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Determination of optimum doses of nitrogen for higher growth and yield of Sesame

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ABSTRACT

The aim of the present study was to find out the optimum doses of nitrogen on the growth and yield of sesame. An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh following a completely randomized block design with three replications. Six nitrogen levels such as 0, 20, 40, 60, 80 and 100 kg N ha^{-1} were included in this study. It was revealed that nitrogen had significant effect on yield and yield contributing characters of sesame such as plant height, number of branches $plant^{-1}$, number of capsules $plant^{-1}$, number of main stem capsules $plant^{-1}$, number of branch capsules $plant^{-1}$, days to first flowering, seed yield $plant^{-1}$, 1000-seed weight, seed yield m^{-2}, seed yield ha^{-1} and harvest index. Our study showed that the highest number of capsules $plant^{-1}$, 1000 seed weight, seed yield m^{-2}, seed yield ha^{-1} and harvest index were observed in 80 kg N ha^{-1} while other parameters performed better in 100 kg N ha^{-1}. The study also revealed that application of nitrogen @ 84.59 kg N ha^{-1} was the optimum for good yield of sesame.

Introduction

Sesame (*Sesamum indicum* L.) is one of the most important oil crops under the Pedaliaceae family. It is locally known as *til* in Bangladesh. According to cultivable area and production it occupies third position among oil crops in Bangladesh followed by rape and mustard (BARI, 2015). As sesame is short duration and photo insensitive crop with wider adaptability it can be cultivated in both *rabi* and *kharif* sessions. Sesame is a versatile crop with high quality edible oil having diversified usage. It contains 42 to 45% oil (BINA, 2015), 14 to 20% carbohydrate and 20% protein (BARI, 2015). It also contain 0.156-0.288% S, 1.12-1.51% reducing sugars, 5.6-7.25% total sugar, 0.8-1.4% Ca, 0.41-0.71% P, 0.4-0.95% K and 40.4-52.7% protein on oil free basis (Dhindsa & Gupta, 1973). Sesame oil taste and odour is pleasant because of presence of aldehyde and acetylpyragin. It also contain more than 80% unsaturated fatty acid for human body including large amount of olic and linoleic acid (BINA, 2004).

In a view of population growth, the requirement of edible oil is increasing day by day. It is, therefore, highly expected that the production of edible oil should be increased considerably to fulfill the increasing demand. The production may be increased either by increasing cropping area under oil crop or increasing yield per unit area. But in the present condition, scope of expansion oil crop area is narrow. So, there is a general consensus that increasing yield per unit area is most reasonable way to increase total production. Bangladesh produced 3608 M.Tons of sesame from 4987 hectare of land every year (BBS, 2010). The average production of sesame in farmers' field is only 500 to 600 kg ha^{-1} (BARI, 2015) which is very low as compared to other sesame producing countries such as Egypt and Ethiopia's, 1323 kg ha^{-1} and 825 kg ha^{-1}, respectively (FAO, 2009). The main reasons for poor yield in Bangladesh are lack of suitable modern varieties, production inputs, improper management fertilizer and cultural practices.

Nitrogen is one of the accelerating factors of crop production. As an essential of protein it is needed for growth and development of all living tissues. It is an important constituent of chlorophyll, the green pigment of healthy tissues. It is very important to supply adequate amount of nitrogen to maintain proper vegetative growth and obtain satisfactory yield of plant (Yoshizawa et al., 1981). In Bangladesh, excessive use of nitrogenous fertilizer for crop production is very common. But, indiscriminate application of nitrogen is not only economically unviable but at the same time it can stimulate physiological disorder and extend the vegetative period which could ultimately delay the maturity of crop (Obreza & Vavrina, 1993). Mitra and Pal (1999) also reported that growth and reproductive parameters as well as is significantly influenced by application of nitrogen fertilizer. They also reported that yield and yield contributing characters of sesame increased significantly up to 100 kg N ha^{-1} and after this dose further increase in nitrogen application resulted in decrease to the seed yield and yield attributes of sesame. However, research is very limited in Bangladesh to see the effects of different levels of nitrogen fertilizer application on the growth and yield of sesame using the most popular sesame variety (T-6) of Bangladesh. At the same time investigation of optimum doses of nitrogen for sesame cultivation is also very limited in Bangladesh. Considering these facts the aim of the present research was to find out the optimum doses of nitrogen on the yield and yield parameters of sesame.

