Original Research Article

Influence of Plant Spacing and NPK Fertilizers on Growth and Yield of Broccoli

ABSTRACT

An experiment was conducted at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh. The study aimed to investigate how plant spacing and NPK fertilizers influence the growth and yield of broccoli. The experiment used a randomized complete block design with three replications. The treatments included three plant spacings: S_1 (60 cm × 50 cm), S_2 (60 cm × 40 cm), and S_3 (50 cm × 50 cm), and four doses of NPK fertilizer: F_0 ($N_0P_0K_0$ kg/ha), F_1 ($N_{100}P_{75}K_{75}$ kg/ha), F_2 ($N_{200}P_{150}K_{150}$ kg/ha), and F_3 ($N_{300}P_{225}K_{225}$ kg/ha). The results showed that plant spacing, NPK fertilizer, and their interaction significantly affected the growth and yield of broccoli. The treatment combination S_2F_3 (60 cm × 40 cm with $N_{300}P_{225}K_{225}$ kg/ha) resulted in the highest plant height (63.27 cm), crown spread (70.20 cm), number of leaves (17), and length of the largest leaves (50.57 cm). For curd initiation, the treatment combination S_2F_2 (60 cm × 40 cm with $N_{200}P_{150}K_{150}$ kg/ha) required 54.33 days, with a primary curd weight of 0.48 kg and a curd diameter of 15.12 cm. Additionally, S_2F_2 resulted in a stem diameter of 4.02 cm, stem length of 26.73 cm, number of secondary curds (8.06), weight of secondary curds (78.99 g), fresh weight of leaves (401.49 g), yield per plant (365 g), and yield per plot (9.13 kg). The highest broccoli curd yield of 13.25 t/ha was obtained from the application of $N_{200}P_{150}K_{150}$ fertilizer, while the lowest yield of 9.36 t/ha was recorded with no NPK fertilizer. The yield of broccoli curd increased with decreasing plant spacing, with the highest yield of 13.81 t/ha from S_2 (60 cm × 40 cm) and the lowest yield of 9.75 t/ha from S_1 (60 cm × 50 cm) spacing. The best treatment combination was S_2F_2, resulting in a yield of 15.21 t/ha.

Keywords: *Brocolli; chemical fertilizers; growth; spacing; yield.*

1. INTRODUCTION

Broccoli (*Brassica Oleracea* var. italica) is an edible green plant in the Brassicaceae family whose large flowering head is eaten as a vegetable. The word broccoli comes from the Italian plural of broccolo, which means "the flowering crest of a cabbage", and is the diminutive form of broccoli, meaning "small nail" or "sprout". Broccoli is often boiled or steamed but may be eaten raw. Broccoli is classified in the Italica cultivar group of the species *Brassica oleracea*. Broccoli has large flower heads, usually green in color, arranged in a tree-like structure branching out from a thick, edible stalk. Broccoli is fairly rich in vitamins A and C and contains appreciable amounts of calcium, phosphorus, potash, riboflavin, thiamin, niacin, and iron [1]. The cancer-fighting properties of broccoli are not new and previous studies have related these benefits to the high levels of active phytochemicals called glucosinolates [2]. Eating more than one serving of broccoli a week reduces the risk of prostate cancer by up to 45 percent. Analytical data presented by Nieuwhof [3] show that broccoli is more nutritious than other cole crops like cabbage, and cauliflower kohlrabi. Many

people consider it as the tastiest among the cole crops. Its preference for the consumers is increasing day by day. Cultivation of broccoli depends on several factors. Plant spacing is one of them. It is well established that plant spacing has a significant influence on the growth and yield of broccoli. Optimal plant spacing is important for crop production through efficient utilization of nutrients, water, and light by the plants. In general, higher plant populations adversely affect yield per unit area hampering the vegetative and reproductive growth of plants [4-5]. The optimum plant spacing depends on several factors including the growing environment, doses of fertilizers, sources of nutrients, cultivars used, moisture availability, and fertility level of the soil. It is also evident that the balanced application of fertilizer is the prerequisite for obtaining a higher yield and better quality of broccoli [6]. Among the fertilizer's nitrogen, phosphorus and potassium appear to be more important. Nitrogen is important for the vegetative growth of plants [7-8]. The nutrient is needed in large amounts, and a plant deficient in nitrogen tends to make poor growth having usually small and yellowish leaves [9]. Mitra et al., [10] reported that increasing N rates from 65 to 224 kg/ha caused a linear increase in broccoli head weight and total yield. Phosphorus fertilization can influence the curd initiation and development of broccoli. Demchack and Smith [11] reported that phosphorous was the most responsible element for the increased yield of broccoli. Application N and P substantially enhance the terminal (central curd), lateral 9 axillary stalk) and total yield of broccoli, and higher rates of N were effective when applied in combination with adequate P, while K application had slightly but consistent effects on the terminal yield of broccoli. Potassium has also an important role in balancing the physiological activities of plants. Ying et al., [12] observed that potassium was the most important element for yield and dry weight of broccoli.

The production technology of broccoli has not yet been standardized in Bangladesh. Available information is scanty regarding the effects of plant spacing and fertilization on the growth and yield of broccoli. From the above consideration, the experiment has been taken to study the combined effect of spacing and NPK fertilizer dose on the growth and yield of broccoli.

2. MATERIAL AND METHODS

2.1 Experimental Site

The research work was carried out at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh to study the effect of plant spacing and NPK fertilizers on the growth and yield of broccoli.

2.2 Characteristics of Soil

The selected plot was a medium highland. The texture of the soil of the experimental area was silty loam and belongs to the Agro-Ecological Zone-9 (AEZ-9), Old Brahmaputra Flood Plain. The selected plot of the land remained fallow during, the previous season. The nutrient status of the farm soil under the experimental plot within a depth of 0-20 cm was determined in the Humboldt Soil Testing Laboratory, Department of Soil Science, Bangladesh Agricultural University, Mymensingh and results have been presented in (Table 1).

Table 1. Physical and chemical analyses of soil of the experimental plots

Soil properties	Value	Critical level
Sand (%)	35.2	---
Silt (%)	58.7	---

Clay (%)	6.1	---
Textural class	Silty loam	---
Soil pH	6.4	---
Organic carbon (%)	0.85	---
Total nitrogen (%)	0.06	0.12
Available phosphorus (ppm)	25.82	10
Available potassium (me/100g soil)	0.11	0.12
Boron (ppm)	0.15	0.2

Source: Humboldt Soil Testing Laboratory, Department of Soil Science, Bangladesh Agricultural University, Mymensingh.

2.3 Climate

The climate of the experimental area (BAU, campus) is sub-tropical in nature, which is characterized by two distinct seasons, the monsoon or rainy season extending from May to October, and the winter or dry season from November to April. The site of the experiment is located at 24°75' N latitude and 90°50' E longitude at a height of 18 m above sea level. The seasonal condition comprises moderate temperature, scanty rainfall, and plenty of sunshine prevailing during the rabi season (October to March). Details of the meteorological data for temperature, rainfall, relative humidity, and total sunshine during the period of the experiment were collected from the weather yard, Department of Irrigation and Water Management, Bangladesh Agricultural University, Mymensingh, and have been presented in (Table 2).

Table 2: Monthly average temperature, relative humidity, total rainfall, and sunshine of the experimental site during the period.

