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Effect of Potassium on Growth, Yield and Shelf Life of Broccoli (*Brassica oleracia* Var. *Botrytis*) Cultivars

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Abstract: Two experiments (Field experiment and laboratory experiment) were conducted at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2005 to February 2006 to study the effect of potassium on growth and yield of broccoli. Four levels of potassium (K) fertilizers viz. K_0 = 0 kg K/ha, K_1 = 50 kg K/ha, K_2 = 75 kg K/ha and K_3 = 100 kg K/ha were used in the experiment. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The highest plant height (55.82cm), stem diameter (5.61 cm), number of leaves (13.64), leaf length (46.03cm) at 60 DAT, shoot length (40.14cm), root length (30.94cm), fresh shoot weight (794.4g), fresh root weight (84.42g), main curd weight (260.0g), curd diameter (17.52cm), number of secondary curd (4.0), weight of secondary curd (166.0g) and curd yield (14.19 t/ha) were recorded from K_3. The laboratory experiment was laid out in two factors Completely Randomized Design (CRD) with four levels of potassium fertilizers viz. K_0 = 0 kg K/ha, K_1 = 50 kg K/ha, K_2 = 75 kg K/ha and K_3 = 100 kg K/ and three storage conditions. The storage conditions were as follows: i. Stored in open condition at room temperature (24°C), ii. Stored in perforated polythene bags at room temperature (24°C) and iii. Stored in perforated polythene bags at 4° C in refrigerator. The maximum shelf life of broccoli in open at room temperature (2.55), polyethylene bag at room temperature (5.63) and polyethylene bag at refrigerator (16.64) were found in K_0.

Key words: Potassium · Growth yield · Shelf life · Broccoli

INTRODUCTION

Broccoli (*Brassica oleracia var. botrytis*) is a member of Brassicaceae family and it's considered as a cole crop. It is one of the most important cole crops in Europe and USA and it is a commercial crop in India [1, 2] but it is a minor vegetable in Bangladesh and its production statistics is not available. Broccoli contains a high amount of vitamin A, ascorbic acid and appreciable amounts of thiamin, riboflavin, niacin, calcium and iron [3, 4]. Broccoli has high nutritive value especially vitamin A and vitamin C. Therefore, it can be met up some degree of vitamin A and vitamin C requirement and can contribute to solve malnutrition problem in Bangladesh. The per capita production of vegetable in Bangladesh is very low as compared to that of other countries. Due to low production of vegetables, the present per capita consumption is only about 30g but it is 70g with potato and sweet potato. It is an alarming situation for vegetable consumption in Bangladesh. So, a large-scale production of broccoli can help to increase vegetable consumption. Broccoli is environmentally better adapted than cauliflower and is reported to withstand comparatively at higher temperature than cauliflower [5]. Broccoli can be grown on a wide range of soil types, ranging from light sand to heavy loam or, even clay that are well supplied with organic matter [6]. Successful production of broccoli depends on various factors. Fertilizer management is one of the most important factors, which assured crop production. Broccoli responds greatly to major essential elements like nitrogen, phosphorus and potassium in respect of its growth and yield [7-9].

Potassium also has an important role in balancing physiological activities. Different levels of potassium influence the growth and yield of broccoli. Ying *et al.* [10] observed that potassium was the most important element for yield and dry weight of broccoli. In our country farmers use fertilizers without following recommended dose and there were also a lack of fertilizer recommendation for newly introduced broccoli. Most of the vegetables have very short shelf life. In our country about 70% vegetables are grown in rabi season (winter).

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If we can increase shelf life of vegetables, the availability of vegetable in the off-season can be increased. Broccoli is an important vegetable having short shelf life, which hasten the post-harvest losses and make the crop unpopular even than it has a greater potential to improve the nutritional situation of our country. The post-harvest loss of broccoli due to the short shelf life results economic loss of the growers as well as the traders, which in turn affects over national economy. In order to have a good return and avoid market glut it becomes essential to store for a considerable period. The major aim of the investigation was to evaluate growth, yield and shelf life performance of Broccoli cultivars under different levels of Potassium.

