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## Effect of Plant Spacing and Sources of Nutrients on the Growth and Yield of Cabbage

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**Abstract:** The effect of plant spacing and different sources of nutrient was studied on the growth and yield of cabbage. The experiment was conducted with two plant spacings (60cm x 45 cm, 60cm x 60 cm) and four levels of nutrients (no fertilizer, organic manures, organic + inorganic fertilizers and inorganic fertilizers) in RCB design. Plant spacing had marked influence on the growth parameters like number of loose leaves per plant and diameter of head. The plant under closer spacing produced high marketable yield (64.38t ha<sup>-1</sup>) than wider spacing. Plants those received organic + inorganic fertilizers produced the highest marketable yield (79.01 t ha<sup>-1</sup>). The treatment combination of 60 cm x 45 cm spacing with organic + inorganic fertilizers gave the highest marketable yield (86.68 t ha<sup>-1</sup>) of cabbage.

**Key words:** Plant spacing, nutrients, growth, cabbage yield

### Introduction

Cabbage (*Brassica oleracea* var. capitata) is a biennial and herbaceous vegetable of the family cruciferae. It is originated from the seacoast of England, Denmark and northwestern part of France (Thomson and Kelly, 1957). This unique vegetable has been widely grown in both tropical and temperate regions of the world. Major cabbage growing counties of the world are South Korea, Germany, Japan, India, South Africa and China (Anonymous, 1996).

Among the vegetables grown in Bangladesh cabbage ranks the second in respect of production and area. The leading cabbage growing districts in Bangladesh are Kustia, Meherpur, Jessore, Bogra and Tangail. There were 12060 hectares of land under cabbage cultivation with a production of 113 thousand metric tons in the country during the year 1997-98 (Anonymous, 1999) with an average yield of 9.29 t ha<sup>-1</sup> which is quite low in comparison with other countries of the world like South Korea (61.17 t ha<sup>-1</sup>), Germany (54.81 t ha<sup>-1</sup>), Japan (40.32 t ha<sup>-1</sup>) and India (19.12 t ha<sup>-1</sup>) (FAO, 1998). Lack of appropriate production technologies adopted by the farmers is one of the main reasons for such low yield of cabbage in our country (Islam *et al.*, 1989). Cultivation of any crop depends on several factors. It is well established that plant spacing has significant influence on the growth and yield of different crops (Rashid and Mannan, 1983). The optimum plant spacing depends on several factors including the growing environment, doses of fertilizer, sources of nutrient, cultivar(s) used, fertility level of the land, etc.

Growth, yield and quality of cabbage are related to judicious application of manures and fertilizers. Nutrients may be applied through two sources, (organic and inorganic). Increased use of inorganic fertilizer causes health hazards and creates environmental pollution. Use of organic sources of nutrients, supply nutrients to the crop, increase soil moisture, microbial activity of the soil, increase buffering action of soil and decrease soil toxicity. Organic sources of nutrients are less expensive and friendly to the environment. To minimize the economic return avoiding health hazards and for a sustainable agriculture, the use of organic sources of nutrients should be encouraged. On the other hand, a judicious combination of organic and inorganic nutrients might be helpful to obtain a good economic return leaving the congenial soil condition. It is evident that appropriate plant spacing and fertilizer application is the most important factor for cabbage production. Considering these two factors the present experiment was designed to determine the optimum plant spacing for a high yielding variety of cabbage and to find out an appropriate source of nutrients for the growth and yield of cabbage.

### Materials and Methods

The experiment was carried out at the Horticulture Farm, BAU, Mymensingh from October 1999 to March 2000 to study the effect of spacing and sources of nutrients on the growth and yield of cabbage. Soil sample collected from the experimental plot and analyzed in the laboratory. The variety was Atlas -70. Seedlings were raised in the Horticulture Center to get seedlings of 25 days at the time of planting.

