha^{-1} (66.56 cm). Broadcasting and 45 kg N ha^{-1} (65.22 cm) occupied the third place. Combination of broadcasting with no nitrogen resulted in the shortest plant height (40.34 cm). At broadcasting, there was no statistical difference of plant height at 30 and 45 kg N ha^{-1} but plant height was significantly higher at 15, 30 and 45 kg N ha^{-1} compared to controlled plots. In line sowing and dibbling, plant height was statistically different at all 4 nitrogen rates and was the highest at 45 kg N ha^{-1}.

Number of branches per plant

The number of branches per plant during harvest was significantly exaggerated by the sowing method (Table 2). Line sowing resulted in the highest number of branches (2.36), followed by broadcasting (1.97), and with the lowest observed in dibbling (1.93). The increased branching in line sowing may be owing to reduced interplant competition (Islam, 2017; Khanam et al., 2022; Hamid et al., 2002). In contrast, Islam et al. (2008) reported that the sowing method had only a minor influence, with broadcasting slightly increasing branch production.

Table 2. Effect of sowing methods on growth and yield parameters of sesame (BARI Til-6)

Sowing method	Branches plant^{-1}	Capsule length (cm)	Capsules plant^{-1}	Seeds capsule^{-1}	1000-seed weight (g)	Seed weight (g plant^{-1})	Harvest index (%)
Broadcasting	1.97b	1.80	10.77b	49.98b	2.80	1.59b	28.60b
Line sowing	2.36a	1.78	13.03a	52.00a	2.80	1.99a	31.10a
Dibbling	1.93b	1.74	9.48c	50.92ab	2.80	1.39c	27.05c
SE (±)	0.04	0.02	0.24	0.49	0.02	0.04	0.49
p value	<0.01	ns	<0.01	<0.01	ns	<0.01	<0.01
CV (%)	5.75	3.13	5.31	2.39	1.89	6.47	3.55

The letters having similar in a column indicate statistically similar while different letters indicate statistically dissimilar among the treatments as revealed by Tukey's HSD test at 95% confidence level. Here, SE = Standard error; ns = non-significant; CV = Coefficient of variation.

The effect of nitrogen on branch production in sesame is given in Table 3. The finding of the present investigation displayed that number of branches per plant was significantly inclined by nitrogen doses. The highest mean number of branches per plant (2.91) was obtained from 45 kg N ha^{-1} followed by 30 kg N ha^{-1} (2.31) and the lowest (1.37) was observed from controlled plots. Our results are consistent with the findings of several other studies (Malik et al., 2003; Umar et al., 2012), who revealed that nitrogen fertilizer has a significant influence on branch production in oilseed crops. Nitrogen application at higher rates increased the number of branch per plants by improving photosynthetic rate, thus eventually increases assimilates availability to the plant, resulting in better plant growth and more branches per plant (Dhaka et al., 2014).

The interaction effect of sowing method and nitrogen rates exerted significant influence on the number of branches per plant (Table 4). Number of branches per plant was noted the highest in combination with line sowing and 45 kg N ha^{-1} (3.13) followed by broadcasting and 45 kg N ha^{-1} (3). Dibbling with 45 kg N ha^{-1} (2.6) remained in the third position. Combination of broadcasting with no nitrogen resulted in the lowest number of branches (1.13). The highest number of branches were produced by nitrogen at 45 kg ha^{-1} and the lowest were produced from no nitrogen at all of the 3 sowing methods.

Table 3. Effect of nitrogen rates on growth parameters of sesame (BARI Til-6)

Nitrogen rate (kg ha^{-1})	Branches plant^{-1}	Capsule length (cm)	Capsules plant^{-1}	Seeds capsule^{-1}	1000-seed weight (g)	Seed weight (g plant^{-1})	Harvest index (%)
0	1.37d	1.54d	6.51d	41.48d	2.76b	0.74d	24.89d
15	1.75c	1.73c	8.57c	49.08c	2.78b	1.17c	26.85c
30	2.31b	1.86b	12.73b	54.13b	2.77b	1.90b	30.33b
45	2.91a	1.98a	16.55a	59.15a	2.87a	2.81a	33.60a
SE (±)	0.05	0.02	0.27	0.57	0.02	0.05	0.57
p value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CV (%)	5.75	3.13	5.31	2.39	1.89	6.47	3.55

The letter(s) having similar in a column indicate statistically similar while different letters indicate statistically dissimilar among the treatments as revealed by Tukey's HSD test at 95% confidence level. Here, SE = Standard error; CV = Coefficient of variation.