MATERIALS AND METHODS

The field experiment was conducted at Horticulture Farm in Sher-e-Bangla Agricultural University, Dhaka-1207 during October 15, 2005 to February 15, 2006. The area had sub tropical climate characterized by high temperature (28°-32°C) accompanied by moderately high rainfall during Kharif (April-September) season and low temperature (15°-20°C) in the Rabi (October-March) season under AEZ-28. Soil pH 5.6 and have organic carbon 0.82 %. The hybrid variety 'Green Sprouting Broccoli' was selected for investigation. Seeds of 'Green Sprouting Broccoli' were collected from seed trader. The experiment was laid-out in Randomize Complete Block Design (RCBD) with three replications. Four levels of potassium fertilizers viz. K_0 = 0 kg K/ha, K_1 = 50 kg K/ha, K_2 = 75 kg K/ha and K_3 = 100 kg K/ha were used in the experiment. The seeds were sown on 28 October 2005 in the seedbed and completed germination within seven days. Healthy and 21 days old seedlings were transplanted into the experimental field on 27 November 2005. Each plot size was 4.5m ×1.2m and spacing of 60 cm x 50 cm was considered for the study. Irrigation and weeding was done at ten days interval. Randomly selected ten plants were harvested from each plot for data collection. Data were collected on plant height (cm), stem diameter (cm), number of leaves per plant, leaf length (cm), shoot length, root length, days required for curd initiation, curd diameter (cm), curd weight (g), number of secondary curds, secondary curd weight (g), yield per plant (g), yield ha^{-1} (t). The laboratory experiment was laid out in two factors Complete Randomized Design (CRD) with four levels of potassium and three storage conditions. The storage conditions were as follows: i. Stored in open condition at room temperature (24°C), ii. Stored in perforated polythene bags at room temperature (24°C) and iii. Stored in perforated polythene bags at 4°C in refrigerator. The three mature broccoli curds were selected for each treatment. The changes of florets color (just started to yellowish) were recorded by eye estimation. The means were separated by DMRT at 5% level of significance [11].

RESULTS AND DISCUSSION

Plant Height: Application of potassium showed significant influence on the height of broccoli plants at 20, 40 and 60 DAT (Figure 1). At 20 DAT, plant height ranged from 18.00 cm to 27.60 cm. K_3 produced the highest plant height (27.60cm), which was statistically similar to that of K_2 (22.36 cm) and the lowest plant height (18.00 cm) was found in K_1, which was statistically similar to that of K_0 (18.32cm). At 40 DAT, plant height ranged from 23.51 cm to 39.13 cm. The highest plant height (39.13 m) was recorded from K_3, which was statistically similar to that of K_2, while the lowest (23.51cm) was recorded from K_0. At 60 DAT, plant height ranged from 33.98 cm to 55.82 cm. The highest plant height (55.82 cm) was recorded from K_3, which was statistically similar to that of K_2 (51.51cm) and the lowest (33.98cm) was recorded from K_0. Similar to phosphorus the plant height was increased with the increased in K application and it was also observed that the plant height increased with the increased in DAT i.e., 20, 40 and 60 DAT. This might be caused that K influenced the uptake of nitrogen and phosphorus, which helped in vegetative growth (IPI, 2005). The trend of the result of the present investigation was similar with Wyatt *et al.* [12], Singh [13] and Reddy *et al.* [14].

Stem Diameter: Marked variation was found in different levels of K application in respect of stem diameter of broccoli plants at 20, 40 and 60 DAT (Figure 2). At 20 DAT, stem diameter ranged from 0.99 cm to 1.73 cm. K_3 produced the highest stem diameter (1.73cm) and the lowest (0.99cm) was found in K_0. At 40 DAT, stem diameter ranged from 2.37 cm to 3.16 cm. The highest stem diameter (3.16 cm) was recorded from K_3, while the lowest figure (2.37 cm) was recorded from K_0. At 60 DAT, stem diameter ranged from 5.16 cm to 5.61cm. The maximum stem diameter (5.61 cm) was found in K_3 and the minimum (5.16 cm) was found in K_0. The stem diameter was statistically insignificant due to the application of different levels of potassium. It was revealed that the stem diameter increased up to 40 DAT at the increased in K application. This might be due to K increased in other