Month	Air temperature (˚C)			Relative humidity (%)	Rainfall (mm)	Sunshine (hours)
	Maximum	Minimum	Average			
October	31.8	23.2	27.5	84.17	15.3	221.8
November	29.9	18.1	23.4	82.8	00.0	186.6
December	23.9	13.6	19.1	86.7	00.0	123.6
January	24.4	13.5	18.9	82.33	23.05	135.50
February	26.8	15.6	21.2	73.07	4.08	190.85
March	31.9	19.6	25.6	73.9	21.0	200.20

Source: Weather Yard, Department of Irrigation and Water Management, Bangladesh Agricultural University, Mymensingh

2.4 Experimental Design

The two-factor experiment consisting of 12 treatment combinations was laid out in a randomized complete block design with three replications. At first, the whole experimental area was marked with measuring tape and rope. The total experimental area (42.5 m × 8 m) was divided into three equal blocks, representing the replications. The total number of plots was 36. The size of each unit plot was 3 m x 2 m. The distance between two adjacent blocks and plots was kept at 50 cm and 50 cm, respectively. There were 12 plots in each block. The total area of the experimental plot was 340 m^2.

2.5 Experimental Treatments

The present research work was conducted with two sets of treatments consisting of 4 levels of NPK fertilizers (Factor A) and 3 levels of plant spacing (Factor B). Factor A: NPK fertilizers (4): F_0 = 0 kg N + 0 kg P + 0 kg K/ha (Control), F_1 = 100 kg N + 75 kg P + 75 kg K/ha (50% of recommended dose), F_2= 200 kg N + 150 kg P + 150 kg K/ha (100% of recommended dose), F_3= 300 kg N + 225 kg P + 225 kg K/ha (150% of recommended dose). Factor B: Plant spacing (3): S_1= 60 cm × 50 cm, S_2= 60 cm × 40 cm= S_3= 50 cm × 50 cm. Thus, there were 12 treatment combinations, which are given below: F_0S_1, F_0S_2, F_0S_3, F_1S_1, F_1S_2, F_1S_3, F_2S_1, F_2S_2, F_2S_3, F_3S_1, F_3S_2 and F_3S_3.

2.6 Methods of Broccoli Cultivation

Land preparation and fertilizers application: The experimental plot was fallow during land preparation. The land of the experimental area was opened with a tractor and it was opened to the sun for a few days before the next ploughing. Afterward, it was prepared by ploughing and cross ploughing with a power tiller followed by laddering to obtain good tilth suitable for growing broccoli. All uprooted weeds and stubbles were removed from the field. The big colds were broken into small soil particles and the surface was leveled until the desired tilth was obtained. The soil was treated with insecticides (Cinocarb 3G @ 4 kg/ha) at the time of final land preparation to protect young plants from the attack of soil-inhabiting, insects such as cutworm and mole cricket. The experimental field was leveled and the plots were laid out according to plan. After that, Well decomposed cow dung manure was applied at the rate of 10 tons per hectare and was incorporated into the soil during final land preparation. Urea, TSP, and MoP were used as the sources of nitrogen, phosphorus, and potassium respectively. Urea, TSP, and MoP were applied @ 200 kg N, 150 kg P, 150 kg K respectively as recommended doses. Urea and MoP were applied in three installments, the first installment being applied 15 days after transplanting. The second and third installments were top-dressed after 30 and 45 days of transplanting.

2.7 Planting Materials and Raising of Seedlings

The variety of broccoli used in this experiment was the Premium Crop, F_1 Hybrid, which was produced by Sakata & Co. Ltd. Kyoto, Japan. The seedlings of broccoli were raised at the Horticulture Farm, BAU, Mymensingh, under special care in two seedbeds of 3m x 1m size under the polythene tunnel. The soil of the seedbed was well ploughed with a spade and converted into loose friable and dried masses to obtain good tilth to provide a favorable condition for the growth of young seedlings. All the weeds, stubbles, and dead roots of the previous crop were removed. The seedbeds were dried in the sun to destroy the soil insects and protect the young seedlings from the infestation of damping off disease. Decomposed cow dung was applied to the prepared seedbeds at the rate of 10 t/ha. Ten grams (10 g) of seeds were sown in each seedbed. After sowing, the seeds were covered with finished light soil. At the end of germination, shading was given by a movable polythene tunnel to protect the young seedlings from scorching sunshine and heavy rainfall. The tunnel was constructed by steel frame which was 4.65 m wide and 12.65 m long. The two sides of the tunnels were erected straight from ground level which was protected by a wire net. The upper part of the tunnel was parabola-shaped and covered with polythene sheet. Light watering, weeding, and mulching were done when necessary to provide seedlings with good or ideal conditions for better growth.

2.8 Transplanting

Healthy and uniform-sized 20-day-old seedlings were transplanted in the experimental plots. The seedlings were uprooted carefully from the seedbed to avoid damage to the root system. To minimize the damage to the roots of the seedlings, the seedbeds were watered

for one hour before uprooting the seedlings. Transplanting was done in the afternoon. Each plot had 20, 25, and 24 plants at the spacing of 60 cm x 50 cm, 60 cm x 40 cm, and 50 cm x 50 cm respectively. The seedlings were watered immediately after transplanting. The young transplants were given shade by banana leaf sheath during the daytime to protect them from scorching sunshine for up to 5 days until they were set in the soil. They (transplants) were kept open at night to allow them to receive dew. Some seedlings were also planted on the border of the experimental plots for gap-filling.

2.9 Intercultural Operations

The transplanted seedlings in the experimental plot were kept under careful observation. Very few seedlings were damaged after transplanting and such seedlings were replaced by new seedlings taken from the same stock planted earlier on the border of the experimental plots. Those seedlings were re-transplanted with a big mass of soil with roots to minimize transplanting shock. Weeding, mulching, and earthing up were done as needed. Insect infestation was a serious problem during the period of establishment of seedlings in the field. Despite Cirocarb 3G applications during final land preparation, a few young plants were damaged due to an attack of mole cricket and cutworm. Cutworms were controlled both mechanically and by spraying Darsban 29EC @ 3%. Some of the plants were infected by Alternaria leaf spot disease caused by Allernaria brassicae. To prevent the spread of the disease Rovral @ 2 g per liter of water was sprayed in the field.

2.10 Harvesting

Harvesting of the broccoli was not possible on a particular date because curd initiation as well as curd maturation period in different plants were not uniform or similar probably due to different management practices and genetic or other factors. Only the compact matured curds were harvested with 2-4 cm stalk by using a sharp knife. To prevent the rotting of the stem the cut portions were slanted so that rainwater could not stay on the cutting portion of the stem. The curds were harvested in compact condition before the flower buds opened [1]. Before harvesting of the broccoli head, the compactness of the head was tested by pressing with thumbs. After harvesting the main curd, secondary shoots were developed from the leaf axils, which also developed into small secondary curds and were harvested over a period of time.

2.11 Methods of Data Collection

Eight plants were randomly selected from the middle rows of a unit plot to avoid border effect, except yields of curds, which were recorded plot-wise. Data were collected concerning the following parameters to assess plant growth; yield attributes and yields as affected by different treatment growth experiments. Data on the height of the plant, leaf number of plants, length of the largest leaf, and crown spread of the plant were collected at 30, 45, and 60 days after transplanting (DAT). All other parameters were recorded during the maximum vegetative stage, harvest, and after harvest.

2.12 Statistical Analysis

The data collected from the experimental plants per plot to various characteristics were compiled and tabulated in proper form for statistical analysis. The means for all the treatments were calculated and the analysis of variances for most of the characters under consideration was performed by the “F” variance test. The significance of difference between pairs of means was evaluated by the least significance difference (LSD) test at 1% and 5% level of probability [13].

3. RESULTS AND DISCUSSION

3.1 Plant Height

Plant height is an important growth contributing characters of broccoli plant. The plant height was significantly influenced by different spacing throughout the growth period. The plant height was increased gradually during the early stages of growth, rapidly between 30 to 45 DAT and later plant grew rather slowly. Plant height was recorded at 30, 45 and 60 days after transplanting (DAT). The highest height was observed with the spacing of 60 cm x 40 cm (S_2) and the lowest was with the spacing of 60 cm x 50 cm (S_1) (Fig. 1).

