EFFECTS OF ORGANIC AND INORGANIC SOURCES OF NUTRIENT ON YIELD, QUALITY AND SHELF LIFE OF BROCCOLI

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ABSTRACT

The study was conducted at Jashore Sadar Upazila, Bangladesh during 2019-20 and 2020-21 to evaluate the effects of organic and inorganic nutrient sources on yield, quality and shelf life of broccoli through Randomized Complete Block Design with three replications and ten treatments which were: T1 = Soil test based 100% NPK, T2 = Vermicompost 4 t ha−1 + soil test based 50% NPK, T3 = Vermicompost 2 t ha−1 + 100% NPK, T4 = Tricho-compost 2 t ha−1 + 100% NPK, T5 = FYM 6 t ha−1 + 100% NPK, T6 = Tricho-compost + t ha−1 + 50% NPK, T7 = FYM 12 t ha−1 + 50% NPK, T8 = Vermicompost 1 t ha−1 + 125% NPK, T9 = Tricho-compost 1 t ha−1 + 125% NPK, T10= FYM 3 t ha−1+125% NPK. Completely Randomized Design was designed to determine the shelf life of broccoli with three replications considering three factors; (i) Organic and inorganic nutrient sources; (ii) storage materials at room temperature (iii) storage materials at cold storage. Findings revealed that treatment T3 produced significantly maximum marketable curd yield 30.57 and 30.23 t ha−1 and the highest Benefit Cost Ratio (3.70 and 3.66) in the respective years. The treatment T9 effectively increased post-harvest quality attributes and also recorded the highest shelf life 8.36 and 8.55 days at room temperature (14–24°C with RH 60-65%), 26.33 and 27.25 days at cold storage (4°C with RH 90-95%) condition using High-Density Polyethylene (HDP; 15 micron) vacuum pack during the years of 2019-20 and 2020-21 respectively.

Contribution/Originality: This study is one of very few studies which have investigated to evaluate pre-harvest foliar application effects of mineral nutrients on yield, quality and shelf life of broccoli. As a new concept, the study is original.

1. INTRODUCTION

Broccoli is one of the most important high value and nutrient rich vegetables of Cole crops belongs to the family Brassicaceae. Broccoli has a reputation as a supper food and it is known to be a healthy and delectable vegetable which is...
wealthy in many supplements. Broccoli is a nutritional powerhouse full of vitamins, minerals, fibers and antioxidants that support many dimensions of human health \cite{1-3}. Broccoli is also considered a low Glycemic Index (GI=10) wonder food for diabetics \cite{4}. Global production of broccoli was 27 million tons in 2019. Out of this, 73\% broccoli production accounted by China and India. The rest of production supplemented by USA, Mexico, Spain, Italy, Turkey, Bangladesh, Poland and France \cite{5}. Farmers of Bangladesh are very much interested to produce and extent broccoli for its high value.

Application of balanced fertilizers is essential to produce high quality and potential yield of broccoli for getting maximum returns \cite{6}. Most of the farmers in Bangladesh are not aware of the use of balanced fertilizers and they produce different vegetables without maintaining proper dose of fertilizers to test the soil. Generally, to get higher yield the farmers are indiscriminately using chemical fertilizers without addition of sufficient quantities of organic manures which are responsible for the improvement of soil health including vegetables high value and shelf life \cite{7}. Only chemical fertilizers may accelerate the crops yield initially but it has adverse effects later on Gupta, et al. \cite{8}. On the other hand, organic manure has the capability to meet up the need based essential plant nutrients for maintain the quality attributes as well as improved properties of soil health \cite{9}. Organic manures viz., Vermicompost, FarmYard Manure (FYM) which are able to maximize the crop’s yield and protect from devastating pests and environmental pollution resulting researchers interest on the use of organic manures avoiding synthetic chemicals. Therefore, use of organic fertilizers combined with inorganic fertilizers leads to higher yield, better quality, and increased shelf life and also improves soil health.