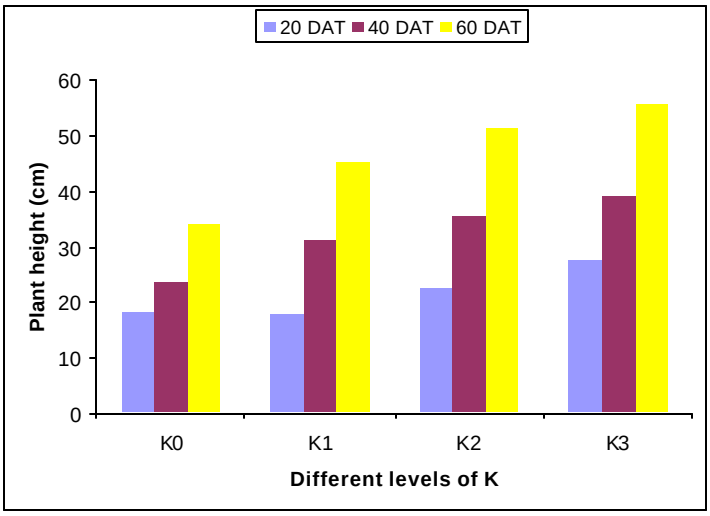

Fig. 1: Effect of different levels of K on plant height at different days after sowing K_0= 0 kg K/ ha, K_1= 50kg K / ha, K_2=75kg K /ha and K_3= 100kg K/ha

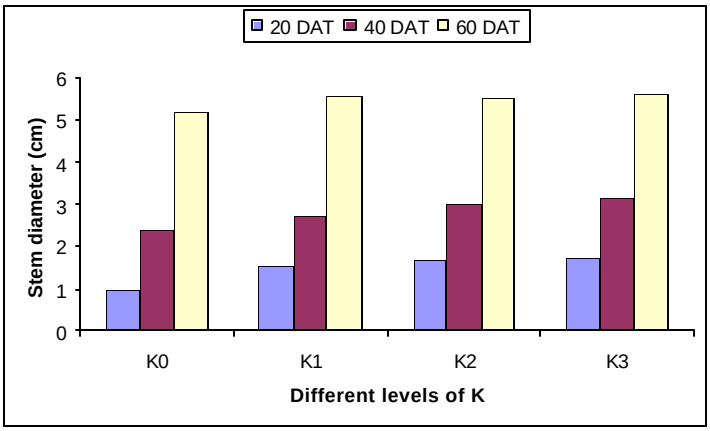

Fig. 2: Effect of different levels of K on stem diameter at different days after sowing K_0= 0 kg K/ ha, K_1= 50kg K / ha, K_2=75kg K /ha and K_3= 100kg K/ha

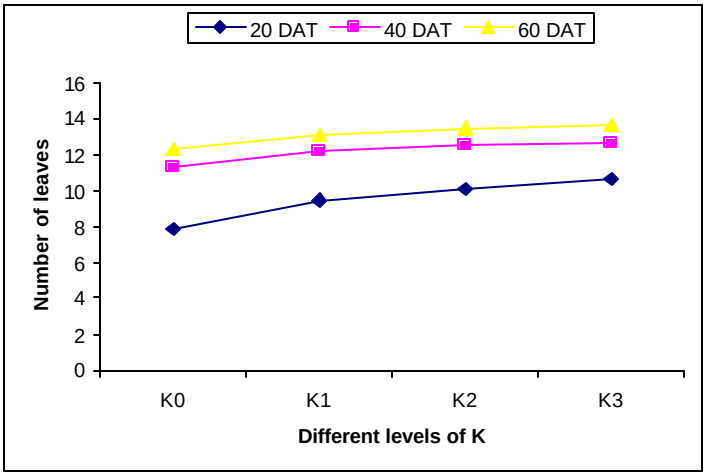

Fig. 3: Effect of different levels of K on number of leaves at different days after sowing K_0= 0 kg K/ ha, K_1= 50kg K / ha, K_2=75kg K /ha and K_3= 100kg K/ha

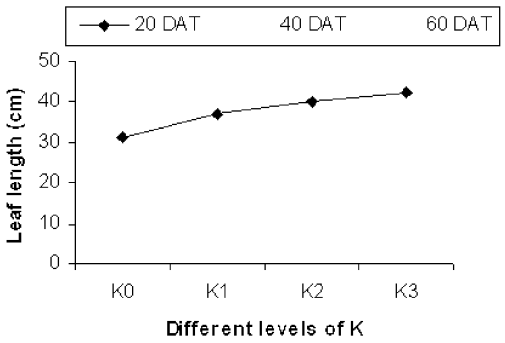

Fig. 4: Effect of different levels of K on leaf length at different days after sowing

nutrients uptake efficiency in the plant, thus increasing the efficiency of applied urea and TSP, which ultimately stimulated stem growth (IPI, 2005). Similar trend of the result was found by other scientists like Wyatt *et al.* [12], Ruan *et al.* [15] and Singh *et al.* [16].