Length of capsule (cm)

The capsule length of BARI Til-6 was not significantly influenced by sowing methods as shown in Table 2. However, the highest mean capsule length (1.8 cm) was obtained from broadcasting method and the shortest capsules were found in dibbling (1.74 cm) method. The various nitrogen doses exhibited significant influence on capsule length of sesame (Table 3). In contrast, nitrogen levels had a significant impact on capsule length (Table 3), with the maximum (1.98 cm) recorded at 45 kg N ha^{-1} and the minimum (1.54 cm) in the control. Nitrogen application had a significant effect on capsule length, with the longest capsules detected at 45 kg and 60 kg N ha^{-1}, both of which differed notably from the 30 kg N ha^{-1} treatment. The shortest capsules were noted in the control group with no nitrogen application. This enhancement in capsule length can be attributed to nitrogen's role in stimulating rapid cell division and increasing chlorophyll content, which boosts the photosynthetic rate (Fatima, 2007). In this study, capsule length was also ominously affected by the interaction between sowing methods and nitrogen levels (Table 5). Although no significant differences were found among the S_1N_3, S_2N_3, S_2N_2, and S_3N_3 treatments, the S_2N_3 combination produced the longest capsules (2.02 cm), while the shortest capsules (1.43 cm) were recorded under dibbling without nitrogen application (S_3N_0).

Table 4. Interaction effect of sowing method and nitrogen rates on plant height (cm) and branch number of sesame (BARI Til-6)

Sowing method × Nitrogen rate	Plant height (cm) at					Branches plant^{-1}
	35 DAS	45 DAS	55 DAS	65 DAS	75 DAS	
S_1N_0	12.36g	18.76e	30.70d	33.53i	40.34f	1.13f
S_1N_1	15.52f	22.17d	26.90e	40.45fg	51.11e	1.40ef
S_1N_2	23.47d	29.58c	39.74c	52.60cd	62.74cd	2.33bc
S_1N_3	31.32bc	37.29b	44.74b	53.70c	65.22bc	3.00a
S_2N_0	13.01g	20.52de	29.14de	38.41gh	44.23f	1.73de
S_2N_1	23.34d	29.48c	39.82c	50.66d	60.15d	2.00cd
S_2N_2	29.61c	37.56b	45.29b	54.88c	67.04b	2.60b
S_2N_3	33.22a	41.95a	51.81a	61.62a	72.18a	3.13a
S_3N_0	12.23g	18.51e	27.13e	36.18h	43.44f	1.26f
S_3N_1	13.81fg	22.52d	31.13d	41.20f	51.42e	1.86d
S_3N_2	21.38e	30.56c	39.20c	46.81e	58.98d	2.00cd
S_3N_3	31.72ab	38.74b	47.34b	57.55b	66.56bc	2.60b
SE (±)	0.48	0.71	0.78	0.70	1.09	0.09
p value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CV (%)	2.70	3.03	2.55	1.84	2.36	5.75

The letter(s) having similar in a column indicate statistically similar while different letters indicate statistically dissimilar among the treatments as revealed by Tukey's HSD test at 95% confidence level. Here, S_1= Broadcasting, S_2 = Line sowing, S_3 = Dibbling, N_0 = 0 kg N ha^{-1}, N_1 = 15 kg N ha^{-1}, N_2 = 30 kg N ha^{-1} and N_3 = 45 kg N ha^{-1}; SE = Standard error; CV = Coefficient of variation.

Number of capsules per plant

The number of capsules per plant was significantly influenced by sowing methods, with line sowing producing the highest capsule count (13.03), followed by broadcasting and dibbling (Table 5). This aligns with previous studies (Hamid et al., 2002; Wakweya and Meleta, 2016; Islam, 2017), which highlight improved spacing and resource use under line sowing. Nitrogen application significantly increased capsule number, with the highest at 45 kg N ha^{-1}, likely due to enhanced vegetative growth and photosynthesis (Waziri et al., 2022). A significant interaction between sowing methods and nitrogen rates was observed, indicating that combining optimized sowing and nitrogen fertilization can maximize capsule production.

