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# SHELF LIFE AND ECONOMIC ANALYSIS OF BROCCOLI (*Brassica oleracea* var. *italica* L.) AS INFLUENCED BY NITROGEN, PHOSPHORUS, POTASSIUM AND MOLYBDENUM

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## Abstract

The study on the shelf life and economic analysis of broccoli under different fertilizer treatments combinations were carried out both in the field and laboratory of Horticulture Department, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, during 10 October 2007 to 28 February 2008. There were 13 treatments viz. control (no application of fertilizer) ($T_1$), $N_{45}P_{30}K_{50}M_{O0.3}(T_2)$, $N_{90}P_{30}K_{50}M_{O0.3}(T_3)$, $N_{135}P_{30}K_{50}M_{O0.3}(T_4)$, $N_{90}P_0K_{50}M_{O0.3}(T_5)$, $N_{90}P_{60}K_{50}M_{O0.3}(T_6)$, $N_{90}P_{90}K_{50}M_{O0.3}(T_7)$, $N_{90}P_{30}K_0M_{O0.3}(T_8)$, $N_{90}P_{30}K_{25}M_{O0.3}(T_9)$, $N_{90}P_{30}K_{75}M_{O0.3}(T_{10})$, $N_{90}P_{30}K_{50}M_{O0.0}(T_{11})$, $N_{90}P_{30}K_{50}M_{O0.1}(T_{12})$, and $N_{90}P_{30}K_{50}M_{O0.5}(T_{13})$. Cowdung was applied @10 t ha$^{-1}$ as basal dose in each case. The maximum shelf life (15.05 days) was observed with no application of inorganic fertilizer and kept at 4$^0$C in polythene bag wrapping the broccoli curd. The maximum gross return per hectare (Tk. 3, 66, 740 ha$^{-1}$) and net benefit (Tk. 2, 56, 182 ha$^{-1}$) were found in $T_4$ ($N_{135}P_{30}K_{50}M_{O0.3}$) followed by $T_7$ ($N_{90}P_{90}K_{50}M_{O0.3}$) (Tk. 3,36,380 and 2, 17, 457, respectively) and the minimum values (Tk. 1, 22, 100 and 21,546, respectively) being noted in $T_1$ (control). The highest cost benefit ratio (3.32) was found in $T_4$ ($N_{135}P_{30}K_{50}M_{O\ 0.3}$). Considering the yield of broccoli and the benefit cost ratio, nutrient application of N, P, K, and Mo @ 135, 30, 50, and 0.3 kg ha$^{-1}$, respectively are the optimum doses for growing broccoli in shallow Red-Brown Terrace Soil of Salna series, Gazipur.

***Key words:*** Shelf life, broccoli, benefit cost ratio, inorganic fertilizers, net benefit

## Introduction

Broccoli (*Brassica oleraceae* var. *italica*) represents the utmost and exquisite vegetable belonging to Cruciferous family with a short erect stem, which produces a large green curd of succulent flowers. It has evolved from the colewort, a stout, weedy perennial of the seacoasts of Great Britain and south-western Europe in the middle of Jacobean period. Afterwards, it holds supremacy over any other cole crops on nutritional aspects (Nieuwhof, 1969). Extensive investigations have shown that the highly nutritive value of broccoli rests largely upon a good content of minerals and a moderate store of vitamins to the human diet plus substantial amount of fiber (Lisiwska and Kmieck, 1996). Per pound of edible portion of broccoli contains protein 9.10 g, fat 0.60 g, carbohydrate 15.20 g, calcium 360.00 mg, phosphorus 211.00 mg, iron 3.60 mg, vitamin-A 970.00 I.U., ascorbic acid 327.00 mg, rivoflavin 0.59 mg and thiamine 0.26 mg (Thompson and Kelly, 1985). Devouring broccoli enriched in antioxidants can reduce the risk of some forms of cancer and heart disease.