K_0= 0 kg K/ ha, K_1= 50kg K / ha, K_2=75kg K /ha and K_3= 100kg K/ha

K_0= 0 kg K/ ha, K_1= 50kg K / ha, K_2=75kg K /ha and K_3= 100kg K/ha

Number of Leaves per Plant: Application of potassium exhibited a significant influence on the number of leaves of broccoli plants at 20, 40 and 60 DAT (Figure 3). At 20 DAT, number of leaves per plant ranged from 7.80 to 10.62. The maximum number of leaves (10.62) was found in K_3 that was statistically similar to that of K_1 and K_2 while the minimum (7.8) was found in K_0. Similar to phosphorus there was no significant difference was found in number of leaves per plant due to K application at 40 DAT, the maximum number of leaves (12.63) was found in K_3 while the minimum (11.28) was found in K_0. At 60 DAT, the maximum number of leaves (13.63) was found in K_3 while the minimum (12.30) was found in K_0.The number of leaves per plant increased with the increased in K application and with the advanced of DAT as well. This might be caused that K enhanced the photosynthesis process in plant.

Leaf Length: There had a significant influence of potassium on broccoli plants in respect of leaf length at 20, 40 and 60 DAT (Figure 4). At 20 DAT, leaf length ranged from 31.26 cm to 42.45 cm. K_3 produced the longest leaf (42.45 cm), which was statistically similar to that of K_1 and K_2 whereas K_0 produced the smallest leaf (31.26 cm). Similar trend of result was found at 40 DAT and 60 DAT. At 40 DAT, K_3 produced the longest leaf (44.91 cm) whereas K_0 produced the smallest leaf (34.64 cm). At 60 DAT, the largest leaf (46.03 cm) was found in K_3 and the smallest leaf (35.47 cm) was found in K_0.

K_0= 0 kg K/ ha, K_1= 50kg K / ha, K_2=75kg K /ha and K_3= 100kg K/ha

Shoot Length: Application of potassium showed a significant influence on shoot length of broccoli plants (Table 1). Shoot length ranged from 28.96 cm to 40.14 cm. The maximum shoot length (40.14 cm) was recorded from K_3, which was statistically similar to that of K_1 and K_2 while the minimum shoot length (28.96 cm) was observed in K_0. Shoot length increased with higher levels of potassium application. This might be caused that potassium regulated plant metabolism ensuring a healthy and sturdy which enhance the shoot length of broccoli plants. Similar trend were found by other scientists like Singh *et al.* [16] and Wyatt *et al.* [12].

Root Length: Application of potassium exhibited a significant influence on root length of broccoli plants (Table 1). The maximum root length (30.94 cm) was recorded from K_3, which was statistically similar to that of K_1 and K_2 while the minimum root length (24.48 cm) was observed in control K_0. It was revealed that root length increased with the increased in potassium application. This might be caused that potassium improved the development of roots and the utilization of nitrogen. Singh *et al.* [16] also reported a similar trend of root length affected by the application of potassium fertilizer.

Fresh Weight of Shoot: Application of potassium exhibited a significant influence on fresh shoot weight of broccoli plants (Table 1). Fresh weight of shoot ranged from 582.90 g to 794.40 g. The maximum fresh weight of shoot (794.40 g) was recorded from K_3, which was statistically similar to that of K_1 and K_2 while the minimum fresh shoot weight (582.90 g) was observed in K_0. It was revealed that fresh shoot weight increased with the increased in potassium application. This might be caused that potassium regulated plant metabolism ensuring a healthy and sturdy, which enhance the fresh shoot weight of broccoli. Similar trend of the result was found by other scientists like Wyatt *et al.* [12] and Singh *et al.* [16].

Fresh Weight of Root: Application of potassium exhibited a significant influence on fresh root weight of broccoli plants (Table 1). Fresh weight of root ranged from 58.58 g to 84.42 g. The maximum fresh weight of root (84.42 g) was recorded from K_3, which was statistically similar to

Table 1: Effect of different levels of potassium on vegetative growth of broccoli

Treatments	Shoot length(cm)	Root length(cm)	Fresh shoot weight(g)	Fresh root weight(g)	Total fresh weight(g)
K0	28.96 b	24.48 b	582.9 b	58.58 c	642.3 c
K1	34.28 ab	27.54 ab	682.4ab	68.92 bc	751.3 bc
K2	37.80 a	29.70 a	756.3 a	78.08 ab	834.4 ab
K3	40.14 a	30.94 a	794.4 a	84.42 a	887.6 a
CV (%)	14.55	9.28	14.23	10.23	10.13