Preservation capability of broccoli is comparatively poor than other Cole crops like cauliflower. Yellowing is the main problem in post-harvest life of broccoli which leads to poor marketability due to consumer dislike \cite{10}. Farmers are not aware about the shelf life of broccoli. They apply huge amount of chemical fertilizers and pesticides often overdoses, more frequencies and even mixing of two or more chemicals as cocktail formulation to achieve better yield during production \cite{11}. Consequently, the storage longevity of broccoli reduces spontaneously. In this circumstance, it is essential to improve post- harvest quality and lingering the shelf life of the said crop. The investigator opined that application of appropriate organic manures viz. Vermicompost, Tricho-compost and Farm Yard Manure (FYM) in combination with chemical fertilizers is one of the best options to maintain the shelf life of broccoli. Packaging materials help not only to keep these vegetables from drying out but also to preserve nutritive value, flavour, texture and color \cite{12}. Polyethylene bag delayed color change due to synchronized effect of increased humidity and fluctuated atmosphere composition \cite{13}. Vacuum pack with low temperature (storage at 4\textdegree C with 95\% RH) is the effective technique to maintain the shelf life of broccoli \cite{14}. Hence, this study also focuses on low cost technology like, Low- Density Polyethylene (LDP; 35 micron) bag, High -Density Polyethylene (HDP; 15 micron) vacuum pack, 2\% egg shell powder and 2\% ascorbic acid solution to sustain the shelf life of broccoli both at room temperature and cold storage condition. Very few investigators studied partially on the above context. Considering above all, the investigator would like to take an in -depth study on "The effects of Organic and Inorganic Sources of Nutrient on Yield, Quality and Shelf life of Broccoli".

2. MATERIALS AND METHODS

The field study was conducted in the Rabi seasons at Chanchra, Jashore Sadar Upazila, Jashore, of Bangladesh during the years 2019-20 and 2020-21. Randomized Complete Block Design (RCBD) had been followed including ten treatments and three replications which were; T\textsubscript{1} = Soil test based 100\% NPK, T\textsubscript{2} = Vermicompost 4 t ha\textsuperscript{-1} + soil test based 50\% NPK, T\textsubscript{3} = Vermicompost 2 t ha\textsuperscript{-1} + 100\% NPK, T\textsubscript{4} =Tricho-compost 2 t ha\textsuperscript{-1} + 100\% NPK, T\textsubscript{5} =FYM 6 t ha\textsuperscript{-1} + 100\% NPK, T\textsubscript{6} = Tricho-compost 4 t ha\textsuperscript{-1} + 50\% NPK, T\textsubscript{7} =FYM 12 t ha\textsuperscript{-1} + 50\% NPK, T\textsubscript{8} = Vermicompost 1 t ha\textsuperscript{-1} + 125\% NPK, T\textsubscript{9} = Tricho-compost 1 t ha\textsuperscript{-1} + 125\% NPK, T\textsubscript{10} = FYM 3 t ha\textsuperscript{-1}+125\% NPK. The soil test based synthetic fertilizers was: N\textsubscript{15}, P\textsubscript{30}, K\textsubscript{20}, S\textsubscript{8}, Zn\textsubscript{5}, B\textsubscript{1}, K\textsubscript{1}. ‘Green Crown’ variety of broccoli was used for conducting the field experiment. Before sowing on the nursery bed, seeds were treated by Thiram @ 2.5 g per kg of seeds. Healthy and appropriate age of seedlings (21 days) had been transplanted to the experimental plots of...
size 3m×2m at spacing of 50 cm × 40 cm as per layout on the 20th November 2019 during the first year and 16th November 2020 during the second year. According to treatment half of organic manures (Vermicompost, Trichocompost and FYM) including TSP, Gypsum, zinc sulphate (Mono) and Boric acid had been used as basal in the respective plots. Rests of organic manures were incorporated in the pits prior to plant seedlings. Urea and Mop fertilizers were used as equal three splits at 15, 30 and 45 days after transplanting and mixed well. Improved intercultural operations were pursued well in all the research plots. The crop was irrigated and managed pests through biological methods meticulously. Broccoli curds were harvested before the buds opened on 22-29 January 2020 during the first year and 17-25 January 2021 during the second year respectively. The observation associated with yield and its contributing characteristics (curd length and diameter, marketable curd weight (g), marketable yield t ha⁻¹ recorded taking five plants randomly each experimental plot in each replication.