The adaptation of broccoli is better compared to cabbage of Cruciferous family; also it can survive at higher temperature. In case of cauliflower there is often possibility of total crop failure if weather conditions are unfavorable during the growing season, but broccoli is much reliable so far the environmental hazards are concerned (Rashid, 1976). Broccoli can be grown on a variety of soils. It makes less demand upon the soil and climate than cauliflower. Immediately after planting, they are able to develop rapidly; therefore, the less fertile soils should be adequately dressed. Broccoli demands a soil with a good moisture supply, ranging from light sand to heavy loam that are well supplied with organic matter (Katayal, 1977). In view of the above facts, broccoli is likely to find favour with the people if it can be properly promoted as its wider adaptability, higher nutritive value, good taste and less risk to crop failure in biotic and abiotic stress conditions which indicates enough scope for its promotional efforts.

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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, potassium and molybdenum in respect of its growth, yield and quality. On the other hand, manure like cowdung, when applied, help on maintaining good soil structure besides being a continuous source of nutrient. Since vegetables are living biological systems, they deteriorate after harvest. Flower vegetables (such as broccoli, cauliflower, etc.) are deteriorated very quickly in postharvest stage condition, ultimately postharvest life is very short (Yahia and Audit-Oubahou, 2001). Researchers on many countries of the world have paid due attention towards developing variety with good shelf life of broccoli (Anonymous, 1992). There is an ample scope to prevent the postharvest losses of broccoli under Bangladeshi climatic condition and it has a great export potential.

Its cultivation has not been spread much beyond the farms of different agricultural organizations. This is mainly due to lack of awareness about its nutritive value and also the method of production. Before an effort is made to spread its cultivation to the farmers' level it is necessary to collect information about its growth, yield, fertilizer requirements, and quality and postharvest preservation.

Considering the above circumstances the present study was undertaken with the following objectives

1. To know the effect of nitrogen, phosphorus, potassium and molybdenum on shelf life of broccoli.
2. To do economic analyses from the utilization of optimum dose of nitrogen, phosphorus, potassium and molybdenum in broccoli production.

## Materials and Methods

The experiment was conducted at the Horticultural Research Farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during the period from **10** October, 2007 to 28 February, 2008. The experimental site is located at the centre of Madhupur Tract $24.09^0$ N latitude and $90.26^0$ E longitudes and at 8.5 meter above the sea level (Anonymous, 1989). Broccoli (*Brassica oleracea* var. *italica*) cv. Premium was used as a plant material. There were 13 treatments viz. control (no application of fertilizer) ($T_1$), $N_{45}P_{30}K_{50}M_{O0.3}$($T_2$), $N_{90}P_{30}K_{50}M_{O0.3}$($T_3$), $N_{135}P_{30}K_{50}M_{O0.3}$($T_4$), $N_{90}P_0K_{50}M_{O0.3}$($T_5$), $N_{90}P_{60}K_{50}M_{O0.3}$($T_6$), $N_{90}P_{90}K_{50}M_{O0.3}$($T_7$), $N_{90}P_{30}K_0M_{O0.3}$($T_8$), $N_{90}P_{30}K_{25}M_{O0.3}$($T_9$), $N_{90}P_{30}K_{75}M_{O0.3}$($T_{10}$), $N_{90}P_{30}K_{50}M_{O0.0}$($T_{11}$), $N_{90}P_{30}K_{50}M_{O0.1}$($T_{12}$), and $N_{90}P_{30}K_{50}M_{O0.5}$($T_{13}$).

**Treatment combinations of different fertilizers**

| Treatment | Nutrient added (kg ha$^{-1}$) | | | |
|---|---|---|---|---|
| | N | P | K | Mo |
| $T_1$ | 0 | 0 | 0 | 0 |
| $T_2$ | 45 | 30 | 50 | 0.3 |
| $T_3$ | 90 | 30 | 50 | 0.3 |
| $T_4$ | 135 | 30 | 50 | 0.3 |
| $T_5$ | 90 | 0 | 50 | 0.3 |
| $T_6$ | 90 | 60 | 50 | 0.3 |
| $T_7$ | 90 | 90 | 50 | 0.3 |
| $T_8$ | 90 | 30 | 0 | 0.3 |
| $T_9$ | 90 | 30 | 25 | 0.3 |
| $T_{10}$ | 90 | 30 | 75 | 0.3 |
| $T_{11}$ | 90 | 30 | 50 | 0 |
| $T_{12}$ | 90 | 30 | 50 | 0.1 |
| $T_{13}$ | 90 | 30 | 50 | 0.5 |