Table 5. Interaction effect of sowing methods and nitrogen rates on yield and yield attributes of sesame (BARI Til-6)

Sowing method × Nitrogen rate	Capsule length (cm)	Capsules plant^{-1}	Seeds capsule^{-1}	1000-seed weight (g)	Seed weight plant^{-1} (g)	Harvest index (%)
S_1N_0	1.58ef	5.86i	41.40f	2.76	0.66h	23.79f
S_1N_1	1.76bcd	7.73gh	46.73e	2.80	1.01fg	25.80def
S_1N_2	1.85b	12.33de	53.73cd	2.80	1.85d	29.96bc
S_1N_3	2.02a	17.13b	58.06ab	2.86	2.85b	34.85a
S_2N_0	1.60de	7.60ghi	42.00f	2.76	0.88fgh	25.34ef
S_2N_1	1.65cde	10.13f	50.26de	2.80	1.42e	29.32cd
S_2N_2	1.86ab	15.13c	54.06c	2.76	2.25c	33.25ab
S_2N_3	2.02a	19.26a	61.66a	2.8	3.40a	36.48a
S_3N_0	1.43f	6.06hi	41.06f	2.80	0.69gh	25.54ef
S_3N_1	1.78bc	7.86g	50.26de	2.76	1.09f	25.43ef
S_3N_2	1.86ab	10.73ef	54.60bc	2.76	1.61de	27.77cde
S_3N_3	1.91ab	13.26d	57.73b	2.86	2.18c	29.47c
SE (±)	0.04	0.48	0.99	0.04	0.08	0.99
p value	<0.01	<0.01	<0.05	ns	<0.01	<0.01
CV (%)	3.13	5.31	2.39	1.89	6.47	3.55

The letter(s) having similar in a column indicate statistically similar while different letters indicate statistically dissimilar among the treatments as revealed by Tukey's HSD test at 95% confidence level . Here, S_1= Broadcasting, S_2 = Line sowing, S_3= Dibbling; N_0 = 0 kg N ha^{-1}, N_1 = 15 kg N ha^{-1}, N_2 = 30 kg N ha^{-1} and N_3 = 45 kg N ha^{-1}; SE = Standard error; ns = non-significant; CV = Coefficient of variation.

Number of seeds per capsule

The number of seeds per capsule was significantly influenced by sowing methods. Line sowing produced the highest seeds per capsule (52.00) followed by dibbling (50.92), while broadcasting resulted in the lowest (49.98) These results align with earlier findings (Caliskan et al., 2004; Svathi et al., 2005), which reported that uniform plant spacing in line sowing enhances crop growth and seed development. Although Waziri et al. (2022) found dibbling to be more effective in some cases, the overall trend supports line sowing for optimal seed setting. Plant spacing, as determined by sowing methods, plays a critical role in crop productivity by influencing light interception, nutrient uptake, and water availability. Line sowing promotes uniform plant spacing, which facilitates better canopy structure and more efficient light distribution within the plant stand (Jan et al., 2015). This structural advantage supports physiological processes such as enhanced photosynthesis, reduced competition for resources, and improved air circulation, all of which contribute to better growth and reproductive outcomes. In contrast, broadcast sowing often results in irregular spacing, leading to intra-specific competition and suboptimal resource utilization. Such non-uniformity has been shown to reduce seed yield across various crops, including sunflower, corn, and sorghum (Barros et al., 2003; Abunyewa et al., 2010). As Snider et al. (2012) emphasized, uniformly spaced plants are better positioned to access light, water, and nutrients, ultimately enhancing overall plant health and yield potential.

Nitrogen application had a significant effect on seeds per capsule (Table 3). (Table 3). The same dose of N_2 (45 kg ha^{-1}) produced taller plants, the highest number of capsules per plant, and the greatest seed output (Saharia and Bayan, 1996). This higher dose enhanced vegetative growth and reproductive efficiency, driven by increased chlorophyll production and enhanced metabolic activity (Waziri et al., 2022).

A significant interaction between sowing method and nitrogen rate was observed (Table 5). The line sowing with 30 kg N ha^{-1} combination yielded the highest number of seeds per capsule (61.66), whereas dibbling with control recorded the lowest. This interaction underscores the importance of integrated agronomic practices in optimizing seed yield in sesame.

