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GROWTH AND YIELD ATTRIBUTES OF CABBAGE (*Brassica oleracea* var. *capitata* L.) INFLUENCED BY SPACING AND NITROGENOUS FERTILIZER

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ABSTRACT

A field experiment was conducted at the research field of the Department of Crop Science and Technology, University of Rajshahi, Rajshahi to evaluate the effect of spacing and nitrogenous fertilizer on the growth and yield attributes of cabbage. In the study, the cabbage (*Brassica oleracea* var. *capitata* L.) variety "BARI Badha kopi-2 (Agradut)" was cultivated during Rabi season (November 2023 to January 2024). The experiment consisted of three spacing i.e. 50cm×30cm, 50cm×40cm and 50cm×50cm as well as three levels of nitrogen fertilizers viz. 50kg/ha, 100kg/ha and 150kg/ha. The results revealed that different treatments significantly affected the growth and yield attributes of cabbage. The combination of wider spacing (50cm×50cm) with highest level of nitrogenous fertilizer (150kg/ha) produced the maximum plant height (40.57 cm), head diameter (23.83 cm), head thickness (15.89 cm), fresh head weight head (1.59 kg), yield per plot (39.92 kg) and yield (63.87 t/ha), whereas closer spacing (50cm×30cm) and lowest level of nitrogenous fertilizer (50kg/ha) required maximum days required to head formation (47.10) and head maturity (98.00). The study concluded that 50cm×50cm spacing and 150kg/ha nitrogenous fertilizer is to be needed for getting maximum yield from cabbage cultivation.

Key words: Spacing, nitrogenous fertilizer, growth and yield, cabbage.

Introduction

Cabbage (*Brassica oleracea* var. *capitata* L.), a member of the Brassicaceae family, is a biennial plant often cultivated annually, characterized by a short stem and dense cluster of leaves forming a compact head (Rubatzky and Yamaguchi, 1997). Cabbage is originally come from Western Europe, especially the Mediterranean area. It is one of the five best vegetables in the world (Rashid, 1999). Now a day, it is become more popular vegetable and the production is increased in Bangladesh. The taste in cabbage is due to the "Sinigrin glucoside". Cabbage is a rich source of vitamins, minerals, fiber and phytochemicals, all of which are crucial for maintaining health and preventing chronic diseases (Podsedek, 2007). Moreover, it is a rich source of vitamins A, B_1, B_2 and C. It may be served in slaw, salads or cooked dishes. A 100 g edible portion of cabbage contains 1.8 g protein, 0.1 g fat, 4.6 g carbohydrate, 0.6 g mineral, 29 mg calcium, 0.8 mg iron and 14.1 mg sodium (Singh and Naik, 1988). The average yield of cabbage in Bangladesh is lower (15.30 tha^{-1}) than other countries (32.31 tha^{-1}) (BBS, 2022-23). To enhance cabbage production, key factors such as the application of adequate fertilizers, particularly nitrogen and the maintenance of optimal plant spacing must be ensured. The use of proper spacing is an important factor for securing higher yield of desirable heads of cabbage. There are reports that successful production of cabbage depends on maintenance of optimum plant density in the field (Wien and Wurr, 1997). They opined that the yield of cabbage depends upon the number of plants per unit area and the size of the harvested portion of each plant. Besides spacing, nitrogenous fertilizer plays a great role for higher yield of cabbage. Fertilizer enhances plant growth by providing amendments to the soil via various macro and micronutrients. The fertilizer application for cabbage should ensure adequate levels of all nutrients (Rahman and Haque, 2018). Optimum nitrogenous fertilization is required to produce top quality and high yields while a lack of essential fertilizers will stunt its growth, leading to undersized and poorly developed heads. The positive effect of nitrogenous fertilizer on the growth and yield of cabbage is well documented. A very few research have so far been done with combined application of spacing and nitrogenous fertilizer in cabbage. Keeping

in view, the present experiment was conducted to find out the suitable spacing and level of nitrogenous fertilizer on the growth, yield attributes and yield of cabbage.