Quality indices of broccoli viz. colour, compactness and texture were detected in fresh and stored condition. The numerical ratings for broccoli quality indices detected were quantified on a scale from 1 to 5 point hedonic scales [15] as per Table 1.

| Table 1. Description of numerical ratings for broccoli quality (According to 1 to 5 point hedonic scale [15]*. |
|---|---|---|---|
| Scale | Ranges of Scores | Color | Compactness | Texture |
| 1 | 4.50-5.00 | Dark green | Very compact | Highly crispy |
| 2 | 3.50-4.49 | Green | Compact | Crispy |
| 3 | 2.50-3.49 | Light green | Medium compact | Moderately crispy |
| 4 | 1.50-2.49 | Light yellow | Slightly loose | Soft |
| 5 | 1.00-1.49 | Very yellow | Loose | Very soft |

Note: *Refer to Table 1 for rating and indicating quality of broccoli.

In order to determine different nutrients content in fresh and stored broccoli curd, samples of each treatment were analyzed in the laboratory of Nutrition and Food Technology, Jashore University of Science and Technology, Jashore, Bangladesh. The standard methods were used to determine Vitamin C [16], Anti-oxidants DPPH free radical scavenging activity [17] and Phenols [18] respectively. To ascertain the shelf life for the said crop the following experimental design and methodology was followed as per the Figure 1.

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![Figure 1. Flow chart of the details of the experimental design for shelf life evaluation.]

The recorded data of various characters were analyzed with the help of Statistical Tool for Agricultural Research (STAR) Program and the mean values of all the treatments had been adjudged by Tukeye's test at 5% level of probability for interpretation.
3. RESULTS AND DISCUSSION

3.1. Yield Attributing Characteristics and Yield

3.1.1. Curd Length and Diameter

The perusal of data Table 2 revealed that maximum curd length 20.47 and 20.36 cm, curd diameter 21.63 and 21.56 cm were observed in the treatment T₃ (Vermicompost 2 t ha⁻¹+ soil test based 100% NPK) as compared to other treatments in the year of 2019-20 and 2020-21 respectively. Whereas, minimum curd length 11.33 and 11.39 cm and curd diameter 12.36 and 12.25 cm were recorded in treatment T₁₀ (Farm Yard Manure 3 t ha⁻¹+ soil test based 125% NPK) during 2019-20 and 2020-21 years respectively. As a result of increased the rate of photosynthesis and carbohydrates accumulation in the curd which accelerated length and diameter due to the synergistic action of different nutrient sources mentioned above. These findings corroborate with the findings of Lodhi, et al. [19] and Dash, et al. [20] in broccoli and Bhowal, et al. [21] in cauliflower.

3.1.2. Marketable Curd Weight per Plant

The perusal of data (Table 1 and 2) revealed that marketable maximum curd weight per plant 611.46 and 604.45 g were recorded in the treatment T₃ (Vermicompost 2 t ha⁻¹ +100% NPK) as compared to other treatments in the year of 2019-20 and 2020-21 respectively. Whereas, marketable minimum curd weight per plant 328.70 and 325.15 g were noted in T₁₀ (Farm Yard Manure 3 t ha⁻¹+ soil test based 125% NPK) during 2019-20 and 2020-21 years respectively. This might have been the better performance on potential vegetative growth which influenced in the deposition of more carbohydrates accumulation in curd and synergistic action of different nutrient sources. These findings corroborate with the findings of broccoli [22, 23] and cauliflower [21].