1000-seed weight (g)

The 1000 seed weight of BARI Til-6 was not significantly influenced by sowing methods (Table 2). However, previous studies (Islam, 2017; Islam et al., 2008) reported that line sowing produced significantly higher 1000-seed weight compared to broadcasting. In contrast, nitrogen rates significantly influenced 1000-seed weight (Table 3). The highest value (2.87 g) was observed at 45 kg N ha^{-1}, while other nitrogen levels showed no significant differences. Nitrogen is a structural component of chlorophyll and protein, therefore having an appropriate supply of nitrogen is beneficial for both carbohydrate and protein metabolism because it promotes cell proliferation and expansion, resulting in better seed yield (Ibrahim et al., 2014). Although higher nitrogen levels (e.g., 45 kg ha^{-1}) were associated with increased seed weight, Fatima (2007) noted that benefits plateau beyond 45 kg N ha^{-1} and may even decline. No significant interaction effect between sowing methods and nitrogen rates was observed for 1000-seed weight (Table 5).

Seed weight per plant (g)

The seed weight per plant of BARI Til-6 was significantly influenced by sowing methods (Table 2). Line sowing produced the highest seed weight (1.99 g), followed by broadcasting (1.59 g), while dibbling recorded the lowest (1.39 g). Line sowing resulted in higher seed weight, as also reported by Islam (2017) and Islam et al. (2008), due to improved spacing and efficient resource use.

The present investigation showed that seed weight per plant was significantly influenced by nitrogen rates (Table 3). The highest mean number of seed weight per plant was obtained from the nitrogen rate of 45 kg N ha^{-1} (2.81 g) followed by 30 kg N ha^{-1} (1.90 g), while the lowest (0.74 g) was recorded from control. Our findings are supported by conclusions of others (Ibrahim et al., 2014, Shilpi et al., 2012, Pathak et al., 2002), who documented greater yield in sesame is owing to enhanced metabolic rate and cell increase in presence of nitrogen.

The present finding showed that seed weight per plant was significantly influenced by the interaction of sowing methods and nitrogen rates as shown in Table 5. S_2N_3 produced the highest seed weight per plant (3.4 g) which was statistically superior to all other treatments. S_1N_0 produced the lowest seed weight/plant and S_1N_0, S_1N_1, S_2N_0, S_2N_1, S_3N_0 and S_3N_1 were statistically similar.

Harvest index (%)

The results of the present trial revealed that the harvest index (%) was significantly differed by sowing methods (Table 2). The highest harvest index (31.10%) was observed in line sowing, trailed by broadcasting (28.60%), while the lowest (27.05%) was noted under dibbling. A number of earlier studies support the outcomes of the current investigation (Caliskan et al., 2004; Islam 2017; Khanam et al., 2022), who reported superior harvest index values with line sowing, but the lowermost with broadcasting. Conversely, Islam et al. (2008) reported no significant impact of sowing methods on the harvest index, specifying variability across crops and environments.

The highest harvest index (33.60%) was achieved with 45 kg N ha^{-1}, followed by 30 kg N ha^{-1} (30.33%), while the lowest (24.89%) was observed in the control (Table 3). Adequate nitrogen enhances sugar and protein metabolism, supporting cell enlargement, loftier leaf area, and eventually improved biomass production and seed yield (Ibrahim et al., 2014; Shehu et al., 2010).

Furthermore, a significant interaction between sowing methods and nitrogen levels was documented (Table 5). The combination S_2N_3 (line sowing with 45 kg N ha^{-1}) produced the highest harvest index (36.48%), statistically similar to S_2N_2 and several other treatments. In contrast, S_1N_3 (dibbling with 45 kg N ha^{-1}) resulted in the lowest harvest index, with S_1N_2, S_2N_1, and S_2N_2 falling to a statistically similar group. Quite a few treatments, including S_1N_0, S_1N_1, S_2N_0, S_3N_0, and S_3N_1, displayed no significant dissimilarities. These results highlight the collective impact of agronomic practices and nutrient administration on harvest index optimization.