Materials and Methods

The experiment was carried out at the research field of Department of Crop Science and Technology, University of Rajshahi, Rajshahi, during the period from November, 2024 to February, 2024 with cabbage (*Brassica oleracea* var. *capitata* L.) variety "BARI Badha kopi-2 (Agradut)". The study area is located at 24. 370^0 N and 88.637^0 E latitude and 200 cm from the sea level and was belonging to the Agro Ecological Zone (AEZ-11) "High Ganges River Floodplain". The soil was sandy loam in texture with pH 7.17. The experimental area is under the sub-tropical climate that is characterized by less rainfall associated with moderately low temperature during rabi season, (October-March) and high temperature, high humidity and heavy rainfall with occasional gusty winds during kharif season (April-September). The two factors Randomized Complete Block Design (RCBD) with three replications was followed to carried out the study. The study consisted three spacing (factor A) i.e. S_1=50cm×30cm, S_2=50cm×40cm and S_3=50cm×50cm as well as three levels of nitrogenous fertilizer (factor B) viz. N_1=50kg/ha, N_2=100kg/ha and N_3=150kg/ha. The unit plot size was 2.5m×2.5m. The seed of cabbage was collected from the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Seeds of variety BARI Badha kopi-2 (Agradut) were sown in the nursery beds at 30th September, 2024. After germination, when the seedlings were attained at a height of 3 cm then the seedlings were transplanted in the other nursery beds 10cm apart for proper growth and development of the seedlings. Thirty days old seedlings were transplanted in the evening time in the experimental plot according to the treatment. Healthy seedlings of uniform size were selected for planting. Before transplantation, the nursery beds were irrigated so that the seedlings could be easily uprooted from the beds without any damage of the root. After one week of transplantation, dead seedlings were replaced by planting fresh seedlings to obtain a uniform stand. Intercultural operations were done as and when necessary. Data were recorded for desired parameters from the sample plants at harvest. Ten (10) plants were randomly selected from each unit plot for the collection of data. The collected data were analyzed using computer package MSTAT and mean differences were adjudged by using Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Plant height: Combined effect of spacing and nitrogenous fertilizer showed highly significant effect for this character of cabbage. There was an increasing tendency of plant height as the level of spacing and nitrogenous fertilizer was increased. The maximum plant height (40.57 cm) was measured from the treatment S_3N_3 (50 cm X 50 cm with 150 kg N/ha) which was significantly different from all other treatments whereas the minimum (32.51cm) was found in S_1N_1 (50 cm X 30 cm with 50 kg N/ha) which was statistically similar with S_3N_1 (Table 1). Minimum plant height was found in S_1N_1 combination due to its poor nutritional status which resulted in retarded growth and reduced plant height. The results of Ullah *et al.* (2013) align with this finding that the S_3N_3 combination treatment (widest spacing and highest nitrogen) produced the tallest cabbage plants.

No. of loose leaves per plant: Table 1 show that the highest no. of loose leaves per plant (22.00) of cabbage was produced by treatment S_3N_3 which was statistically different from all other treatments. On the other hand the lowest no. of loose leaves per plant (18.33) was obtained from S_1N_1 which was statistically similar with S_3N_1. Thus, it was observed that cabbage that received maximum nitrogen and wider spacing fetched the highest outcomes. These results collaborate with the findings of Tejashwini *et al*. (2024) who reported that no. of loose leaves per plant was highest with the highest rate of fertilizer application (75kg N/ha) with optimum spacing.

Leaf length: The present investigation showed that various levels of spacing and nitrogenous fertilizer have significant effect on leaf lengths of cabbage (Table 1). That is plants grew more vigorously where

spacing and nitrogenous fertilizer were applied. However, the maximum leaf length (34.76cm) was measured from the treatment combination of S_3N_3 (50 cm X 50 cm with 150 kg N/ha) which was significantly different from all other treatments, whereas the lowest leaf length (27.95cm) was recorded from treatment S_1N_1 which was also statistically different from all other treatments. Haque *et al*. (2020) also reported that wider plant spacing combined with higher nitrogen levels produced the longest leaves in cabbage, aligning with the present findings.