The two-factor experiment was laid out in a randomized complete block design (RCBD) with three replications and 24 treatment combinations. The unit plot size was 4 x 3m<sup>2</sup>. Seedlings were raised in the seed bed and transplanted in the plot at the age of 25 days. There were two factors in the experiment: I) Plant spacing a) 60 cm x 45 cm, b) 60 cm x 60 cm and ii) sources of nutrients; a) no fertilizer b) Organic manures c) Organic + inorganic fertilizers and d) Inorganic fertilizers. The land was ploughed several times to provide a good tilth and favorable condition for growing cabbage. Weeds and stubbles were removed and laddered to level the plot. The experimental plot except the control received a constant dose of 132 kg N, 44 kg P<sub>2</sub>O<sub>5</sub> and 120 kg K<sub>2</sub>O per hectare (Anonymous, 1997). Details of manures and fertilizers used for the crop are given in Tables 5 and 6. Intercultural operations like gap filling, weeding, earthing up, etc. were done properly. Data on plant height, spread of plant, number of loose leaves per plant, diameter of head, thickness of head, gross yield, marketable yield were recorded from 10 randomly selected plants from each unit plot avoiding border effect.

Collected data were statistically analyzed according to the principal of experimental design. Analysis of variance was made on yield and yield attributes of cabbage. The means were separated and compared by LSD method.

### Results and Discussion

**Plant height:** There was no significant effect of plant spacing on plant height at different days after transplanting (DAT) ranging from 23.49 to 23.72 cm for 30DAT (Table 1). But there was significant difference among different sources of nutrients on plant height. During the growth period increasing trend of plant heights were found up to organic + inorganic fertilizers treatments at 30 and 60 DAT and inorganic fertilizers at 90 DAT. The combined effect of plant spacing and sources of nutrients on plant height were found significant at 60 DAT but non significant at 30 and 90 DAT. The highest plant height (34.06 cm) at 60 DAT was observed in the treatment combination of 60 cm x 45 cm spacing with organic + inorganic fertilizers and the lowest (21.05 cm) in the same spacing with no fertilizer (Table 3).

**Sarker *et al.*: Effect of plant spacing and nutrients on cabbage**

Table 1: Effect of plant spacing and different sources of nutrients on plant height, spread of plant and number of loose leaves per plant of cabbage

Treatments	Plant height (cm)			Spread of plants (cm)			Number of leaves/plant		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
<b>Plant spacing:</b>									
60 cm X 45 cm	23.49	28.65	36.99	55.55	58.78	63.04	5.28	12.23	16.93
60 cm X 60 cm	23.72	28.92	37.06	55.64	59.21	64.45	5.98	14.29	17.86
LSD (0.05)	NS	NS	NS	NS	NS	NS	0.22	0.54	0.12
(0.01)	-	-	-	-	-	-	0.30	0.72	0.16
<b>Sources of nutrients:</b>									
F <sub>0</sub>	19.59	22.24	31.65	49.30	51.81	52.76	6.14	14.35	18.06
F <sub>1</sub>	24.06	31.11	36.86	52.97	58.01	64.55	5.78	12.92	16.74
F <sub>2</sub>	25.81	33.11	39.34	59.55	63.73	71.14	5.73	13.20	16.93
F <sub>3</sub>	24.96	28.69	40.24	57.96	62.43	64.68	4.82	12.57	17.85
LSD (0.05)	1.13	1.29	1.12	2.83	1.44	1.58	0.22	0.87	0.21
(0.01)	1.51	1.73	1.66	3.78	1.91	2.11	0.29	1.16	0.34

Sources of nutrients: F<sub>0</sub> = No fertilizer, F<sub>1</sub> = Organic fertilizer, F<sub>2</sub> = Organic + inorganic fertilizer, F<sub>3</sub> = Inorganic fertilizer

Table 2: Effect of plant spacing and different sources of nutrients on some yield contributing characters of cabbage

Treatments	Diameter of head (cm)	Thickness of head (cm)	Gross yield (t ha <sup>-1</sup> )	Marketable yield (t ha <sup>-1</sup> )	Harvest Index
<b>Plant spacing:</b>					
60 cm X 45 cm	20.74	12.96	91.99	64.38	70.77
60 cm X 60 cm	22.56	13.31	79.39	53.92	68.55
LSD (0.05)	0.98	NS	6.85	0.72	NS
(0.01)	1.30	-	9.14	1.06	-
<b>Sources of nutrients:</b>					
F <sub>0</sub>	16.14	8.34	50.04	30.65	61.64
F <sub>1</sub>	22.50	13.79	91.75	60.38	76.54
F <sub>2</sub>	24.83	14.55	103.78	79.01	76.54
F <sub>3</sub>	23.12	13.52	97.19	66.54	70.63
LSD (0.05)	1.39	1.08	9.71	0.99	4.26
(0.01)	1.85	1.44	12.9	1.32	5.68