Functional Relationships

Seed weight per plant in BARI Til-6 disclosed a positive correlation with stover weight (R^2 = 0.94) and harvest index (R^2 = 0.96), indicating that 94% and 96% of the variation in seed weight can be described by differences in stover weight and harvest index, respectively (Figures 3 and 4). This highlights the close relationship between biomass production, harvest effectiveness, and seed yield in sesame.

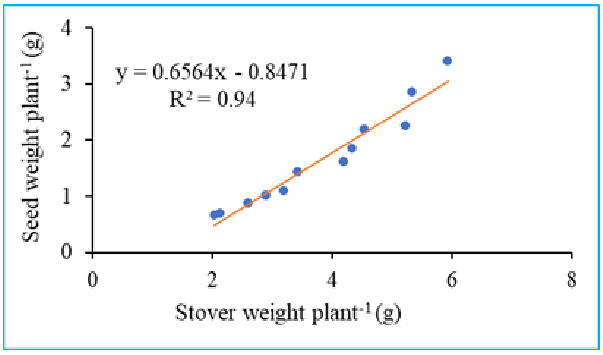

Figure 3. Relationship between seed weight/plant (g) and stover weight/plant (g) of BARI Til-6.

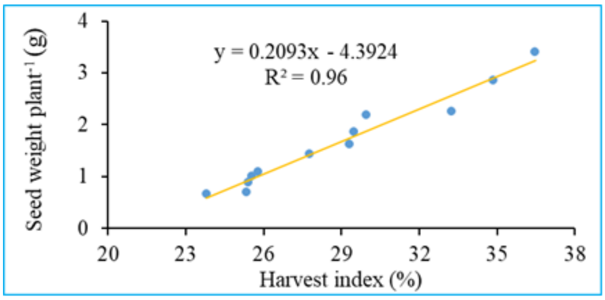

Figure 4. Relationship between seed weight/plant (g) and harvest index (%) of BARI Til-6.

CONCLUSION

Experimental results indicate that all the yield contributing and plant characters varied significantly due to different sowing methods except the capsule length and 1000 seed weight. Line sowing rendered the highest plant height (60.90 cm), number of branches per plant (2.36), number of capsules/plant (13.03), number of seeds/capsule (52), seed weight/plant (1.99 g), and harvest index (31.10%).

Regarding nitrogen application, the highest growth and yield parameters were observed at 45 kg N/ha, including plant height (69.99 cm), branches per plant (2.91), capsule length (1.98 cm), capsules per plant (16.55), seeds per capsule (59.15), 1000-seed weight (2.87 g), seed weight per plant (2.81 g), and harvest index (33.60%.

Interaction between sowing methods and nitrogen rates significantly influenced all the plant growth and yield contributing characters except the capsule width and 1000-seed weight. Combination of line sowing with 45 kg N ha^{-1} produced the tallest plants (72.18 cm), more branches/plant (3.13), highest capsules/plant (19.26), maximum number of seed/capsule (61.66), seed weight per plant (3.40 g), and harvest index (36.48%).

REFERENCES

Abdalsalam, A., & Al-Shebani, Y. (2010). Phenological and productivity characteristics of sesame (*Sesamum indicum* L.) as affected by nitrogen rates under Sana'a conditions. *Journal of Plant Production*, *1*(2), 251–264. https://doi.org/10.21608/jpp.2010.86351

Abunyewa, A. A., Ferguson, R. B., Wortmann, C. S., Lyon, D. J., Mason, S. C., & Klein, R. N. (2010). Skip-row and plant population effects on sorghum grain yield. *Agronomy Journal*, *102*(1), 296–302. https://doi.org/10.2134/agronj2009.0040

Alam, A. Y. (2002). Effect of gypsum, nitrogen fertilization and hill spacing on seed yield and oil yields of sesame cultivated on sandy soils. *Assiut Journal of Agricultural Sciences*, *33*(4), 1–16.

Bangladesh Bureau of Statistics. (2022). *Statistical year book of Bangladesh*. Government of the People's Republic of Bangladesh.