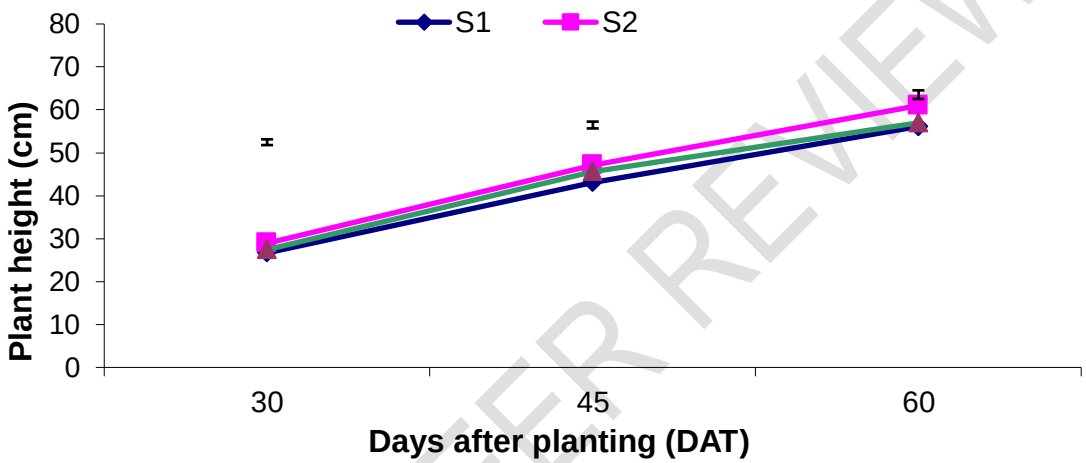

Fig. 1. Main effect of plant spacing on plant height of broccoli at different days after transplanting. Vertical bars indicate LSD at 5% level of significance
S_1 = 60 cm x 50 cm, S_2 = 60 cm x 40 cm, S_3 = 50 cm x 50 cm.

Plant height was also influenced by the application of different levels of NPK fertilizers. The plant height was increased gradually with the advancement of time and continued up to 60 DAT. The highest plant height was observed with the application of $N_{300}P_{225}K_{225}$ kg/ha (F_3) fertilizers while the lowest was observed with the application of $N_0P_0K_0$ kg/ha (F_0) fertilizers (Fig. 2).

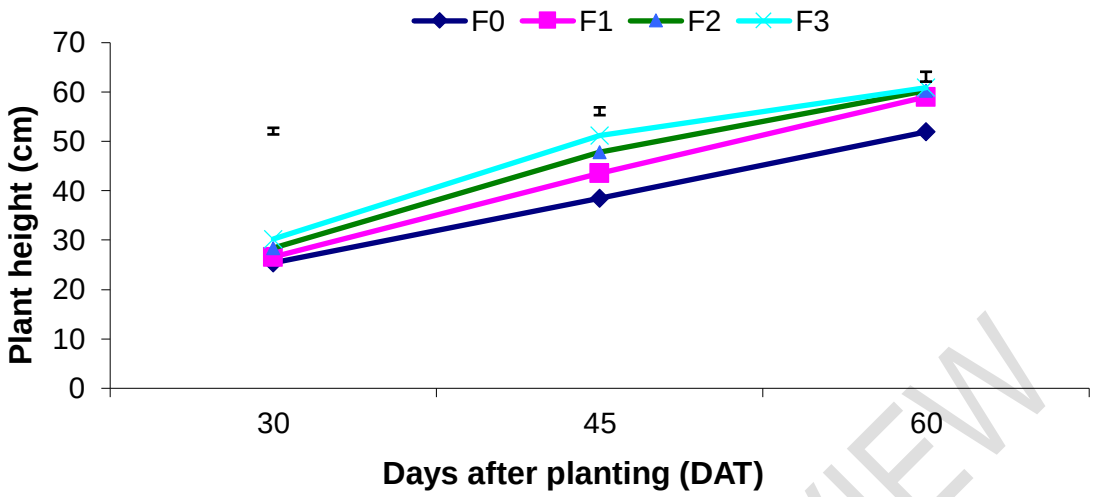

Fig. 2. Main effect of NPK fertilizers on plant height of broccoli at different days after transplanting. Vertical bars indicate LSD at 5% level of significance.
F_0 = $N_0P_0K_0$ kg/ha, F_1 = $N_{100}P_{75}K_{75}$ kg/ha, F_2 = $N_{200}P_{150}K_{150}$ kg/ha, F_3 = $N_{300}P_{225}K_{225}$ kg/ha

The results also show that, the combined effect of different plant spacing and levels of NPK fertilizers on plant height was found statistically significant at 30 DAT, 45 DAT and 60 DAT. The highest plant height (63.27 cm) was observed (Table 2) with the treatment combination of S_2F_3 (60cm x 40cm spacing with $N_{300}P_{225}K_{225}$ kg/ha fertilizers). The lowest was found (49.80 cm) with S_1F_0 (60cm x 50cm with $N_0P_0K_0$ kg/ha fertilizers) (Table 3).

Table 3. Combined effect of plant spacing and NPK fertilizers on plant height at different days after planting of broccoli

Spacing x fertilizer management	Plant height (cm)		
	30 DAT	45 DAT	60 DAT
S_1F_0	23.80	37.17	49.80
S_1F_1	25.57	41.37	56.47
S_1F_2	26.90	45.40	58.73
S_1F_3	30.43	48.43	59.53
S_2F_0	27.70	39.63	56.00
S_2F_1	28.03	45.33	62.00
S_2F_2	29.50	49.77	62.73
S_2F_3	30.43	53.73	63.27
S_3F_0	24.77	38.83	50.00
S_3F_1	26.23	44.10	58.63
S_3F_2	28.83	48.23	59.40
S_3F_3	29.87	51.50	59.87
$LSD_{0.05}$	0.66	0.78	0.99
$LSD_{0.01}$	0.89	1.05	1.33
Level of significance	**	**	**

*** = Significant at 1% level of probability, * = Significant at 5% level of probability, S_1 = 60 cm x 50 cm, S_2 = 60 cm x 40 cm, S_3 = 50 cm x 50 cm, F_0 = $N_0P_0K_0$ kg/ha, F_1 = $N_{100}P_{75}K_{75}$ kg/ha,F_2 = $N_{200}P_{150}K_{150}$ kg/ha ,F_3= $N_{300}P_{225}K_{225}$kg/ha.*

3.2 Crown Spread of Plant

There were significant effects on crown spread of broccoli in relation to different spacing. The widest crown spread was found with 60 cm x 40 cm spacing (S_2) and lowest was found in 60 cm x 50 cm (S_1) of spacing (Fig. 3).