Sources of nutrients: F<sub>0</sub> = No fertilizer, F<sub>1</sub> = Organic fertilizer, F<sub>2</sub> = Organic + inorganic fertilizer, F<sub>3</sub> = Inorganic fertilizer

Table 3: Combined effect of plant spacing and different sources of nutrients on plant height, spread of plant and number of loose leaves per plant of cabbage

Treatments	Plant height (cm)			Spread of plants (cm)			Number of leaves/plant		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
S <sub>1</sub> F <sub>0</sub>	19.50	21.05	31.6	49.17	51.76	52.76	6.51	15.51	18.38
S <sub>1</sub> F <sub>1</sub>	23.9	30.85	36.82	53.84	57.64	64.53	6.01	13.09	17.64
S <sub>1</sub> F <sub>2</sub>	25.67	34.06	39.35	61.20	63.14	71.07	5.97	14.53	17.35
S <sub>1</sub> F <sub>3</sub>	24.81	28.65	40.11	58.01	62.59	65.44	5.33	13.74	18.05
S <sub>2</sub> F <sub>0</sub>	19.69	23.43	31.91	52.10	58.38	64.57	5.44	12.74	15.83
S <sub>2</sub> F <sub>1</sub>	24.95	32.17	39.33	57.90	64.32	71.20	5.50	11.87	16.51
S <sub>2</sub> F <sub>2</sub>	25.95	32.17	39.33	57.90	64.32	71.20	5.50	11.87	16.51
S <sub>2</sub> F <sub>3</sub>	25.10	28.73	40.90	57.90	62.27	63.93	4.32	11.41	17.65
LSD (0.05)	1.61	1.84	1.76	4.01	2.03	2.23	0.27	1.08	0.24
(0.01)	2.06	2.45	2.35	5.35	2.71	2.98	0.36	1.44	0.32

Spacing: S<sub>1</sub> = 60 cm X 45 cm, S<sub>2</sub> = 60 cm X 60 cm

Sources of nutrients: F<sub>0</sub> = No fertilizer, F<sub>1</sub> = Organic fertilizer,

F<sub>2</sub> = Organic + inorganic fertilizer, F<sub>3</sub> = Inorganic fertilizer

Table 4: Combined effect of plant spacing and different sources of nutrients on some yield contributing characters of cabbage

Treatments	Diameter of head (cm)	Thickness of head (cm)	Gross yield (t ha <sup>-1</sup> )	Marketable yield (t ha <sup>-1</sup> )	Harvest Index
S <sub>1</sub> F <sub>0</sub>	15.48	8.73	53.47	32.47	63.59
S <sub>1</sub> F <sub>1</sub>	21.85	13.63	96.86	65.69	70.98
S <sub>1</sub> F <sub>2</sub>	24.26	16.07	110.12	86.68	78.56
S <sub>1</sub> F <sub>3</sub>	21.35	13.40	107.50	72.66	69.95
S <sub>2</sub> F <sub>0</sub>	16.79	9.13	46.59	28.84	59.68
S <sub>2</sub> F <sub>1</sub>	23.14	13.95	86.64	55.08	66.96
S <sub>2</sub> F <sub>2</sub>	25.41	16.53	97.44	71.34	74.53
S <sub>2</sub> F <sub>3</sub>	24.90	13.63	86.89	60.43	71.32
LSD (0.05)	1.95	1.52	13.72	1.40	6.02
(0.01)	2.61	2.03	18.31	1.87	8.03

Spacing: S<sub>1</sub> = 60 cm X 45 cm, S<sub>2</sub> = 60 cm X 60 cm

Sources of nutrients: F<sub>0</sub> = No fertilizer, F<sub>1</sub> = Organic fertilizer,