Barros, J. F. C., de Carvalho, M., & Basch, G. (2004). Response of sunflower (*Helianthus annuus* L.) to sowing date and planting density under Mediterranean conditions. *European Journal of Agronomy*, *21*(3), 347–356. https://doi.org/10.1016/j.eja.2003.10.005

Caliskan, S., Arslan, M., Arioglu, H., & Isler, N. (2004). Effect of planting method and plant population on growth and yield of sesame (*Sesamum indicum* L.) in a mediterranean type of environment. *Asian Journal of Plant Sciences*, *3*(5), 610–613. https://doi.org/10.3923/ajps.2004.610.613

Dhaka, M. S., Yadav, S. S., Shivran, A. C., Choudhary, G. L., & Prajapat, K. (2013). Effect of weed management on performance of sesame (*Sesamum indicum* L.) under varying levels of nitrogen. *Annals of Agricultural Research New Series*, *34*(2), 179–184.

Fatima, K. (2007). *Effect of different levels of nitrogen and phosphorus on yield and yield attributes of sesame* [Unpublished master's thesis]. Sher-e-Bangla Agricultural University.

Gardner, F. P., Pearce, R. B., & Mitchell, R. I. (1985). *Physiology of crop plants*. Iowa State University Press.

Hamid, M. A., Islam, M. Z., Biswas, M., Begum, A. A., Saifullah, M., & Asaduzzaman, M. (2002). Effect of method of sowing and seed rate on the growth and yield of soybean. *Pakistan Journal of Biological Sciences*, *5*(10), 1010–1013. https://doi.org/10.3923/pjbs.2002.1010.1013

Hossain, M. A., Hamid, A., & Nasreen, S. (2007). Effect of nitrogen and phosphorus fertilizer on N/P uptake and yield performance of groundnut (*Arachis hypogea* L.). *Journal of Agricultural Research*, *45*(2), 119–127.

Ibrahim, M., Hussain, M., Khan, A., Jamal, Y., Ali, M., & Malik, M. (2014). Effect of nitrogen and phosphorus on yield and yield components of sesame (*Sesamum indicum* L.). *International Journal of Sciences: Basic and Applied Research*, *18*(1), 95–101.

https://doi.org/10.13140/2.1.4456.8965

Imoloame, E. O., Gworgwor, N. A., & Joshua, S. D. (2007). Sesame (*Sesamum indicum* L.) weed infestation yield components as influenced by sowing method and seed rate in Sudan Savannah Agro-ecology of Nigeria. *African Journal of Agricultural Research*, *2*(10), 528–533. https://doi.org/10.5897/AJAR.9000630

Islam, M. S., Akhter, M. M., Sikder, M. S. I., Rahman, M. M., & Azad, A. K. (2008). Effect of planting density and methods of sowing on yield and yield attributes of sesame. *International Journal of Sustainable Agricultural Technology*, *4*(2), 83–88.

Islam, R. (2017). *Effect of sowing methods and variety on yield and yield components of sesame* [Unpublished doctoral dissertation]. Sher-e-Bangla Agricultural University.

Jan, A., Khan, I., Ali, A., Amanullah, S., & Sohail, A. (2015). Sowing dates and sowing methods influenced on growth, yield and yield components of pearl millet under rainfed conditions. *Journal of Environment and Earth Science*, *5*, 105–109.

Khanam, A., Salam, M. A., Uddin, M. R., Rabbani, M. G., & Hoshain, S. (2021). Effect of sowing methods and weeding regimes on the yield of sesame (*Sesamum indicum* L.). *Research in Agriculture, Livestock and Fisheries*, *8*(3), 291–299.

Malik, A. M., Saleem, M. F., Cheema, M. A., & Ahmed, S. (2003). Influence of nitrogen levels on productivity of sesame (*Sesamum indicum* L.) under varying planting patterns. *International Journal of Agriculture and Biology*, *4*, 490–492.

Miah, M. A. M., Afroz, S., Rashid, M. A., & Shiblee, S. A. M. (2015). Factors affecting adoption of improved sesame technologies in some selected areas in Bangladesh: An empirical study. *The Agriculturists*, *13*(1), 140–151.

Mohammad, M., Mukhtar, F. B., Basiru, S., Munir, G., & Adamu, M. (2023). Effect of soil types and sowing methods on growth and yield of some varieties of sesame (*Sesamum indicum* L.) grown in Dutse, Jigawa State. *Dutse Journal of Pure and Applied Sciences*, *9*(2b), 109–116. https://doi.org/10.4314/dujopas.v9i2b.12

Ndor, E., & Nasir, I. U. (2019). Response of sesame (*Sesamum indicum* L.) to sowing methods and fertilizer types on degraded soil of southern Guinea savanna agroecological zone, Nigeria. *East African Scholars Journal of Agriculture and Life Sciences*, *2*(6), 312–316.