Cowdung applied 10 t ha$^{-1}$ as per recommended doses. The source of N, P, K and Mo were urea, triple super phosphate (TSP), muriate of potash (MoP) and ammonium molybdate, respectively. Total quantity of cowdung, TSP and ammonium molybdate were applied as broadcast and incorporated during final land preparation in individual plot as per treatment. Urea and MoP were applied in three installments 50% at the time of land preparation and the rest 50% weres applied at two installments (15 and 30 days after transplanting). The treatments were randomly allocated in each block. In each plot 18 plants were accommodated. Block to block and plot to plot distances were 0.75 m. The size of each unit plot was 3 m × 1.8 m = 5.4 $m^2$. The plants were spaced with 60 × $50^2$ cm spacing (Rashid, 1983 and Anon. 1991). During the experimental period normal cultivation procedures such as manure and fertilizer application, mulching, weeding, irrigation and others application were followed. The crop was harvested during 10 January to 30 January, 2008. The Broccoli curd was harvested before the buds opened (Thompson and Kelly, 1985). Shelf life of broccoli was studied after harvesting under following storage conditions.

1. Stored in open at room temperature ($24^0$C)
2. Stored in sealed polythene bags at $4^0$C in refrigerator.

Three mature broccoli curds were assigned for each treatment. Visual and sensory quality was observed in daily basis. The change of florets color (just started to yellowing) was recorded by eye estimation.

The shelf life experiment was laid out in two factors completely randomized design (CRD) with thirteen fertilizer combinations and two storage conditions. The collected data were analyzed statistically with the help of "MSTAT-C" program. The mean values for all the treatments were calculated and analysis of variance for each of the characters was performed and mean differences among the treatment were done by Duncan's Multiple Range Test.

Economic evaluation of different fertilizer combinations was done through partial budgeting and dominant analysis (Appendix 1) followed by marginal analysis of the cost undominated treatments as suggested by Perrins *et al.* (1979). Gross return and variable cost were calculated considering the following rates: Broccoli 22 Tk. $kg^{-1}$, Urea 6.5 Tk. $kg^{-1}$, TSP 30 Tk. $kg^{-1}$, MP 30 Tk. $kg^{-1}$, ammonium molybdate 2000 Tk. $kg^{-1}$ and Cowdung 1100 Tk. $ton^{-1}$.

Benefit cost ratio (BCR) was calculated using the following formula:

$$BCR = \frac{\text{Gross Return}}{\text{Total variable cost}}$$

**Water content (%)**

The fresh samples were weighed and sun dried for 72 hours then oven dried for 48 hours at 80 $^0$C temperature to make them totally water free. Water content (%) was determined by using the following formula:

$$\%\ \text{Water} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

## Results and Discussion

**Shelf life of Broccoli**

Almost all fruits and vegetables are known to exhibit a rise in respiration after harvest. High rates of respiration deteriorate the storage quality of vegetables. Postharvest changes i.e. yellowing of curds take place rapidly in broccoli and make it unsuitable for consumption if appropriate storage conditions are not maintained.

The results revealed that shelf life of broccoli curds produced with different fertilizer treatment varied from 3.02 to 4.82 days at $24^0$C with open storage condition (Table 1). The broccoli produced without fertilizer showed longest shelf life (4.82 days) at $24^0$C and open condition followed by $T_2$ and $T_{12}$ (4.42 days) while it was lowest/shortest (3.02 days) in $T_4$ treatment. Broccoli produced with different fertilizer treatment also showed variable shelf life (9.21 to 15.05 days) at $4^0$C with polybaging conditions (Table 1). The longest shelf life (15.05 days) was documented under no fertilizer application ($T_1$) and it was kept in polybag condition at $4^0$C followed by $T_5$ (13.53 days), $T_2$ (13.49 days) and $T_8$ (12.77 days) while broccoli produced with $T_4$ showed the lowest shelf life (9.21 days). It was also observed that broccoli produced without fertilizer showed longest shelf life in both the storage conditions might be due to the presence of low water and high dry matter content.