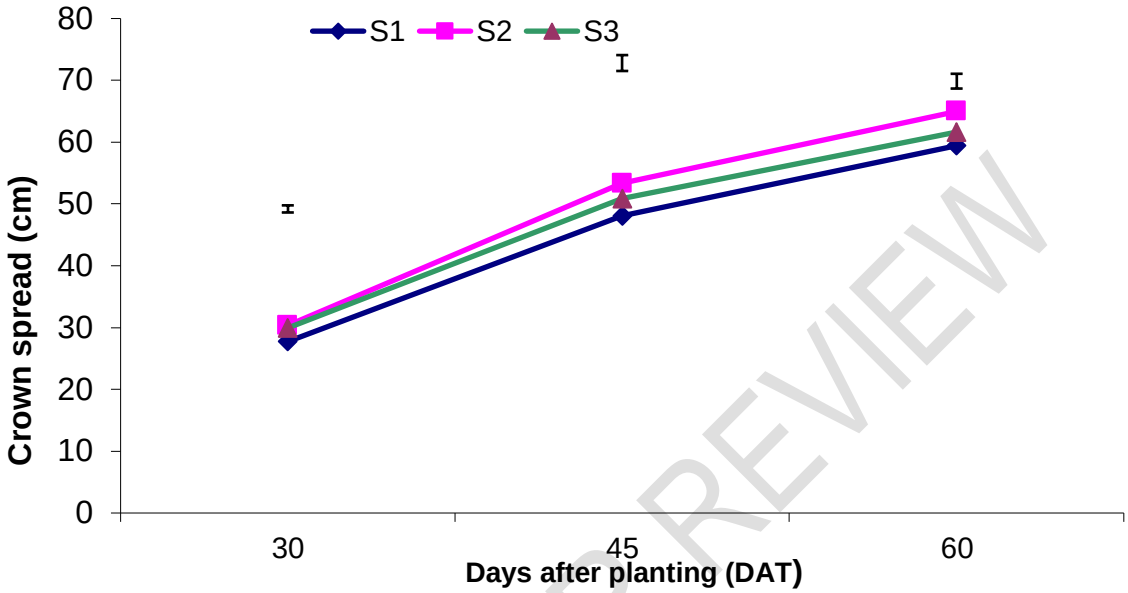

Fig. 3. Main effect of plant spacing on crown spread of broccoli at different days after transplanting. Vertical bars indicate LSD at 5% level of significance.

S_1 = 60 cm x 50 cm, S_2 = 60 cm x 40 cm, S_3 = 50 cm x 50 cm.

Application of different levels of NPK fertilizers were also found significant effect on crown spread of broccoli throughout the growing period. The widest and lowest crown spread were found with F_3 ($N_{300}P_{225}K_{225}$ kg/ha) and F_0 ($N_0P_0K_0$ kg/ha), respectively (Table 4). From the result, it was observed that the combination effect of plant spacing and NPK levels had significant influence on crown spread of broccoli. The widest crown spread was observed with the combination S_2F_3 (60 cm x 40 cm spacing with $N_{300}P_{225}K_{225}$ kg/ha) and lowest crown spread was observed with the combination of S_1F_0 (60 cm x 50 cm spacing with $N_0P_0K_0$ kg/ha) application (Table 5).

Table 4. The Main effect of NPK fertilizers on crown spread at different days after planting of broccoli

Fertilizer management	Crown spread (cm)		
	30 DAT	**45 DAT**	**60 DAT**
F_0	26.53	44.52	57.07
F_1	27.74	50.00	59.95
F_2	30.74	53.91	64.46
F_3	32.34	54.54	66.55
$LSD_{0.05}$	0.32	0.73	0.67
$LSD_{0.01}$	0.44	0.98	0.91
Level of significance	**	**	**

** = *Significant at 1% level of probability, $F_0 = N_0P_0K_0$ kg/ha, $F_1 = N_{100}P_{75}K_{75}$ kg/ha, $F_2 = N_{200}P_{150}K_{150}$ kg/ha, $F_3 = N_{300}P_{225}K_{225}$ kg/ha*

Table 5. Combined effect of plant spacing and fertilizer management on crown spread at different days after planting of broccoli

Spacing x fertilizer management	Crown spread (cm) at		
	30 DAT	45 DAT	60 DAT
S_1F_0	24.90	43.22	54.85
S_1F_1	27.33	47.65	57.87
S_1F_2	28.37	50.23	61.88
S_1F_3	30.30	51.08	63.10
S_2F_0	27.45	45.40	58.57
S_2F_1	28.05	53.98	61.50
S_2F_2	32.43	56.53	69.58
S_2F_3	33.48	57.40	70.20
S_3F_0	27.25	44.93	57.78
S_3F_1	27.83	48.37	60.48
S_3F_2	31.42	54.97	61.92
S_3F_3	33.25	55.13	66.35
$LSD_{0.05}$	0.56	1.26	1.18
$LSD_{0.01}$	0.76	1.70	1.58
Level of significance	**	**	**

*** = Significant at 1% level of probability, S_1 = 60 cm x 50 cm, S_2 = 60 cm x 40 cm, S_3 = 50 cm x 50 cm, F_0 = $N_0P_0K_0$ kg/ha, F_1 = $N_{100}P_{75}K_{75}$ kg/ha, F_2 = $N_{200}P_{150}K_{150}$ kg/ha, F_3 = $N_{300}P_{225}K_{225}$ kg/ha*

3.3 Number of Leaves

A good foliage indicates higher growth, development and productivity of plant. The present study shows significant relations of plant spacing effect on number of leaves per plant. The highest and lowest number of leaves were found with spacing 60 cm x 40 cm (S_2) and 60 cm x 50 cm (S_1), respectively (Fig. 4).

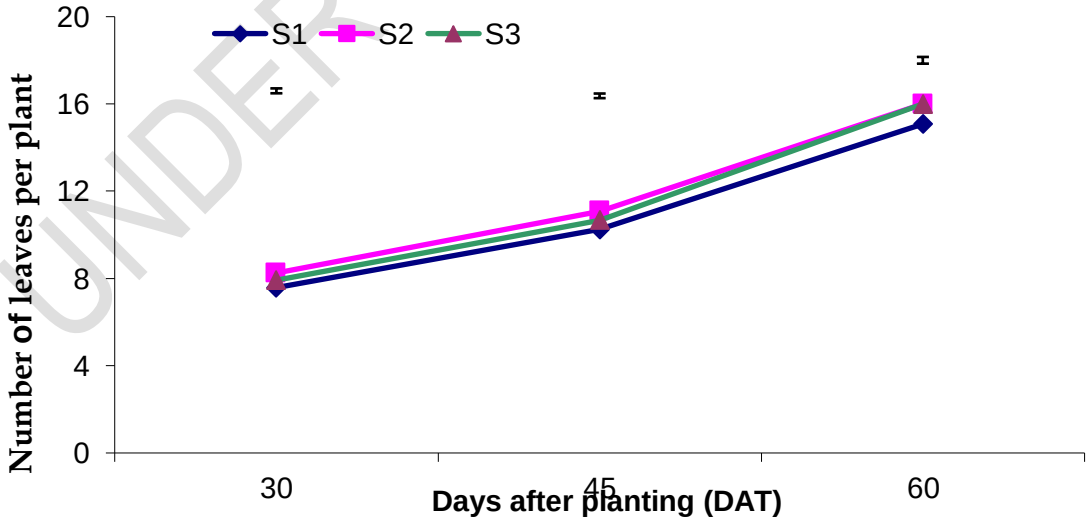

Fig. 4. Main effect of plant spacing on number of leaves of broccoli at different days after transplanting. Vertical bars indicate LSD at 5% level of significance.
S_1 = 60 cm x 50 cm, S_2 = 60 cm x 40 cm, S_3 = 50 cm x 50 cm.

There was also significant relation with the application of different levels of NPK fertilizers on number of leaves of broccoli. The highest and lowest number of leaves were found with the application of $N_{300}P_{225}K_{225}$ kg/ha(F_3) and $N_0P_0K_0$ kg/ha (F_0) fertilizers, respectively (Table 6). The results revealed highly significant relation with the combination effect of plant spacing and different levels of NPK fertilizers. The maximum number of leaves per plant was found with the combination of 60 cm x 40 cm spacing with $N_{300}P_{225}K_{225}$ kg/ha (S_2F_3) fertilizers and the lowest was found with the combination of 60 cm x 50 cm spacing with 0% $N_0P_0K_0$ kg/ha (S_1F_0) fertilizers (Table 7).