Obreza, T. A., & Vavrina, C. S. (1993). Production of chinese cabbage in relation to nitrogen source, rate and leaf nutrient concentration. *Communications in Soil Science and Plant Analysis*, *24*(13–14), 1465–1479.

Pathak, A. F. L., Shinidi, Y. M., & Jadhav, N. D. (2002). Influence of nitrogen levels and spacing on grain yield of sesame. *Journal of Maharashtra Agricultural Universities*, *27*(3), 368–369.

Saharia, P., & Bayan, N. C. (1996). Production potential of sesamum (*Sesamum indicum* L.) as influenced by weed management and nitrogen level. *Journal of the Agricultural Science Society of North East India*, *9*(2), 199–201.

Salam, M. A., Khatun, A., & Kader, M. A. (2020). Effect of levels of nitrogen on the growth and yield of sesame (*Sesamum indicum* L.) cultivars. *Journal of Bangladesh Agricultural University*, *18*(4), 949–955. https://doi.org/10.5455/JBAU.135411

Shehu, E. H., Kwari, J. D., & Sandabe, M. K. (2010). Nitrogen, phosphorus and potassium nutrition of sesame (*Sesamum indicum* L.). *New York Science Journal*, *3*(12), 21–27.

Shilpi, S., Islam, M. N., Sutradhar, G. N. C., Husna, A., & Akter, F. (2012). Effect of nitrogen and sulfur on the growth and yield of sesame. *International Journal of Bio-resource and Stress Management*, *3*(2), 177–182.

Snider, J. L., Raper, R. L., & Schwab, E. B. (2012). The effect of row spacing and seed rate on biomass production and plant stand characteristics of non-irrigated photoperiod sensitive sorghum (*Sorghum bicolor* L. Moench). *Industrial Crops and Products*, *37*, 527–535. https://doi.org/10.1016/j.indcrop.2011.07.032

Svathi, A., Rammohan, J., Nadanassababady, T., & Chellamuthu, V. (2005). Influence of sowing methods and weed management on sesame (*Sesamum indicum*) yield under irrigated condition. *Journal of Crop and Weed*, *2*(1), 4–7.

Troedson, R. J., Law, R. J., Byth, K. F., & Wiloon, G. L. (1989). Response of field grown wheat to saturated soil culture. *Field Crops Research*, *21*, 171–187. https://doi.org/10.1016/0378-4290(89)90001-4

Umar, U. A., Mahmud, M., Abubakar, I. U., Babaji, B. A., & Idris, U. D. (2012). Effect of nitrogen fertilizer level and intra row spacing on growth and yield of sesame (*Sesamum indicum* L.) varieties. *International Journal of Agronomy and Plant Production*, *3*, 139–144.

Venu, M., Reddy, G. S., Mahesh, N., & Devi, M. U. (2022). Effect of integrated weed management practices on growth and yield of sesame (*Sesamum indicum* L.). *Biological Forum - An International Journal*, *14*(2a), 271–275.

Wakweya, K., & Meleta, T. (2016). Effect of sowing method and seed rate on the growth, yield and yield components of faba bean (*Vicia faba* L.) under highland conditions of Bale, Southeastern Ethiopia. *Research Journal of Agriculture and Environmental Management*, *5*(3), 86–94.

Waziri, A., Fagam, A. S., Garba, A. A., & Aliyu, M. (2022). Effect of nitrogen fertilizer and sowing methods on yield of sesame (*Sesamum indicum* L.) varieties in Bauchi State, Nigeria. *Nigerian Journal of Agriculture and Agricultural Technology*, *2*(1), 93–101. https://doi.org/10.59331/njaat.v2i1.7

Wei, P., Zhao, F., Wang, Z., Wang, Q., Chai, X., Hou, G., & Meng, Q. (2022). Sesame (*Sesamum indicum* L.): A comprehensive review of nutritional value, phytochemical composition, health benefits, development of food, and industrial applications. *Nutrients*, *14*(19), 4079. https://doi.org/10.3390/nu14194079