Leaf breadth: Data of the present investigation showed that various levels of spacing and nitrogenous fertilizer have highly significant on leaf breadth of cabbage. It was noted that 50 cm X 50 cm spacing + 150 kg N/ha combination produce the highest leaf breadth (36.06 cm) which was statistically different from all other treatments, whereas the treatment S_1N_1 produced the lowest (25.11 cm) which was statistically similar with S_2N_1 (Table 1). The widest spacing and highest nitrogen level resulted in the best vegetative growth. These results collaborate with the findings of Singh *et al.* (2017).

Root length: The present investigation showed that various levels of spacing and nitrogenous fertilizer have significant root length of cabbage (Table 1). Treatment S_3N_3 produced the highest root length (23.00 cm) which was significantly different from all other treatments and the lowest root length (18.23 cm) was obtained from S_1N_1 which were statistically similar with S_1N_2. This trend clearly indicates that both wider spacing and higher nitrogen levels contribute to increased root development. These findings are consistent with the observations of Miah *et al*. (2015).

Stem length: Stem length of cabbage was highly significant as influenced by the interaction of spacing and nitrogenous fertilizer. The result reveled that stem length was gradually increased with the increased of combined effect of spacing and nitrogenous fertilizer. However, the maximum stem length (8.71 cm) was found from treatment S_3N_3 which was statistically similar with S_2N_3 whereas the lowest stem length (8.11 cm) was obtained from S_1N_1 which was significantly different from all other treatments (Table 1). It is evident that wider spacing and higher nitrogen have a positive influence on stem elongation. These findings are consistent with the results of Singh *et al.* (2014).

Table 1. Effect of spacing and nitrogenous fertilizer on the vegetative growth of cabbage

Treatments	Plant height (cm)	No. of loose leaves/plant	Leaf length (cm)	Leaf breadth (cm)	Root length (cm)	Stem length (cm)
S_1N_1	32.51 d	18.33 c	27.95 d	25.11 d	18.23 e	8.11 d
S_1N_2	34.12 c	20.33 b	29.80 bc	29.83 c	18.77 de	8.52 bc
S_1N_3	35.02 c	20.67 b	32.47 b	32.73 b	19.33 d	8.63 b
S_2N_1	33.75 c	17.67 d	28.32 c	27.37 cd	19.80 cd	8.48 bc
S_2N_2	38.00 bc	20.67 b	30.53 bc	29.47 c	20.38 cd	8.66 b
S_2N_3	39.81 b	20.33 b	32.38 b	35.40 b	21.74 bc	8.90 a
S_3N_1	32.86 d	18.67 c	29.33 b	28.23 c	20.08 cd	8.36 c
S_3N_2	37.26 bc	19.33 bc	32.51 b	34.36 b	21.28 bc	8.88 b
S_3N_3	40.57 a	22.00 a	34.76 a	36.06 a	23.00 a	8.71 a
Level of significance	**	*	*	**	*	**
CV (%)	4.99	6.85	6.45	4.67	5.28	1.89

Means followed by the same letter(s) do not statistically differ at 5% level tested by DMRT.

Days required to head formation and head maturity: The effect of spacing and nitrogenous fertilizer was found to be significant in case of days required to head formation and head maturity of cabbage. The combined effect of 50cm X 30cm + 50 kg N/ha required maximum days for head formation and head

maturity of cabbage (47.10 and 98.00) which was significantly different from all other treatments whereas the treatment combination of 50cm X 50cm + 150 kg N/ha required minimum days for head formation and head maturity (37.83 and 78.53) which was also statistically different from all other treatments (Table 2). However, excessive nitrogen beyond optimal levels can sometimes delay maturity or reduce postharvest quality, observation made by the experiment of Gelaye (2024).

Head diameter: Head diameter is a tone character for economic yield which depends upon various factors such as genetic makeup of the cultivars and their response to prevailing environmental conditions. The maximum head diameter (23.83 cm) was measured from the treatment combination of S_3N_3 and the minimum (19.13 cm) was observed from S_1N_1 which was statistically non-significant (Table 2). The data suggest a trend where wider spacing and higher nitrogen promote greater head expansion, likely due to better photosynthetic efficiency and canopy development (Islam *et al*., 2019).