Table 6. Main effect of NPK fertilizers on number of leaves/plant at different days after planting of broccoli

Fertilizer management	Number of leaves/plants		
	30 DAT	**45 DAT**	**60 DAT**
F_0	7.33	10.00	13.67
F_1	7.89	10.44	15.89
F_2	8.00	10.67	16.33
F_3	8.44	11.56	16.89
$LSD_{0.05}$	0.14	0.13	0.20
$LSD_{0.01}$	0.20	0.18	0.27
Level of significance	**	**	**

*** = Significant at 1% level of probability, $F_0 = N_0P_0K_0$ kg/ha, $F_1 = N_{100}P_{75}K_{75}$ kg/ha, $F_2 = N_{200}P_{150}K_{150}$ kg/ha, $F_3=N_{300}P_{225}K_{225}$ kg/ha*

Table 7. Combined effect of plant spacing and NPK fertilizers on number of leaves per plant at different days after transplanting of broccoli.

Spacing x fertilizer management	Number of leaves/plants		
	30 DAT	**45 DAT**	**60 DAT**
S_1F_0	7.00	9.33	13.00
S_1F_1	7.33	10.33	15.00
S_1F_2	7.67	10.33	15.67
S_1F_3	8.33	11.00	16.67
S_2F_0	7.67	10.67	14.00
S_2F_1	8.33	10.67	16.33
S_2F_2	8.33	11.00	16.67
S_2F_3	8.67	12.00	17.00
S_3F_0	7.33	10.00	14.00
S_3F_1	8.00	10.33	16.33
S_3F_2	8.00	10.67	16.67
S_3F_3	8.33	11.67	17.00
$LSD_{0.05}$	0.25	0.24	0.35
$LSD_{0.01}$	0.34	0.32	0.47
Level of significance	*	**	**

*** = Significant at 1% level of probability, * = Significant at 5% level of probability, S_1 = 60 cm x 50 cm, S_2 = 60 cm x 40 cm, S_3 = 50 cm x 50 cm, $F_0 = N_0P_0K_0$ kg/ha, $F_1 = N_{100}P_{75}K_{75}$ kg/ha, $F_2 = N_{200}P_{150}K_{150}$ kg/ha, $F_3 = N_{300}P_{225}K_{225}$ kg/ha.*

3.4 Length of Largest Leaf

The length of largest leaf per plant was significantly influenced by plant spacing. The maximum length of largest leaf (46.57cm) was obtained from S_2 (60cm x 40cm) spacing and the minimum from S_1 (60 cm x 50 cm) spacing throughout the growing period (Fig. 5).

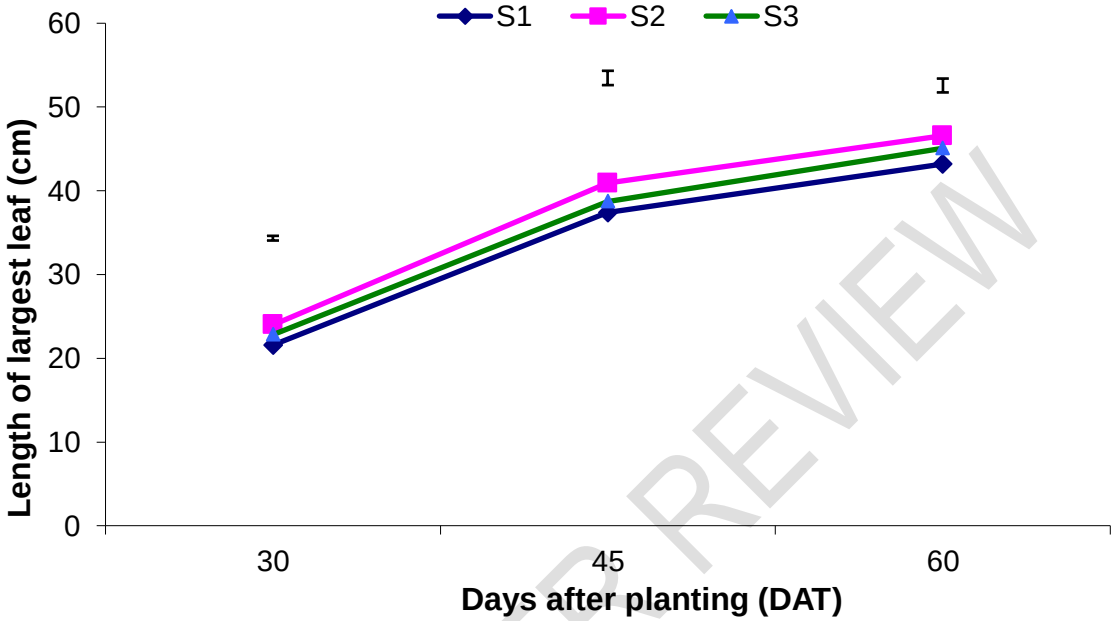

Fig. 5. Main effect of plant spacing on number of largest leaves of broccoli at different days after transplanting. Vertical bars indicate LSD at 5% level of significance.

S_1 = 60 cm x 50 cm, S_2 = 60 cm x 40 cm, S_3 = 50 cm x 50 cm.

The length of the largest leaf per plant was also significantly influenced by different levels of NPK fertilizers. From the results, the maximum length of largest leaf (48.38 cm) was with the application of $N_{300}P_{225}K_{225}$ kg/ha fertilizers (F_3) and the lowest from the application of $N_0P_0K_0$ kg/ha fertilizers (F_0) throughout the growing period (Table 8).

The combined effect of plant spacing and NPK fertilizers were also highly significant. The longest length of leaf was obtained from the treatment combination of S_2F_3 (60 cm x 40 cm plant spacing with 150% of NPK fertilizers). The shortest leaf was obtained from the treatment combination of S_1F_0 (60 cm x 50 cm plant spacing with 0% NPK fertilizers) (Table 9).

Table 8. Effect of fertilizer management on length of largest leaf at different days after transplanting of broccoli

Fertilizer management	Length of largest leaf (cm)		
	30 DAT	**45 DAT**	**60 DAT**
F_0	20.24	33.08	40.64
F_1	21.86	38.61	44.70
F_2	23.67	40.84	46.04
F_3	25.37	43.47	48.38
$LSD_{0.05}$	0.31	0.97	0.94
$LSD_{0.01}$	0.42	1.31	1.27
Level of significance	**	**	**

*** = Significant at 1% level of probability, $F_0 = N_0P_0K_0$ kg/ha, $F_1 = N_{100}P_{75}K_{75}$ kg/ha, $F_2 = N_{200}P_{150}K_{150}$ kg/ha, $F_3 = N_{300}P_{225}K_{225}$ kg/ha*

Table 9. Combined effect of plant spacing and NPK fertilizers on length of largest leaf at different days after transplanting of broccoli

Spacing x fertilizer management	Length of largest leaf (cm)		
	30 DAT	45 DAT	60 DAT
S_1F_0	19.07	32.57	38.00
S_1F_1	20.80	35.63	42.67
S_1F_2	21.60	39.10	45.90
S_1F_3	24.80	42.20	46.20
S_2F_0	20.90	33.97	43.57
S_2F_1	23.00	40.80	45.87
S_2F_2	25.70	43.37	46.27
S_2F_3	26.30	45.47	50.57
S_3F_0	20.77	32.70	40.37
S_3F_1	21.77	39.40	45.57
S_3F_2	23.70	40.07	45.97
S_3F_3	25.00	42.73	48.37
$LSD_{0.05}$	0.55	1.68	1.63
$LSD_{0.01}$	0.74	2.26	2.19
Level of significance	**	*	**

** = *Significant at 1% level of probability, * = Significant at 5% level of probability,* S_1 *= 60 cm x 50 cm,* S_2 *= 60 cm x 40 cm,* S_3 *= 50 cm x 50 cm,* $F_0 = N_0P_0K_0$ *kg/ha,* $F_1 = N_{100}P_{75}K_{75}$ *kg/ha,* $F_2 = N_{200}P_{150}K_{150}$ *kg/ha,* $F_3 = N_{300}P_{225}K_{225}$ *kg/ha.*

3.5 Days Required for Curd Initiation

Days required for initiation of curd was recorded. The record time was calculated from transplanting to initiation of curd. There were significant variations among different plant spacing. The highest days required for initiation of curd was found with S_1 (60 cm x 50 cm plant spacing) and the lowest days was found with S_2 (60 cm x 40 cm) (Table 10).