Materials and Methods

Experimental site

The experiment was conducted at the Agronomy Field Laboratory which is located at the Southern part of the Bangladesh Agricultural University Farm and at a height of 18 m above the mean sea level. The land is medium high belonging to the Sonatola soil series of Old Brahmaputra Floodplain Agro-ecological Zone (UNDP & FAO, 1988). The soil of the experimental field being sandy loam in texture is more or less neutral in nature with pH value ranging from 6.5 to 6.7, low in organic matter and fertility level. Status of phosphorus and cation exchange capacity (CEC) is medium and that of potassium is low (BARC, 1983).

Planting materials

Sesame (*Sesamum indicum* L.) variety T-6 was used as planting material in this study. Seeds were collected from the Oilseed Research Division of Bangladesh Agricultural Research Institute, Gazipur, Bangladesh.

Cultivation procedures

The experiment was laid out in randomized complete block design with three replications. Each block was divided into 24 plots for accommodation of combination of nitrogen fertilizer. Nitrogen fertilizer were applied in each plots as 0 kg N ha^{-1} (N_0), 20 kg N ha^{-1} (N_1), 40 kg N ha^{-1} (N_2), 60 kg N ha^{-1} (N_3), 80 kg N ha^{1} (N_4) and 100 kg N ha^{-1} (N_5). The land was prepared by four ploughing and cross-ploughing followed by laddering. The plots were fertilized with triple super phosphate, muriate of potash, gypsum and zinc sulphate at the rate of 140, 45, 100 and 5 kg ha^{-1}, respectively (BARI, 1998). The whole of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied during final land preparation. Half of urea was applied during final land preparation. The rest half of urea for all treatments was top dressed at 30 days after sowing. The seed was sown at the rate of 8 kg ha^{-1} by hand. The rows were separated from each other by a distance of 30 cm. In each unit plot there were 8 rows. The distance between levees and first row was 15 cm. The experimental field was weeded on 15 and 30 days after sowing. Drainage operation for draining out of rain water was done as and when required for proper growth and development of crop. Thinning was done once 15 days after sowing to maintain optimum plant population. The crop was harvested after 90 days of sowing where the crop attained the full maturity. The harvested area was 1 m^2 per unit plot (1 m × 1 m) which was taken randomly within the unit plot. After harvesting, the plants were bundled, tagged properly and brought to the threshing floor. The bundles were dried in open sunshine, threshed and the seeds were cleaned.

Data collection

Data were collected from five randomly selected plants from each unit plot on the following yield and yield attributing parameters viz. plant height; branch number plant^{-1}; capsule number plant^{-1}; main stem capsule plant^{-1}, branch capsule plant^{-1}, seed yield (g plant^{-1}), 1000 seed weight (g), seed yield (g m^{-2}), stalk yield (g m^{-2}), harvest index (%). The height of each sample plant was measured unit plot wise from the base to the tip of main stem of the plant and then averaged. The number of branches plant^{-1} was counted from total branches of five sampled plants and then averaged. Main stem bearing capsules were counted separately and averaged for obtaining main stem capsules of five plants. All the capsules that were borne on all the five sampled plants of each unit plot were counted to determine the average number of capsule plant^{-1}. Branch bearing all capsules were counted from five plants separately and averaged for obtaining branch capsules plant^{-1}. One thousand sun-dried seeds were counted at random from the seed stock of sampled plants. Weight of 1000 seeds was then recorded by means of a digital electrical balance. The crop from selected portion (1 m^2) of each unit plot, which was kept for taking yield data, harvested seeds were dried and threshed separately. The entire quantity of seeds obtained from each unit plot was dried in the sun to bring them to a normal storable state and the seed yield m^{-2} was recorded in terms of g^{-2}. After separating the seeds from the crop of the middle portion (5 m^2) of each plot, the stover was sub-dried to constant weight and the stover yield was recorded in terms of g and it was, thereafter converted to kg ha^{-1}. Five sample plants from each unit plot were processed together. The entire quantity of seeds obtained from five samples was dried in the sun to bring them to normal stable state. Then the total amount of seeds was divided by five for determining seed yield plant^{-1}. Each plot was closely observed every day to detect the first opening of flowers from 25 day after sowing to 37 days after sowing, the day of flower opening. Harvest index was determined using the following formula:

$$HarvestIndex(\%) = \frac{\text{Grain yield}}{\text{Biological yield}}\ x\ 100$$

Statistical analysis

All the recorded data were analyzed with computer based MSTAT software and differences among treatment means were calculated by Duncan's Multiple Range Test (DMRT) (Gomez & Gomez, 1984).

Results and Discussion

Effects of nitrogen doses on plant growth parameters of sesame

The plant growth parameters were greatly influenced by the application of different doses of nitrogen. Being the prime nutrient element it had significant influence on plant height of sesame. Plant height increased with the increasing rates of nitrogen. The highest plant height of 97.78 cm was observed from 100 kg N ha^{-1} which was statistically similar with that of 80 kg N ha^{-1} application. The second highest plant height 96.67 cm followed by 90.38, 86.40, 83.44 and 72.54 cm was obtained from 60, 40, 20 and 0 kg N ha^{-1} application respectively. The lowest plant height was recorded from control (Table 1). Increasing height might be due to higher availability and uptake of nitrogen that progressively enhanced the vegetative growth of the plant. Similar effect of nitrogen on plant height has also been observed by several researchers (Om et al., 2001; Patra, 2001; Allam, 2002).

Level of nitrogen fertilizer significantly influenced on the number of capsules plant^{-1}. The highest number of capsules plant^{-1} (41.98) was produced by 80 kg N ha^{-1} followed by 60 kg N ha^{-1} while the lowest number (24.32) was produced from control treatment (Table1). From the result it appears that capsules plant^{-1} increased due to the increased rates of nitrogen application upto certain level but excess application of nitrogen enhance the vegetative growth instead of capsule formation. In a study, Allam (2002) also reported that increasing rate of N increased capsules plant^{-1} in sesame.

Level of nitrogen significantly influenced the number of main stem capsules plant^{-1}. The maximum number of main stem capsules (19.39) was recorded from 60 kg N ha^{-1} which was statistically identical with 40 kg N ha^{-1} and 80 kg N ha^{-1}. The lowest number of main stem capsules was recorded from control treatment. From the result it was found that higher or lower dose of nitrogen than 60 kg N ha^{-1} decreased main stem capsules plant^{-1} (Table1). Number of branch capsules plant^{-1} was significantly influenced by level of nitrogen. It was observed that number of branches plant^{-1} gradually increased with increasing rate of nitrogen. The highest number of branch capsules plan^{-1} (22.89) were obtained from 100 kg N ha^{-1} which was statistically similar to 60 and 80 kg N ha^{-1}. The lowest number of branch capsules plant^{-1} (8.73) was recorded from control (Table 1). This might be due to increase branch number plant^{-1} due to increasing nitrogen levels.

It was also observed that nitrogen had significant effects on the growth parameters of sesame. Application of nitrogen @ 80 kg N ha^{-1} produced the highest plant height, number of capsules per plant and number of branch capsules per plant (Umar et. al., 2012; Bonsu, 2003; Adebisi et al., 2005; Olowe & Busari, 1996). In another study Om et al., 2001 also reported the highest number of capsules plant^{-1}, seed capsule^{-1} from application of 80 kg N ha^{-1}.

Table 1. Effects of different doses of nitrogen application on the plant growth parameters of Sesame.