F<sub>2</sub> = Organic + inorganic fertilizer, F<sub>3</sub> = Inorganic fertilizer

Sarker *et al.*: Effect of plant spacing and nutrients on cabbage

Table 5: Combination of manures and fertilizers used for the crop

Name of manures and fertilizers	Dose ha <sup>-1</sup>	Available nutrients (kg ha <sup>-1</sup> )		
		N (132)	P <sub>2</sub> O <sub>5</sub> (44)	K <sub>2</sub> O (120)
<b>Organic (F<sub>1</sub>):</b>				
Cowdung	21.0ton	91.38	42.0	21.0
MOC	800.0kg	39.44	3.2	5.2
Ash	4.0ton	1.08	0.16	94.0
Total		131.9	45.3	120.2
<b>Organic + inorganic (F<sub>2</sub>):</b>				
Cowdung	10.5ton	45.69	21.0	10.5
MOC	400.0kg	19.72	1.6	2.6
Ash	2.0ton	0.52	0.8	47.0
Urea	143.0kg	65.78	-	-
TSP	46.0kg	-	22.08	-
MP	100.0kg	-	-	60.0
Total		131.9	45.3	120.0
<b>Inorganic (F<sub>3</sub>):</b>				
Urea	286.0kg	132.0	-	-
TSP	92.0kg	-	44.0	-
MP	200.0kg	-	-	120.0
Total		132.0	44.0	120.0

MOC= Mustard oil cake

Source: Fertilizer Recommendation Guide, (Anonymous, 1997)

Table 6: Nutrient content of different manures and fertilizers

Sources of nutrients	Nutrient content (%)		
	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
Cowdung	0.435	0.2	0.1
MOC	4.93	0.4	0.65
Ash	0.027	0.02	2.35
Urea	46.0	-	-
TSP	-	48.0	-
MP	0.0	-	60.0

MOC= Mustard oil cake

Source: Fertilizer Recommendation Guide (Anonymous, 1997)

**Spread of plant:** Effect of plant spacing on spread of plant was found non-significant at different DAT but different sources of nutrients (on spread of plant at 30, 60 & 90 DAT) was found significant. Maximum spread of plant at 90 DAT (71.14 cm) was obtained from the organic + inorganic fertilizers used followed by inorganic fertilizers (64.68 cm) and the lowest (52.76 cm) from control (Table 1). The combined effect of plant spacing and different sources of nutrients were found non-significant at different DAT. At 30 DAT, highest spread of plant (61.20 cm) was found from the treatment S<sub>1</sub>F<sub>2</sub> (Table 3).

**Number of loose leaves per plant:** The number of loose leaves per plant was varied due to the influence of plant spacing at different DAT. Number of loose leaves increased with the increase in time. Maximum number of loose leaves (17.86) per plant was obtained from 90 DAT with 60 cm x 60 cm plant spacing and the minimum (16.93) (Table 1) from closer spacing. These results are similar with the findings of Islam *et al.* (1992). Table 1 also shows that number of loose leaves increased with time irrespective of fertilizer treatments. At 90 DAT the control treatment gave maximum number of loose leaves (18.06) whereas, the minimum number (16.74) was obtained from organic fertilizer treatment. The combined effect of plant spacing and sources of nutrients on the number of loose leaves per plant was found significant at 60 and 90 DAT. At 90 DAT, the highest number of loose leaves per plant (18.38) were observed in the treatment combination of 60 cm x 45 cm spacing with no fertilizer and the lowest (15.83) were found in the treatment combination of 60cm x 60cm with organic manures (Table 3).

**Diameter of cabbage head:** There was a significant effect of plant spacing and sources of nutrients on the diameter of cabbage head.

The highest diameter (22.56cm) was found in 60 cm x 60 cm spacing than that of 60cm x 45cm spacing (20.74 cm) (Table 2). These results are in agreement with the reports of Saha *et al.* (1994) and Hossain (1983). The formation of bigger heads at wider spacing was probably due to the availability of more nutrients, light and moisture to the plants. The maximum diameter (24.83 cm) of head was found with the plant having both organic + inorganic fertilizers followed by inorganic fertilizers treatment (23.12cm). The lowest diameter of head (16.14cm) was obtained from the control (Table 2). Similar views (application of organic manure increase head diameter) were expressed by Subhan (1989).