Curd initiation time also influenced by different levels of NPK fertilizers application. $N_0P_0K_0$ kg/ha fertilizers (F_0) required maximum time to curd initiation while minimum with $N_{200}P_{150}K_{150\ kg/ha}$ application (F_2) (Table 11).

There was also significant interaction effect between different treatment combination. The combination S_2F_3 (plant spacing with 60 cm x 40 cm with $N_{300}P_{225}K_{225}$ kg/ha fertilizers) was found to be minimum to initiation of curd, while maximum time for curd initiation was found with the combination of S_1F_0 (plant spacing of 60 cm x 50 cm with $N_0P_0K_0$ fertilizers) (Table 12).

3.6 Weight of Primary Curd

A significant variation was found due to plant spacing in respect of weight of primary curd per plant. The highest primary curd weight 0.33 kg was obtained from the spacing S_2 (60 cm × 40 cm) and the lowest weight (0.25 kg) was obtained from the spacing S_1 (60 cm × 50 cm) (Table 10)

Weight of primary curd also influenced by different levels of NPK fertilizers application. The highest weight of primary curd was obtained from $F_2(N_{200}P_{150}K_{150}$ kg/ha) and the lowest weight of primary curd was F_0 ($N_0P_0K_0$ kg/ha) (Table 11).

There was also significant interaction effect between different treatment Combination. The combination S_2F_2 (60 cm × 40 cm spacing with $N_{200}P_{150}K_{150}$ kg/ha fertilizers) was found maximum curd weight (.48 kg/plant) while the minimum curd weight with combination S_1F_0 (60 cm × 50 cm spacing with $N_0P_0K_0$ fertilizer) was .15kg/plant. (Table 12).

3.7 Diameter of Primary Curd

A significant variation was found due to plant spacing in respect of weight of primary curd per plant. The maximum diameter of curd of broccoli (13.19 cm) was observed from the treatment S_2 (60 cm × 40 cm) and minimum (11.01 cm) was observed from the treatment S_3 (50 cm × 50 cm) (Table 10).
The diameter of curd of broccoli was significantly influenced by the different levels of NPK fertilizers. The highest diameter was obtained from F_2 ($N_{200}P_{150}K_{150}$ kg/ha) and the lowest diameter was F_0 ($N_0P_0K_0$ kg/ha) (Table11)
There was also significant interaction effect between different treatment Combination. The combination S_2F_2 (60 cm × 40 cm spacing with $N_{200}P_{150}K_{150}$ kg/ha fertilizers) was found maximum curd diameter (15.12 cm) while the minimum curd diameter with combination S_3F_0(50 cm × 50 cm spacing with $N_0P_0K_0$ kg/ha fertilizer) was 10.00 cm (Table 12).

3.8 Diameter of Stem

A non-significant variation was found due to plant spacing in respect of diameter of stem per plant. The maximum diameter of stem was observed 3.66 cm from the treatment S_2 (60 cm × 40 cm) and minimum (cm) was observed 3.38 cm from the treatment S_1 (60 cm × 50 cm) (Table 10).
The diameter of stem of broccoli was significantly influenced by the different levels of NPK fertilizers. The highest diameter was obtained (3.88 cm) from F_2 ($N_{200}P_{150}K_{150}$ kg/ha) and the lowest diameter was 3.13 cm from F_0 ($N_0P_0K_0$ kg/ha) (Table11)
There was also significant interaction effect between different treatment Combination. The combination S_2F_2 (60 cm × 40 cm spacing with $N_{200}P_{150}K_{150}$ kg/ha fertilizers) was found maximum stem diameter (4.02 cm) while the minimum stem diameter with combination S_1F_0(60 cm × 50 cm spacing with $N_0P_0K_0$ kg/ha fertilizer) was (3.06 cm) (Table 12).

3.9 Length of Stem

The variation was found significant due to plant spacing in respect of length of stem per plant. The maximum length of stem was observed 25.19 cm from the treatment S_2 (60 cm × 40cm) and minimum (cm) was observed (23.17 cm) from the treatment S_1 (60 cm × 50 cm) (Table 10).
The length of stem of broccoli was significantly influenced by the different levels of NPK fertilizers. The highest length was obtained (25.80 cm) from F_2 ($N_{200}P_{150}K_{150}$ kg/ha) and the lowest diameter was (21.10 cm) from F_0 ($N_0P_0K_0$ kg/ha) (Table 11)
There was also significant interaction effect between different treatment Combination. The combination S_2F_2 (60 cm × 40 cm spacing with 100% $N_{200}P_{150}K_{150}$ kg/ha fertilizers) was found maximum stem length (26.73 cm) while the minimum stem length with combination S_1F_0 (60 cm × 50 cm spacing with $N_0P_0K_0$ kg/ha fertilizer) was (20.80 cm) (Table 12).

Table 10. Main effect of plant spacing on yield and yield contributing characters of broccoli

Plant spacing	Days required for curd initiation	Weight of primary curd (kg)	Diameter of curd (cm)	Diameter of stem (cm)	Length of stem (cm)
S_1	58.56	0.25	11.01	3.38	23.17
S_2	57.39	0.33	13.19	3.66	25.19
S_3	57.95	0.27	12.04	3.54	24.23
$LSD_{0.05}$	0.45	0.05	0.23	0.10	0.21
$LSD_{0.01}$	0.61	0.07	0.31	0.13	0.28
Level of significance	**	**	**	**	**

*** = Significant at 1% level of probability, S_1 = 60 cm x 50 cm, S_2 = 60 cm x 40 cm, S_3 = 50 cm x 50 cm.*

Table 11. Main effect of fertilizer management on yield and yield contributing characters of broccoli

Fertilizer management	Days required for curd initiation	Weight of primary curd (kg)	Diameter of curd (cm)	Diameter of stem (cm)	Length of stem (cm)
F_0	59.67	0.17	10.67	3.13	21.10
F_1	58.85	0.22	11.68	3.38	24.27
F_2	55.41	0.40	13.36	3.88	25.80
F_3	57.93	0.33	12.61	3.73	25.60
$LSD_{0.05}$	0.51	0.06	0.26	0.114	0.24
$LSD_{0.01}$	0.69	0.08	0.35	0.153	0.32
Level of significance	**	**	**	**	**

*** = Significant at 1% level of probability, $F_0 = N_0P_0K_{0\ kg}$/ha, $F_1 = N_{100}P_{75}K_{75}$ kg/ha, $F_2 = N_{200}P_{150}K_{150}$ kg/ha, $F_3 = N_{300}P_{225}K_{225}$ kg/ha.*

Table 12. Combined effect of plant spacing and fertilizer management on yield and yield contributing characters of broccoli