Nitrogen level (kg ha^{-1})	Plant height (cm)	No. of branches plant^{-1}	No. of capsules plant^{-1}	Main stem capsules plant^{-1}	Branch capsules plant^{-1}
0	72.54 d	1.37 f	24.32 e	15.52 c	8.73 d
20	83.44 c	2.05 e	32.52 d	17.32 b	15.18 c
40	86.40 c	2.57 d	37.75 c	18.81 a	18.88 b
60	90.38 c	2.97 c	40.77 ab	19.39 a	21.38 a
80	96.67 ab	3.17 b	41.98 a	18.78 a	21.58 a
100	97.78 a	3.37 a	40.35 d	17.58 b	22.89 a
SX	2.44	0.05	0.44	0.21	0.71
CV (%)	9.60	6.77	5.16	6.05	13.63
Level of significance	**	**	**	**	**

Figures in a column having the same letter or without letter do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT at 5% level of probability. ** = Significant at 1% level of probability

Effects of nitrogen doses on reproductive growth and yield of sesame

Application of different doses of nitrogen showed significant effect on reproduction growth and yield attributes of sesame (Table 2). It had significant effect on days to first flowering from sowing. From the result it was observed that earliest flowering was obtained from control treatment, which was statistically similar to 20 kg N ha^{-1}. The latest flowering (35.50 days) was obtained from 100 kg N ha^{-1}. This might happen due to longer vegetative phase with increasing rates of nitrogen fertilizer.

Seed yield plant^{-1} significantly increased with increasing nitrogen levels. The highest seed yield plant^{-1} (3.03 g) was obtained by 100 kg N ha^{-1} which was superior to all other levels of nitrogen but statistically similar to 60 and 80 kg N ha^{-1}. The lowest seed was obtained from control. The cause of yield increased might be due to higher nitrogen consumption and favourable effect of yield contributing characters of sesame.

Weight of 1000-seed differed significantly due to the application of different levels of nitrogen fertilizer. Numerically, the highest 1000-seed weight (2.65 g) was found by applying nitrogen at 80 kg ha^{-1} which was not statistically similar to that of 60 kg N ha^{-1} and 100 kg N ha^{-1}. The lowest 1000-seed weight was obtained from control. It was also reported that seed weight decreased above and below 80 kg N ha^{-1} (Manik et al., 2003). Level nitrogen fertilizer showed significant influence on seed yield m^{-2}. It was observed that highest seed yield m^{-2} (114.95 g) was obtained from 80 kg N ha^{-1} which was statistically dissimilar to that of 100 kg N ha^{-1}. But increased application of nitrogen fertilizer (100 kg N ha^{-1}) decreased seed yield m^{-2} (111.60 g). The lowest seed yield m^{-2} (67.53 g) was obtained from control which was followed by 20, 40 and 60 kg N ha^{-1}. This was due to more vegetative growth, with excessive branches, less number of filled and more numbers of unfilled seed yield m^{-2}.

Stover yield was significantly influenced by different levels of nitrogen. Application of 100 kg N ha^{-1} produced highest stover yield (460.03 g) which was statistically similar to that of 80 kg N ha^{-1}. It was further observed control treatment produced the lowest stover yield (320.78 g). The variation of results at different N levels might be accounted for the variation in vegetative growth of sesame.

Different research findings also confirmed that application of nitrogenous fertilizers have significant effects on the reproductive growth and yield of sesame. For instance, Nahar et al., (2008) reported that nitrogen fertilizer considerably boosted up the vegetative and reproductive growth of sesame which significantly results in higher yield. This study also reported that the highest 1000-seed weight and seed yield was obtained from the application of 100 kg N ha^{-1} in sesame variety T-6 (Nahar et al., 2008). Mitra and Pal (1999) also reported that number of seeds capsule^{-1} and seed yield of sesame increased significantly up to 100 kg N ha^{-1}. Chandrakar et al., (1994) also found that seed yield increased with increasing nitrogen rates.