Head thickness: Head thickness is an important yield influencing character. A significant variation was observed on head thickness due to different spacing and nitrogenous fertilizer (Table 2). The maximum head thickness (15.89 cm) was measured from the treatment of S_3N_3 which was statistically different from all other treatments except S_3N_2 and the minimum (14.40 cm) was found S_1N_1 which were statistically similar with S_1N_2 and S_2N_1. This outcome agrees with Singh *et al.* (2014), who highlighted the role of appropriate spacing and nutrient application in enhancing cabbage head development.

Fresh weight of head: The effect of spacing and nitrogenous fertilizer in the respects of fresh head weight was found to be highly significant (Table 2). The maximum fresh weight of head (1.59 kg) was found from the combined treatment of S_3N_3 which was statistically different from all other treatments. On the other hand, the minimum fresh weight of head (1.05 kg) was observed from the treatment combination of S_1N_1 which was also statistically different from all other treatments. Treatments with wider spacing and higher nitrogen level consistently showed higher head weight. This increase may be attributed to enhanced nutrient uptake and reduced intra-specific competition (Ali *et al*., 2012).

Table 2. Effect of spacing and nitrogenous fertilizer on the yield attributes and yield of cabbage

Treatments	Days required to head formation	Days required to head maturity	Head diameter (cm)	Head thickness (cm)	Fresh weight of head (kg)	Yield per plot (kg)	Yield (t/ha)
S_1N_1	47.10 a	98.00 a	19.13	14.40 f	1.05 g	26.25 g	42.00 f
S_1N_2	45.67 de	82.00 d	20.11	14.73 ef	1.18 f	29.50 f	47.20 e
S_1N_3	44.53 cd	83.00 c	21.07	15.16 cd	1.31 e	32.83 e	52.53 e
S_2N_1	46.57 b	90.33 b	19.73	14.81 def	1.34 cde	33.58 de	53.73 de
S_2N_2	43.33 c	80.00 c	21.33	15.39 bc	1.43 bcd	35.83 cd	57.33 cd
S_2N_3	40.33 d	78.67 d	23.20	15.13 cde	1.48 b	36.75 b	58.80 b
S_3N_1	46.33 b	90.00 b	22.03	14.89 de	1.33 de	33.17 de	53.07 de
S_3N_2	39.33 e	79.00 d	23.44	15.74 ab	1.46 bc	36.42 bc	58.27 bc
S_3N_3	37.83f	78.53 e	23.83	15.89 a	1.59 a	39.92 a	63.87 a
Level of significance	*	**	NS	*	**	**	**
CV (%)	1.74	0.56	1.96	1.58	4.96	5.02	5.02

Means followed by the same letter(s) do not statistically differ at 5% level tested by DMRT

Yield per plot and yield: Highly significant differences were found between different levels of spacing and nitrogenous fertilizer in respect of yield per plot and yield hectare **(**Table 2). The maximum yield per plot (39.92 kg) and yield (63.87 t/ha) were measured from the combined treatment of S_3N_3 (50 cm X 50 cm spacing + 150 kg N/ha) which was statistically different from all other treatments. On the other hand, the

minimum yield per plot (26.25 kg) and yield (42.00 t/ha) were found from the treatment combination of S_1N_1 (50 cm X 30 cm spacing + 50 kg N/ha) which was also significantly different from all other treatments. The results reveal a consistent trend that higher nitrogen levels combined with wider spacing lead to increased yield per plot. Similar outcomes were reported by Ali *et al*. (2021) in their experiments. The results obtained in the present study were supported by various researchers. The higher yield in above treatment is due to better plant survival owing to the favorable conditions for growth and development of plant and the closer spacing accommodates more number of plants per unit area. Similar results were reported by Rehman and Ali (2000).

Conclusion

The study concluded that cabbage needs to be cultivated at the spacing of 50 cm×50 cm with 150 kg/ha nitrogen is to be provided for getting maximum yield. The study may be continued further to find out the yield potentiality of cabbage under different spacing and levels of nitrogenous fertilizer.

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