**Table 1. Storage life (days) of broccoli as influenced by different fertilizer treatment combinations and storage condition**

| Treatments (kg ha$^{-1}$) | Shelf life (Days) | |
|---|---|---|
| | Polythene bag in refrigerator at 4$^0$C | Open at room temperature (24$^0$C) |
| $T_1$ ($N_0P_0K_0$ $Mo_{0\ 0}$) | 15.05 a | 4.82 g |
| $T_2$ ($N_{45}P_{30}K_{50}Mo_{0.3}$) | 13.49 b | 4.42 gh |
| $T_3$ ($N_{90}P_{30}K_{50}Mo_{0.3}$) | 11.30 d | 3.48 hi |
| $T_4$ ($N_{135}P_{30}K_{50}Mo_{0.3}$) | 9.21 f | 3.02 i |
| $T_5$ ($N_{90}P_0K_{50}$ $Mo_{0.3}$) | 13.53 b | 4.11 gh |
| $T_6$ ($N_{90}P_{60}K_{50}$ $Mo_{0.3}$) | 10.05 ef | 4.16 gh |
| $T_7$ ($N_{90}P_{90}K_{50}$ $Mo_{0.3}$) | 9.21 f | 3.02 i |
| $T_8$ ($N_{90}P_{30}K_0$ $Mo_{0.3}$) | 12.77 bc | 3.86 ghi |
| $T_9$ ($N_{90}P_{30}K_{25}$ $Mo_{0.3}$) | 10.35 e | 3.39 hi |
| $T_{10}$ ($N_{90}P_{30}K_{75}$ $Mo_{0.3}$) | 11.38 d | 3.83 ghi |
| $T_{11}$ ($N_{90}P_{30}K_{50}$ $Mo_0$) | 12.18 cd | 3.99 ghi |
| $T_{12}$ ($N_{90}P_{30}K_{50}$ $Mo_{0.1}$) | 11.83 cd | 4.42 gh |
| $T_{13}$ ($N_{90}P_{30}K_{50}$ $Mo_{0.5}$) | 11.85 cd | 3.88 ghi |
| CV% | 6.99 | |

*In a column, means followed by common letters are not significantly different from each other at 1% level of probability by DMRT*

**Relationship between water content (%) and shelf life (days)**

A negative linear relationship was found between water content and shelf life of broccoli when the data were regressed (Fig. 1). It can be concluded that from the Fig. 1 that shelf life decreased with the increase of water content (%). The negative relationship between water content and shelf life of broccoli indicated that more water content in broccoli enhances respiration and biochemical activities and fungal attack resulting rapid deterioration in quality.