Determination of optimum dose of nitrogen for sesame

Optimum application dose of nitrogen fertilizer was calculated using statistical regression analysis. From the regression analysis optimum application dose of nitrogen (N) was obtained as 84.59 kg N ha^{-1} (Fig. 1). Optimum doses of nitrogen for better yield of sesame were studied by (Haruna et al., 2011). This study stated that seed yield of sesame could be optimized at moderate doses of nitrogen (80 kg N ha^{-1}) application. It was also reported that application of nitrogen beyond this moderate dose could results in yield reduction of sesame. This could be due to the facts that increasing manure and application of nitrogen fertilizer had been stated to decrease the number of fruit and yield of sesame (Haruna et al., 2010; Olowe & Busari, 2000; Okpara et al., 2007; Fathy & Mohammed, 2009). In another study per hectare grain yield of sesame was reported to be optimum at 60 kg N ha^{-1} for satisfactory and increased yield of sesame (Haruna, 2011).

Conclusion

All the characters under studies were significantly influenced by different level of nitrogen. The nitrogen fertilizer at the rate of 100 kg N ha^{-1} gave the highest plant height (97.78), number of branch plant^{-1} (3.37) branch capsules plant^{-1} (22.89), seed yield plant^{-1} (3.03), stalk yield plant^{-1} (460.03). But the highest number of capsules plant^{-1} (41.98), 1000 seed weight (2.65), seed yield m^{-2} (114.95) and harvest index (20.80) was obtained from 80 kg N ha^{-1}. The lowest of all characters were obtained when any nitrogen fertilizer was applied. Therefore, nitrogen at the rate of 80 kg ha^{-1} had significant effect for improving yield components and increasing yield of sesame cv. T-6. However, further study is necessary to confirm the results of the present study and draw a definite conclusion for recommendation.

Table 2. Effects of different doses of nitrogen on reproductive growth and yield of Sesame.

Nitrogen level (kg ha^{-1})	Days to first flowering	Seed yield (g) plant^{-1}	1000-seed weight (g)	Seed yield (g) m^{-2}	Stalk yield (g) m^{-2}	Harvest index (%)
0	32.25 d	1.67d	2.00 d	67.53 e	320.78 e	17.30 e
20	33.08 cd	2.22 c	2.30 c	85.29 d	389.48 d	18.68 d
40	34.08 be	2.62 b	2.45 c	101.50 c	419.35 c	19.49 c
60	34.33 ab	2.87 a	2.55 b	109.50 b	437.17 b	19.94 b
80	34.83 ab	2.98 a	2.65 a	114.95 a	449.50 ab	20.30 a
100	35. 50 a	3.03 a	2.55 b	111.60 b	460.03 a	19.51 c
SX	0.42	0.06	0.06	1.70	5.86	0.10
CV (%)	5.25	7.99	8.36	5.98	5.92	4.72
Level of significance	**	**	**	**	**	**

Figures in a column having the same letter or without letter do not differ significantly whereas figures with dissimilar letters differ significantly (as per DMRT) at 5% level of probability. ** = Significant at 1% level of probability

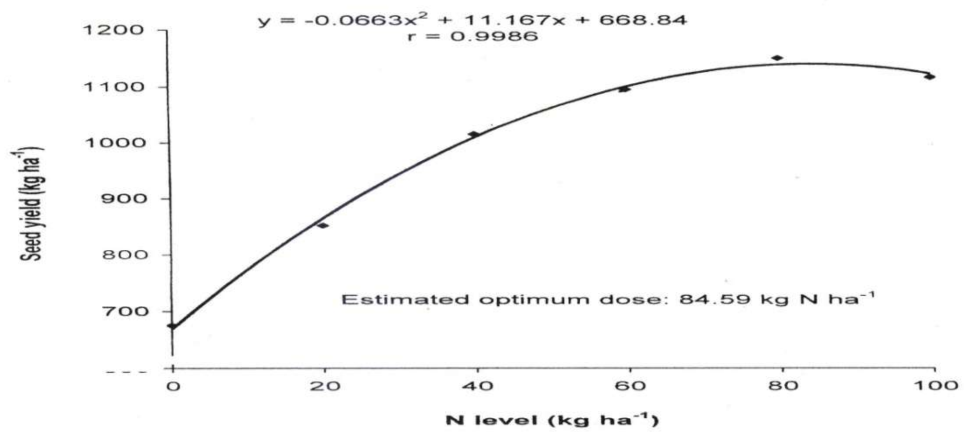

Fig. 1. Response of different nitrogen level on seed yield of sesame

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