The diameter of cabbage head was not significantly influence by the combined effect. The highest diameter (25.41cm) was obtained from S<sub>2</sub>F<sub>2</sub> and the lowest (15.48cm) from S<sub>1</sub>F<sub>0</sub> treatment combination (Table 4).

**Thickness of cabbage head:** Plant spacing had no significant effect on thickness of cabbage head but the sources of nutrients had significant effect. The maximum thickness of head (14.55cm) was noted with organic + inorganic fertilizers application and was statistically identical with inorganic fertilizers. The lowest thickness of head (8.34cm) was found from control treatment (Table 2). The combined effect of plant spacing and sources of nutrients was found non significant on thickness of cabbage head. The highest thickness (16.53cm) was obtained from S<sub>2</sub>F<sub>2</sub> and the lowest (8.73 cm) from S<sub>1</sub>F<sub>0</sub> treatment combination (Table 4).

**Gross yield of cabbage:** Gross yield of cabbage per hectare was significantly influenced by plant spacing and sources of nutrients. Higher gross yield (91.99 t ha<sup>-1</sup>) was obtained from 60 cm x 45cm plant spacing than 60 cm x 60cm plant spacing (79.39 t ha<sup>-1</sup>). These results are in agreement with Saha *et al.* (1994), and Hossain (1983). The higher gross yield per hectare at closer spacing was possibly due to more number of plants per unit area. The highest gross yield (103.78 t ha<sup>-1</sup>) was obtained when crop received both organic + inorganic fertilizers which is identical with inorganic fertilizers (97.19 t ha<sup>-1</sup>). The lowest gross yield was obtained from control (50.04 t ha<sup>-1</sup>) (Table 2).

Gross yield was not significantly influenced by the combined effect of plant spacing and source of nutrients. The highest gross yield (110.12t ha<sup>-1</sup>) was obtained from the treatment combination S<sub>1</sub>F<sub>2</sub> and the lowest (46.59t ha<sup>-1</sup>) from S<sub>2</sub>F<sub>0</sub> (Table 4)

**Marketable yield of cabbage:** Marketable yield of cabbage was significantly influenced by the plant spacing and sources of nutrients. The maximum marketable yield (64.38 t ha<sup>-1</sup>) was obtained from the spacing of 60cm x 45cm and the highest (79.01 t ha<sup>-1</sup>) was produced by the plants which received both organic and inorganic fertilizers. The lowest yield (30.65 t ha<sup>-1</sup>) was obtained from the control treatment (Table 2).

Marketable yield was significantly influenced by the combined effect. The treatment combination of 60 cm x 45 cm plant spacing with organic + inorganic fertilizers gave the highest marketable yield of cabbage (86.68 t ha<sup>-1</sup>) and the lowest from the control (32.47 t ha<sup>-1</sup>) (Table 4).

**Harvest index (HI):** Harvest index was significantly influenced by the plant spacing and sources of nutrients. Higher HI (70.77) was obtained from 60cm x 45cm plant spacing and the highest HI (76.54) was obtained from the treatment of organic + inorganic fertilizers (F<sub>2</sub>). The lowest HI (61.64) was found from control treatment (Table 2).

There was no significant combined effect on H.I. Highest HI (74.53) was obtained from the treatment combination S<sub>1</sub>F<sub>2</sub> and the lowest (63.59) from S<sub>1</sub>F<sub>0</sub> (Table 4).

It is apparent from the study that closer spacing of 60 cm x 45cm is suitable for cabbage variety Atlas-70. Among the sources of nutrients, Organic + inorganic fertilizers gave higher yield. But organic manures alone cannot produce marked effect in

**Sarker *et al.*: Effect of plant spacing and nutrients on cabbage**

comparison with the above two treatments. Organic + inorganic fertilizers application may be encouraged for cabbage production. Therefore, the treatment combination of 60 cm x 45 cm spacing with organic + inorganic fertilizer may be suggested for higher yield of cabbage.

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