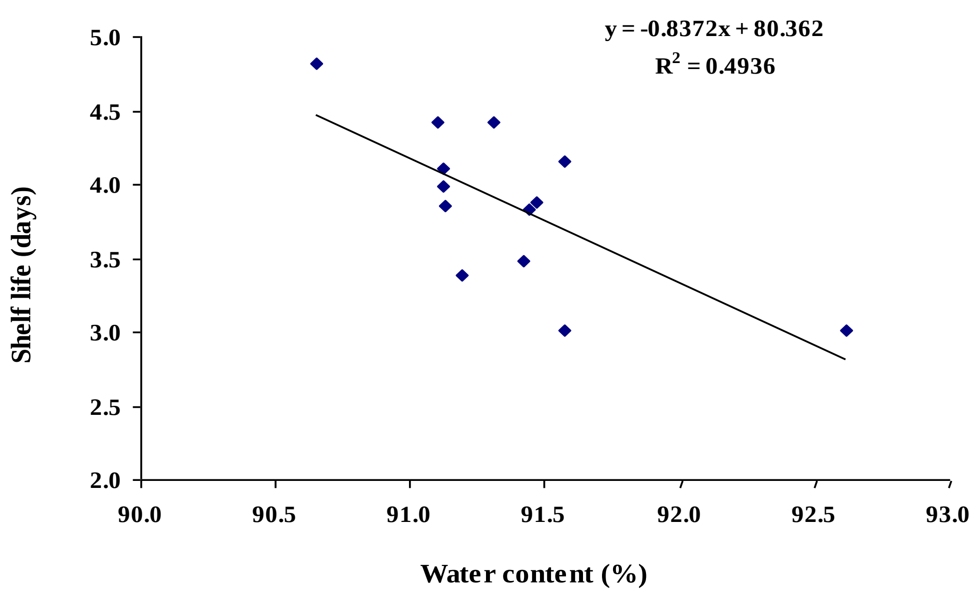


**Fig. 1. Relationship between the water content (%) and shelf life (days) of broccoli**

**Economic analysis**

The production cost of broccoli varied due to different fertilizer combinations (Table 2). Production cost was the highest (Tk.1,18,923 ha$^{-1}$) in $T_7$ followed by $T_6$ (Tk.1,14,423 ha$^{-1}$) treatment and it was the lowest (Tk.1,00,554 ha$^{-1}$) in control. The highest gross return (Tk.3,66,740 ha$^{-1}$) and net benefit (Tk.2,56,182 ha$^{-1}$) were found in $T_4$ followed by $T_7$ (Tk. 3,36,380 ha$^{-1}$ and TK.2,17,457 ha$^{-1}$ for gross and net benefit, respectively) while these were lowest (Tk.1,22,100 ha$^{-1}$ and TK. 21,546 ha$^{-1}$ for gross and net benefit, respectively) in $T_1$ (control). The highest benefit cost ratio (3.32) was found in $T_4$ followed by $T_7$ (2.83) while it was lowest (1.21) in $T_1$ treatment.

**Table 2. Partial budget analysis of broccoli under different fertilizer treatment**

| Treatment (kg ha$^{-1}$) | Total yield (t ha$^{-1}$) | Total variable cost (Tk.) | Gross return (Tk. ha$^{-1}$) | Net return (Tk. ha$^{-1}$) | BCR |
|---|---|---|---|---|---|
| $T_1$ ($N_0P_0K_0Mo_0$) | 5.55 | 100554 | 122100 | 21546 | 1.21 |
| $T_2$($N_{45}P_{30}K_{50}Mo_{0.3}$) | 7 | 109240 | 154000 | 44760.1 | 1.41 |
| $T_3$ ($N_{90}P_{30}K_{50}Mo_{0.3}$) | 11.77 | 109923 | 258940 | 149017 | 2.36 |
| $T_4$ ($N_{135}P_{30}K_{50}Mo_{0.3}$) | 16.67 | 110558 | 366740 | 256182 | 3.32 |
| $T_5$ ($N_{90}P_0K_{50}Mo_{0.3}$) | 7.86 | 105423 | 172920 | 67496.6 | 1.64 |
| $T_6$ ($N_{90}P_{60}K_{50}Mo_{0.3}$) | 14.38 | 114423 | 316360 | 201937 | 2.76 |
| $T_7$ ($N_{90}P_{90}K_{50}Mo_{0.3}$) | 15.29 | 118923 | 336380 | 217457 | 2.83 |
| $T_8$ ($N_{90}P_{30}K_0Mo_{0.3}$) | 8.45 | 106924 | 185900 | 78976.5 | 1.74 |
| $T_9$ ($N_{90}P_{30}K_{25}Mo_{0.3}$) | 9.74 | 108423 | 214280 | 105857 | 1.98 |
| $T_{10}$ ($N_{90}P_{30}K_{75}Mo_{0.3}$) | 13.51 | 111423 | 297220 | 185797 | 2.67 |
| $T_{11}$ ($N_{90}P_{30}K_{50}Mo_0$) | 8.93 | 109323 | 196460 | 87136.6 | 1.80 |
| $T_{12}$ ($N_{90}P_{30}K_{50}Mo_{0.1}$) | 10.52 | 109523 | 231440 | 121917 | 2.11 |
| $T_{13}$ ($N_{90}P_{30}K_{50}Mo_{0.5}$) | 12.96 | 110323 | 285120 | 174797 | 2.58 |

*Benefit cost Ratio = Gross Return/Total variable cost*

Considering yield and economic aspect it can be concluded that application of 135 kg N ha$^{-1}$, 30 kg P ha$^{-1}$, 50 kg K ha$^{-1}$ and 0.3 kg $M_O$ ha$^{-1}$ found to be the most suitable fertilizer dose for broccoli in the present agro ecological environment.

The findings of the study led to the following conclusions: Shelf life of broccoli may be improved through use of organic fertilizer only and preserved at 24$^0$C at open conditions. Gross return and net benefit were the highest in $T_4$ treatment (135 kg N, 30 kg P, 50 kg K and 0.3 kg Mo ha$^{-1}$) and benefit cost ratio was maximum (3.32) in $T_4$ followed by $T_7$ (2.83).

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