3.1.3. Marketable Curd Yield

The perusal of data in Table 2 revealed that significantly maximum marketable curd yield 30.57 and 30.23 t ha⁻¹ were observed in the treatment T₃ (Vermicompost 2 t ha⁻¹ +100% NPK) followed by T₄ (Tricho-compost 2 t ha⁻¹+100% NPK) with marketable curd yield 28.25 and 28.15 t ha⁻¹, T₅ (FYM 6 t ha⁻¹+100% NPK) with marketable curd yield 26.28 and 26.43 t ha⁻¹, T₆ (Soil test based 100% NPK) with marketable curd yield 24.52 and 23.76 t ha⁻¹, T₇ (Vermicompost 4 t ha⁻¹+soil test based 50% NPK) with marketable curd yield 22.36 and 21.67 t ha⁻¹, T₈ (Tricho-compost 4 t ha⁻¹ +50% NPK) with marketable curd yield 20.76 and 20.54 t ha⁻¹, T₉ (FYM 12 t ha⁻¹+50% NPK) with marketable curd yield 19.59 and 19.43 t ha⁻¹, T₁₀ (Vermicompost 1 t ha⁻¹+125% NPK) with marketable curd yield 18.16 and 17.86 t ha⁻¹, T₁₁ (Tricho-compost 1 t ha⁻¹+125% NPK) with marketable curd yield 17.56 and 17.33 t ha⁻¹ in the year of 2019-20 and 2020-21 respectively. Whereas, minimum marketable curd yield 16.43 and 16.26 t ha⁻¹ were noted in treatment T₁₀ (FYM 3 t ha⁻¹+125% NPK) in the year of 2019-20 and 2020-21 respectively. This might have been the better performance on potential vegetative growth which influenced in the deposition of more carbohydrates accumulation in curd and synergistic action of different nutrient sources helped to meet up need based essential nutrients to plants and enhanced the rate of photosynthesis during growth and development of the broccoli bunches and consequently produced maximum marketable curd yield. These findings corroborate with the findings of broccoli [22-24] and cauliflower [21].

3.4. Quality Attributes

3.4.1. Physico-Chemical Analysis of Fresh Broccoli

3.4.1.1. Sensory Evaluation of colour, Compactness and Texture

The perusal of data in Table 3 revealed that maximum colour rating 4.97, 4.79, compactness rating 4.85, 4.77, texture rating 4.75 and 4.67 were detected in the treatment T₄ (Vermicompost 4 t ha⁻¹+soil test based 50% NPK) in the year of 2019-20 and 2020-21 respectively. Whereas, minimum colour rating 3.53, 3.44, compactness rating 3.25,
3.19, texture rating 3.39 and 3.25 were noted in treatment T₁ (Soil test based 100% NPK) in the year of 2019-20 and 2020-21 respectively. This finding corroborates with [10].

### Table 2: Effects of organic and inorganic sources of nutrient on yield attributes and yield of broccoli.

| Treatment | Curd length (cm) | Curd diameter (cm) | Marketable curd weight per plant (g) | Marketable curd yield (t ha⁻¹) |
|-----------|------------------|--------------------|-------------------------------------|-------------------------------|
|           | 2019-20          | 2020-21            | 2019-20                            | 2020-21                       |
| T₁        | 16.45abc         | 16.39abc           | 17.57abc                           | 17.42abc                     |
| T₂        | 14.67abc         | 14.55abc           | 15.75abc                           | 15.66abc                     |
| T₃        | 20.47a           | 20.36a             | 21.63a                             | 21.56a                        |
| T₄        | 18.23ab          | 18.07ab            | 19.56ab                            | 19.48ab                       |
| T₅        | 17.25abc         | 17.33abc           | 18.43abc                           | 18.88abc                     |
| T₆        | 14.33abc         | 14.25abc           | 15.39abc                           | 15.25abc                     |
| T₁₀       | 13.76bc          | 13.69bc            | 14.27bc                            | 14.22bc                       |
| Tₙ         | 12.63bc          | 12.36bc            | 13.53cd                            | 13.46bc                       |
| SEm ±     | 1.72             | 1.76               | 1.51                               | 1.92                          |
| LSD(P=0.05) | 0.10             | 0.09               | 0.01                               | 0.28                          |

Note: Means in the column followed by different letter(s) differed significantly by DMRT at (P=0.05) level of significance. Here, T₁ = Soil test based 100% NPK, T₂ = Vermicompost + 1 t ha⁻¹ + soil test based 50% NPK, T₃ = Vermicompost + 1 t ha⁻¹ + 100% NPK, T₄ = Tricho-compost + 1 t ha⁻¹ + 100% NPK, T₅ = FYM + soil test based 100% NPK, T₆ = Vermicompost + 1 t ha⁻¹ + 125% NPK, T₇ = Tricho-compost + 1 t ha⁻¹ + 125% NPK.