Table 2: Effect of different levels of potassium on curd diameter, curd weight, number of secondary curd and weight of secondary curd of broccoli

Treatments	Days to curd initiation	Curd diameter(cm)	Main curd weight(g)	Number of secondary curd weight(g)	Weight ofSecondary curd(g)	Yield/ plant(g)
K0	53.17 a	13.12 b	184.0 c	2.58 b	67.50 d	251.5 d
K1	53.42 a	15.27 ab	219.2 bc	3.50 ab	110.3 c	329.4 c
K2	57.92 a	16.72 a	250.8 ab	3.50 ab	127.0 b	377.8 b
K3	58.42 a	17.52 a	260.0 a	4.00 a	166.0 a	425.8 a
CV (%)	9.11	11.84	11.68	20.21	8.97	8.10

that of K_2 and while the minimum fresh weight of root (58.58g) was observed in K_0. It was revealed that the fresh weight of root increased with the increased in potassium application. This might be caused that potassium improved the development of roots and the utilization of nitrogen. Singh *et al.* [16] found the same trend of the present investigation.

Total Fresh Weight: Application of potassium exhibited a significant influence on total weight of broccoli plants (Table 1). Total fresh weight ranged from 642.30 g to 887.60 g. The maximum fresh weight (887.60 g) was recorded from K_3, which was followed by other treatments. The minimum fresh weight (642.30 g) was observed in K_0.

Means in the column followed by different letter(s) differed significantly by DMRT at 5% level of significance K_0= 0 kg K/ ha, K_1= 50kg K / ha, K_2=75kg K /ha and K_3= 100kg K/ha

Days to Require for Curd Initiation: The application of potassium was not significantly influenced the number of days required for curd imitation (Table 2). It was ranged from 53.17 to 58.42 days. The lowest (53.17days) days were required for curd initiation by K_0 and the highest (58.42) days were required by K_3.

Main Curd Diameter: Application of potassium should a significant influence on curd diameter of broccoli plants (Table 2). Main curd diameter ranged from 13.12cm to 17.52 cm. The maximum curd diameter (17.52 cm) was recorded from K_3, which was statistically similar to that of K_1 and K_2 while the minimum (13.12 cm) was observed in K_0. This result was revealed that the curd diameter increased with the increased in potassium application. Watt *et al.* [12] was found the same trend of the present investigation.

Main Curd Weight: Potassium had a significant influence on main curd weight of broccoli plants (Table 2). Main curd weight ranged from 184.00 g to 260.00 g. The maximum main curd weight (260.00 g) was recorded from K_3, which was statistically similar to that of K_2 and while the minimum main curd weight (184.00g) was observed in K_0. It was revealed that the main curd weight increased with the increased in potassium application. This might be caused that potassium promoted growth and increased yield. It regulated plant metabolism ensuring a healthy and sturdy that was stimulated ultimately main curd weight of broccoli plant. Corroborative results were obtained by other scientists like Wyatt *et al.* [12], Singh *et al.* [16], Pardeep *et al.* [17] and Brahma *et al.* [18].

Number of Secondary Curd per Plant: Potassium exhibited a significant influence on number of secondary curds of broccoli plants (Table 2). Number of secondary curd per plant ranged from 2.58 to 4.00. The maximum numbers of secondary curds (4.0) were recorded from K_3, which was statistically similar to that of K_1 and K_2 while the minimum number of secondary curds (2.58) was observed in K_0. It was revealed that the number of secondary curd increased with the increased in potassium application. This might be caused that potassium regulates the photosynthesis and also translocation of metabolites, which ultimately increased the number of secondary curd. Corroborative results were obtained by other scientists like Wyatt *et al.* [12], Cai *et al.* [19] and Singh *et al.* [16].