Spacing x fertilizer management	Days required for curd initiation	Weight of primary curd (kg)	Diameter of curd (cm)	Diameter of stem (cm)	Length of stem (cm)
S_1F_0	60.78	0.15	10.00	3.06	20.80
S_1F_1	59.00	0.20	10.77	3.17	23.11
S_1F_2	56.22	0.35	11.93	3.77	24.39
S_1F_3	58.22	0.30	11.33	3.53	24.38
S_2F_0	58.78	0.21	11.18	3.21	21.44
S_2F_1	58.67	0.25	12.53	3.49	26.18
S_2F_2	54.33	0.48	15.12	4.02	26.73
S_2F_3	57.78	0.38	13.93	3.92	26.39
S_3F_0	59.44	0.15	10.82	3.12	21.06
S_3F_1	58.89	0.22	11.76	3.48	23.53
S_3F_2	55.67	0.37	13.03	3.84	26.27
S_3F_3	57.78	0.32	12.56	3.73	26.04
$LSD_{0.05}$	0.88	0.11	0.45	0.19	0.41
$LSD_{0.01}$	1.19	0.15	0.61	0.26	0.56
Level of significance	*	*	**	**	**

*** = Significant at 1% level of probability, * = Significant at 5% level of probability, S_1 = 60 cm x 50 cm, S_2 = 60 cm x 40 cm, S_3 = 50 cm x 50 cm, F_0 = $N_0P_0K_0$ kg/ha, F_1 = $N_{100}P_{75}K_{75}$ kg/ha, F_2 = $N_{200}P_{150}K_{150}$ kg/ha, F_3 = $N_{300}P_{225}K_{225}$ kg/ha*

3.10 Number of Secondary Curds per Plant

A significant effect was observed among the plant spacing in respect of secondary curds per plant. However, numerically the highest number of secondary curds per plant (6.90) was obtained from the S_2 (60 cm ×40 cm) and the lowest number of secondary curds per plant (4.76) was obtained from the treatment S_1 (60 cm × 50 cm) (Table 13).

The effect of NPK fertilizers revealed that it had significant influence on the production of secondary curds. The highest number of secondary curds per plant (6.72) from F_2 ($N_{200}P_{150}K_{150}$ kg/ha) and the lowest was 4.79 from F_0 ($N_0P_0K_0$ kg/ha) (Table 14). There was also significant interaction effect between different treatment Combination. The combination S_2F_2 (60 cm × 40 cm spacing with $N_{200}P_{150}K_{150}$ kg/ha fertilizers) was found highest no of secondary curds (8.06) while the lowest no of secondary curds with combination S_1F_0 (60 cm × 50 cm spacing with $N_0P_0K_0$ kg/ha fertilizer) was (4.25) (Table 15).

3.11 Weight of Secondary Curd per Plant

A significant effect was observed among the plant spacing in respect of weight secondary curds per plant. However, numerically the highest weight of secondary curds per plant (67.64) was obtained from the S_2 (60 cm × 40 cm) and the lowest weight of secondary curds per plant (39.23) was obtained from the treatment S_1 (60 cm × 50 cm) (Table 13).

The effect of NPK fertilizers revealed that it had significant influence on the weight of secondary curds. The highest weight of secondary curds per plant (60.18) from F_2 ($N_{200}P_{150}K_{150}$ kg/ha) and the lowest was 42.72 from F_0 ($N_0P_0K_0$ kg/ha) (Table 14)

There was also significant interaction effect between different treatment combination. The combination S_2F_2 (60 cm × 40 cm spacing with $N_{200}P_{150}K_{150}$ kg/ha fertilizers) was found highest weight of secondary curds (78.99) while the lowest weight of secondary curds with combination S_1F_0 (60 cm × 50 cm spacing with 0% $N_0P_0K_0$ kg/ha fertilizer) was (35.06) (Table 15).

4.12 Fresh Weight of Leaves per Plant

A significant effect was observed among the plant spacing in respect of fresh weight of leaves per plant. However, numerically the highest fresh weight of leaves per plant (369.06 g) was obtained from the S_2 (60 cm ×40 cm) and the lowest fresh weight of leaves per plant (292.38) was obtained from the treatment S_1 (60 cm × 50 cm) (Table 13).
The effect of NPK fertilizers revealed that it had significant influence on the fresh weight of leaves. The highest fresh weight of leaves per plant (379.18) from F_2 ($N_{200}P_{150}K_{150}$ kg/ha) and the lowest was 277.82from F_0 ($N_0P_0K_0$ kg/ha) (Table 14)
There was also significant interaction effect between different treatment combination. The combination S_2F_2 (60 cm × 40 cm spacing with $N_{200}P_{150}K_{150}$ kg/ha fertilizers) was found highest fresh weight of leaves (401.49 g) while the lowest weight of secondary curds with combination S_1F_0 (60 cm × 50 cm spacing with $N_0P_0K_{0\ kg}$/ha fertilizer) was (35.06) (Table 15).

4.13 Yield per Plant

The curd yield per plant showed highly significant variation by the plant spacing. The maximum yield per plant (331.42 g) was produced by spacing S_2 (60 cm × 40 cm) and the lowest yield per plant (292.38 g) was produced by spacing S_1 (60 cm × 50 cm) (Table 13).
The effect of different levels of NPK fertilizers on the yields of broccoli per plant was found significant. The maximum yield per plant (344.78 g) was recorded from the F_2 ($N_{200}P_{150}K_{150}$ kg/ha) and the minimum yield (243.06 g) was recorded from the F_0 (N_0P_{0K0} kg/ha) (Table 14).
There was also significant interaction effect between different treatment combination. The combination S_2F_2 (60 cm × 40 cm spacing with $N_{200}P_{150}K_{150}$ kg/ha fertilizers) was found highest yield per plant (365.00 g) while the lowest yield per plant with combination S_1F_0 (60 cm × 50 cm spacing with $N_0P_0K_0$ kg/ha fertilizer) was (229.17 g) (Table 15).

3.14 Yield per Plot

The curd yield per plot showed highly significant variation by the plant spacing. The maximum yield per plot (8.29 kg) was produced by spacing S_2 (60 cm × 40 cm) and the lowest yield per plot (5.85 kg) was produced by spacing S_1 (60 cm × 50 cm) (Table 13). The effect of different levels of NPK fertilizers on the yields of broccoli per plot was found significant. The maximum yield per plot (7.95 kg) was recorded from the F_2 ($N_{200}P_{150}K_{150}$ kg/ha) and the minimum yield (5.62 kg) was recorded from the F_0 ($N_0P_0K_0$ kg/ha) (Table 14).
There was also significant interaction effect between different treatment combination. The combination S_2F_2 (60 cm × 40 cm spacing with $N_{200}P_{150}K_{150}$ kg/ha fertilizers) was found highest yield per plot (9.13 kg) while the lowest yield per plot with combination S_1F_0 (60 cm × 50 cm spacing with $N_0P_0K_0$ kg/ha fertilizer) was (4.58 kg) (Table 15).

3.15 Yield per Hectare

The curd yield per hectare showed highly significant variation by the plant spacing. The maximum yield per hectare (13.81 ton) was produced by spacing S_2 (60 cm × 40 cm) and the lowest yield per plot (9.75 ton) was produced by spacing S_1 (60 cm × 50 cm) (Table 13).
The effect of different levels of NPK fertilizers on the yields of broccoli per hectare was found significant. The maximum yield per hectare (13.25 ton) was recorded from the F_2 ($N_{200}P_{150}K_{150}$ kg/ha) and the minimum yield (9.36 ton) was recorded from the F_0 ($N_0P_0K_0$ kg/ha) (Table 14).