### Table 3: Quality indices of fresh broccoli as influenced by organic and inorganic sources of nutrient.

| Treatment | Color rating score | Compactness rating score | Texture rating score |
|-----------|--------------------|--------------------------|----------------------|
|           | 2019-20            | 2020-21                  | 2019-20              | 2020-21                  | 2019-20              | 2020-21              |
| T₁        | 3.53 d             | 3.44 c                   | 3.25 c               | 3.19c                   | 3.39 b               | 3.25 d               |
| T₂        | 4.97 a             | 4.79 a                   | 4.85 a               | 4.77 a                  | 4.75 a               | 4.67 a               |
| T₃        | 4.49 ab            | 4.41 ab                  | 4.33 b               | 4.26 b                  | 4.45 a               | 4.21 ab              |
| T₄        | 4.33 bc            | 4.17 b                   | 4.25 b               | 4.19 b                  | 3.83 b               | 3.75 bc              |
| T₅        | 3.95 cd            | 3.63 c                   | 3.49 c               | 3.45 c                  | 3.75 b               | 3.63 cd              |
| SEm ±     | 0.14               | 0.13                     | 0.01                 | 0.01                    | 0.08                 | 0.09                 |
| LSD(P=0.05) | 0.14             | 0.13                     | 0.01                 | 0.01                    | 0.08                 | 0.09                 |

Note: Means in the column followed by different letter(s) differed significantly by DMRT at (P=0.05) level of significance. Here, T₁ = Soil test based 100% NPK, T₂ = Vermicompost + 1 t ha⁻¹ + soil test based 50% NPK, T₃ = Vermicompost + 1 t ha⁻¹ + 100% NPK, T₄ = Tricho-compost + 1 t ha⁻¹ + 100% NPK, T₅ = FYM + soil test based 100% NPK, T₆ = Vermicompost + 1 t ha⁻¹ + 125% NPK, T₇ = Tricho-compost + 1 t ha⁻¹ + 125% NPK.

### 3.4.1.2. Chemical Analysis of Fresh Broccoli Curds

The perusal of data in Table 4 and 5 revealed that maximum dry matter 16.37%,16.23%, carbohydrates 5.33 g, 5.45 g, vitamin C, 89.54 mg /100 g, 89.73 mg/ 100 g, anti oxidants, 74.29 mg / 100 g, 75.33 mg/ 100 g, phenols, 45.69 mg/ 100 g, 45.33 mg/100 g were recorded in the treatment T₂ (Vermicompost @ 4 t ha⁻¹ + Soil test based 50% NPK) in the year of 2019-20 and 2020-21 respectively except protein which was maximum noted in treatment T₁ (Soil test based 100% NPK). It might be due to synergistic effects of vermicompost with inorganic nutrient sources helped to meet up need based essential nutrients to plants and enhanced the rate of photosynthesis during growth and development of the broccoli bunches and consequently produced maximum dry matter, carbohydrates, vitamin C, antioxidants and phenols in broccoli curd. This finding corroborates with Mohanta, et al. [22]; Singh, et al. [24]; Zaki, et al. [25].

### 3.5. Physico-Chemical Analysis of Stored Broccoli

#### 3.5.1. Sensory Evaluation of Colour, Compactness and Texture

The perusal of data in Table 6 revealed that maximum colour rating 4.19, 4.29, compactness rating 3.95, 4.29, texture rating 4.21 and 4.17 were detected in the treatment T₂ (Vermicompost + 4 t ha⁻¹ + Soilm test based 50% NPK) using High-Density Polyethylene (HDP; 15 micron) vacuum pack after 20 days at cold storage (4°C with RH 90-95%) condition in the year of 2019-20 and 2020-21 respectively. Whereas, minimum colour rating 1.77,1.71,
compartment rating 2.33, 2.47, texture rating 1.81 and 1.99 were noted in the treatment T\(_1\) (Soil test based 100% NPK) after 12 days at open place condition within cold storage in the year of 2019-20 and 2020-21 respectively. Similarly, when broccoli curds stored at room temperature (14-24\(^\circ\) C with RH 70-75%), maximum colour rating 4.23, 4.33, compactness rating 4.17, 4.37, texture rating 3.97 and 4.25 were detected in the same treatment T\(_1\) using High-Density Polyethylene (HDP; 15 micron) vacuum pack after 5 days in the year of 2019-20 and 2020-21 respectively. Minimum colour rating 1.63, 1.69, compactness rating 2.25, 2.33, texture rating 1.75 and 1.83 were noted in treatment T\(_1\) (Soil test based 100% NPK) after 3 days at room temperature (14-24\(^\circ\) C with RH 60-65%) condition. This finding corroborates with Chingtham and Banik [10].