Table 3: Effect of different levels of potassium and storage condition on shelf life (days) of broccoli

	Storage condition on shelf life (days) of broccoli.		
Treatments	Open at room temperature (24°C)	Polyethylene bag at room temperature (24°C)	Polyethylene bag at refrigerator (4°C)
K_0	2.55 a	5.63 a	16.64 a
K_1	2.17 b	4.87 b	15.23 ab
K_2	1.91 c	4.50 bc	14.37 ab
K_3	1.77 c	4.07 c	13.65 b
CV (%)	7.38	7.38	7.38

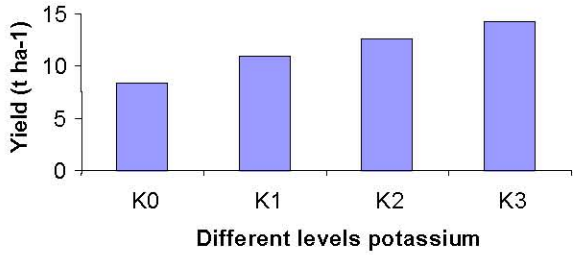

Fig. 5: Effect of different levels of potassium on yield of broccoli

Secondary Curd Weight: Application of potassium exhibited a significant influence on secondary curd weight of broccoli plants (Table 2). Secondary curd weight ranged from 67.50 g to 166.00 g. The maximum secondary curd weight (166.00 g) was recorded from K_3 while the minimum (67.50 g) was observed in K_0. It was revealed that the weight of secondary curd increased with the increased in potassium application. This might be caused that potassium regulates the photosynthesis and also translocation of metabolites, which ultimately increased the weight of secondary curd. Corroborative results were obtained by other scientists like Wyatt *et al.* [12], Cai *et al.* [19] and Singh *et al.* [16].

Yield per Plant: Application of potassium exhibited a significant influence on total yield per plant (Table 2). Yield per plant ranged from 251.50 g to 425.80 g. The maximum yield (425.80 g) was recorded from K_3 while the minimum (251.50 g) was observed in K_0. It was revealed that the yield per plant increased with the increased in potassium application. This might be caused that potassium regulates the photosynthesis and also translocation of metabolites, which ultimately increased the yield per plant. Corroborative results were obtained by other scientists like Wyatt *et al.* [12], Ruan *et al.* [15], Cai *et al.* [19] and Singh *et al.* [16].

Means in the column followed by different letter(s) differed significantly by DMRT at 5% level of significance K_0= 0 kg K/ ha, K_1= 50kg K / ha, K_2=75kg K /ha and K_3= 100kg K/ha

Yield per Hectare: Application of potassium exhibited a significant influence on total yield per hectare of broccoli plants (Figure 5). Yield per hectare ranged from 8.37t to 14.19t. The maximum yield (14.19 t) was recorded from K_3, which was statistically identical with K_2 while the minimum yield (8.37 t) was observed in K_0. It was revealed that the yield per hectare increased with the increased in potassium application. This might be caused that potassium regulates the photosynthesis and also translocation of metabolites, which ultimately increased the yield per hectare. Corroborative results were obtained by other scientists like Wyatt *et al.* [12], Ruan *et al.* [15], Cai *et al.* [19] and Singh *et al.* [16].

K_0= 0 kg K/ ha, K_1= 50kg K / ha, K_2=75kg K /ha and K_3= 100kg K/ha

Shelf Life of Broccoli: Potassium exhibited a significant influence on shelf life of broccoli at different storage conditions viz., open at room temperature, polyethylene bag at room temperature and polyethylene bag at refrigerator (Table 2). Shelf life of broccoli in open at room temperature condition ranged from 1.77 to 2.55 days. The maximum shelf life (2.55 days) of broccoli was found in K_0 and minimum (1.77 days) was found in K_3. Shelf life of broccoli in polyethylene bag at room temperature condition ranged from 4.07 to 5.63 days. The maximum shelf life (5.63 days) of broccoli was found in K_0 and minimum (4.07 days) was found in K_3. Shelf life of broccoli in polyethylene bag at refrigerator condition ranged from 13.65 to 16.64 days. The maximum shelf life (16.64 days) of broccoli was found in K_0 which was statistically similar to that of K_1 and minimum (13.65 days) was found in K_3. It was revealed that the shelf life of broccoli increased with the decreased in K application in all the three storage condition. Among the three storage condition it was found that the shelf life of broccoli increased in the polyethylene bag at refrigerator condition. This could be due the effect of low temperature in refrigerator. Low temperature minimizes the respiration of broccoli as well as polyethylene bag also minimize the respiration process.

The positive effect of polymeric film was also reported by Barth *et al.* [20].

Means in the column followed by different letter(s) differed significantly by DMRT at 5% level of significance K_0= 0 kg K/ ha, K_1 = 50 kg K / ha, K_2 =75 kg K /ha and K_3= 100 kg K/ha

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