There was also significant interaction effect between different treatment combination. The combination S_2F_2 (60 cm × 40 cm spacing with $N_{200}P_{150}K_{150}$ kg/ha fertilizers) was found highest yield per hectare (15.21 ton) while the lowest yield per hectare with combination S_1F_0 (60 cm × 50 cm spacing with $N_0P_0K_0$ fertilizer) was 7.64 ton (Table 15)

Table 13. Main effect of plant spacing on yield and yield contributing characters of broccoli

Plant spacing	No. of secondary curd per plant	Weight of secondary curd per plant (g)	Fresh wt. of leaves per plant (g)	Yield per plant (g)	Yield per plot (kg)	Yield (t/ha)
S_1	4.76	39.23	315.53	292.38	5.85	9.75
S_2	6.90	67.64	369.06	331.42	8.29	13.81
S_3	5.63	47.89	343.53	306.25	7.35	12.25
$LSD_{0.05}$	0.16	1.19	7.07	5.61	0.13	0.23
$LSD_{0.01}$	0.22	1.62	9.61	7.62	0.18	0.31
Level of significance	**	**	**	**	**	**

*** = Significant at 1% level of probability, S_1 = 60 cm x 50 cm, S_2 = 60 cm x 40 cm, S_3 = 50 cm x 50 cm*

Table 14. Main effect of fertilizer management on yield and yield contributing characters of broccoli

Fertilizer management	No. of secondary curd per plant	Weight of secondary curd per plant (g)	Fresh wt. of leaves per plant (g)	Yield per plant (g)	Yield per plot (kg)	Yield (t/ha)
F_0	4.79	42.72	277.82	243.06	5.62	9.36
F_1	5.43	48.56	349.90	317.78	7.36	12.26
F_2	6.72	60.18	379.18	344.78	7.95	13.25
F_3	6.11	54.87	363.91	334.44	7.72	12.87
$LSD_{0.05}$	0.18	1.36	8.04	6.38	0.15	0.26
$LSD_{0.01}$	0.24	1.83	10.83	8.59	0.21	0.35
Level of significance	**	**	**	**	**	**

*** = Significant at 1% level of probability, $F_0 = N_0P_0K_0$ kg/ha, $F_1 = N_{100}P_{75}K_{75}$ kg/ha, $F_2 = N_{200}P_{150}K_{150}$ kg/ha, $F_3 = N_{300}P_{225}K_{225}$ kg/ha.*

Table 15. Combined effect of plant spacing and fertilizer management on yield and yield contributing characters of broccoli

Spacing x fertilizer management	No. of secondary curd per plant	Weight of secondary curd per plant (g)	Fresh wt. of leaves per plant (g)	Yield per plant (g)	Yield per plot (kg)	Yield (t/ha)
S_1F_0	4.25	35.06	268.37	229.17	4.58	7.64
S_1F_1	4.60	37.95	309.16	289.33	5.79	9.64
S_1F_2	5.23	43.18	355.90	334.33	6.69	11.14
S_1F_3	4.94	40.73	328.68	316.67	6.33	10.56
S_2F_0	5.42	53.12	289.46	263.00	6.58	10.96
S_2F_1	6.44	63.11	390.01	345.00	8.63	14.38
S_2F_2	8.06	78.99	401.49	365.00	9.13	15.21
S_2F_3	7.69	75.33	395.27	352.67	8.82	14.69
S_3F_0	4.70	39.98	275.63	237.00	5.69	9.48
S_3F_1	5.25	44.63	350.54	319.00	7.66	12.76
S_3F_2	6.87	58.37	380.16	335.00	8.04	13.40
S_3F_3	5.71	48.56	367.78	334.00	8.02	13.36
$LSD_{0.05}$	0.32	2.35	13.93	11.05	0.27	0.45
$LSD_{0.01}$	0.43	3.17	18.76	14.88	0.36	0.61
Level of significance	**	**	**	**	**	**

*** = Significant at 1% level of probability, S_1 = 60 cm x 50 cm, S_2 = 60 cm x 40 cm, S_3 = 50 cm x 50 cm, $F_0 = N_0P_0K_0$ kg/ha, $F_1 = N_{100}P_{75}K_{75}$ kg/ha, $F_2 = N_{200}P_{150}K_{150}$ kg/ha, $F_3 = N_{300}P_{225}K_{225}$ kg/ha*

4. DISCUSSION

The investigation shows a highly significant effect on plant height, crown spread, number of leaves, and length of the largest leaf. That indicates that plant spacing has a beneficial effect on the growth of broccoli. The variation in this as influenced by spacing was probably due to the proper utilization of nutrients, space, moisture, and light. Similar results were reported by Islam et al., [14]. NPK fertilizer doses have also a beneficial effect on this. This might be due to the fertilizers supplying adequate plant nutrients for better vegetative growth of broccoli plants which ultimately increased plant height. Haque et al., [15] and Anonymous [16] found the highest plant growth by applying the highest dose of nitrogen. The widest spacing required maximum days and the closest spacing required minimum days while NPK is not used required maximum days and optimum doses required minimum days. This might be due to optimum plant spacing and fertilization. The highest primary curd weight was obtained from S2 (60 cm × 40 cm) spacing probably due to loose terminal head and longer flower stalks of broccoli curds. Dufault [17] also found a similar in the case of curd broccoli. The maximum curd weight was recorded when the required doses were used. The present results were supported by the report of Mitra et al., [10]. For the plant spacing the stem diameter was non-significant but doses of NPK have significant variation. The diameter of the curd was significantly influenced by the plant spacing and different levels of NPK fertilizers. The highest diameter of primary curd was obtained from the widest spacing and proper NPK fertilizer. The present results were in full agreement with Gorski and Armstrong [18]. Optimum spacing and NPK fertilizer application increase the stem diameter and ultimately increase the production of broccoli. The length of the stem was influenced by the plant spacing and different levels of NPK fertilizer. The highest length of the stem was observed when the recommended doses were used and for the plant spacing, S2 (60cm × 40 cm) was used. This might be due to the fertilizers supplying adequate plant nutrients for better vegetative growth of broccoli. A significant effect was observed among the plant

spacing for secondary curds per plant. The highest no of secondary curd was recorded from spacing S2 (60 cm × 40 cm) and from optimum doses of NPK fertilizers. This might be due to proper utilization of nutrients, space, moisture, and light. The weight of secondary curd was also significant among the plant spacing and different levels of NPK fertilizer application. This may be a favorable effect of plant spacing and proper NPK fertilizer application. The fresh weight of leaves was highest at the spacing of S2 (60 cm × 40 cm) and from the recommended doses F2 (N200P150K150 kg/ha) of NPK fertilizers. This is because nitrogen plays an important role in the vegetative growth of plants. The highest yield per plant was produced by the plant grown at the spacing (60 cm x 40 cm). The highest yield per plant was recorded from the treatment F2 (N200P150K150 kg/ha). The present result corresponds with that of Pornsuriya et al., [19]. The highest yield of broccoli curd per plot and per hectare was recorded from the closest spacing. The higher yield with closer spacing was also reported by Csizinszky and Stanley [20], Dufault [21], and Mitra et al., [10]. The yields of broccoli per plot and per hectare were significantly influenced by different levels of NPK fertilizer. The highest production was obtained due to the recommended doses of fertilizers.

5. CONCLUSION

Broccoli is a newly introduced winter cole crop in Bangladesh. It is a horticultural hybrid closely related to cauliflower. It is a biennial and herbaceous vegetable crop belonging to the family Brassicaceae. In the production of broccoli plant spacing and fertilizer plays an important role. From this plant spacing and fertilizer have a significant role in yield contributing attributes. The present study was therefore carried out to investigate the appropriate plant spacing and NPK fertilizer application. From the experiment, it is revealed that plant spacing of (60cm x 40 cm) with recommended doses of NPK has positive influences on different yield-controlling attributes of growth and yield of broccoli. The results indicated that the application of 200 kg urea+ 150 kg TSP + 150 kg MoP/ha is beneficial in broccoli cultivation. However, to reach a specific conclusion and recommendation, further research work on the growth and yield of broccoli needs to be done in different Agroecological zones of Bangladesh.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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