**Table 4.** Effects of organic and inorganic sources of nutrient-on-nutrient content in fresh broccoli curd (2019-20).

| Treatment | Dry Matter (%) | Protein (g) | Carbohydrates (g) | Vitamin C (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) |
|-----------|----------------|-------------|--------------------|---------------------|------------------------|-----------------|
| T\(_1\)   | 10.49 c         | 2.69 a      | 2.85 c             | 70.33 c             | 57.13 c                | 28.55 c         |
| T\(_2\)   | 16.37 a         | 2.17 c      | 5.33 a             | 89.54 a             | 74.29 a                | 43.69 a         |
| T\(_3\)   | 13.45 b         | 2.55 ab     | 4.05 b             | 81.79 b             | 67.33 b                | 38.47 ab        |
| T\(_4\)   | 12.33 bc        | 2.43 abc    | 3.49 bc            | 79.86 b             | 65.46 b                | 36.65 b         |
| T\(_5\)   | 12.17 bc        | 2.55 bc     | 3.27 bc            | 77.13 bc            | 64.21 b                | 36.49 b         |
| SE\(\pm\) | 0.0957          | 0.1237      | 0.4001             | 3.13                | 3.01                   | 2.84            |
| LSD(P=0.05) | 0.66         | 2.46        | 0.21               | 0.34                | 0.59                   | 0.87            |

**Note:** Means in the column followed by different letter(s) differed significantly by DMRT at (P=0.05) level of significance. Here, T\(_1\) = Soil test based 100% NPK, T\(_2\) = Vermicompost 4 t ha\(^{-1}\) + soil test based 50% NPK, T\(_3\) = Vermicompost 5 t ha\(^{-1}\) + 100% NPK, T\(_4\) = Tricho-compost 2 t ha\(^{-1}\) + 100% NPK, T\(_5\) = FYM 6 t ha\(^{-1}\) + 100% NPK.

**Table 5.** Effects of organic and inorganic sources of nutrient on nutrient content in fresh broccoli curd (2020-21).

| Treatment | Dry Matter (%) | Protein (g) | Carbohydrates (g) | Vitamin C (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) |
|-----------|----------------|-------------|--------------------|---------------------|------------------------|-----------------|
| T\(_1\)   | 10.45 c         | 2.68 a      | 2.83 c             | 70.26 c             | 56.75 c                | 28.48 c         |
| T\(_2\)   | 16.25 a         | 2.23 c      | 5.45 a             | 89.73 a             | 75.33 a                | 45.33 a         |
| T\(_3\)   | 13.36 b         | 2.49 ab     | 4.08 b             | 82.17 b             | 69.27 ab               | 38.66 b         |
| T\(_4\)   | 12.45 bc        | 2.38 bc     | 3.53 bc            | 79.25 b             | 65.56 b                | 36.47 b         |
| T\(_5\)   | 12.09 bc        | 2.27 c      | 3.25 bc            | 77.33 bc            | 64.55 b                | 36.13 b         |
| SE\(\pm\) | 0.9095          | 0.0892      | 0.4001             | 3.12                | 3.10                   | 2.84            |
| LSD(P=0.05) | 0.24         | 0.43        | 0.15               | 0.30                | 0.37                   | 0.46            |

**3.5.2. Chemical Analysis of Post-Storage Broccoli Curds at Maximum Shelf-Life Stage**

A cursory glance of Table 7 and 8 revealed that maximum appreciable amount of nutrients viz. carbohydrates 5.25 g, 5.23 g, vitamin C 86.33 mg/100 g, 83.13 mg/100 g, antioxidants 70.27 mg/100 g, 67.88 mg/100 g, phenols 41.66 mg/100 g and 41.16 mg/100 g were found to be retained in the treatment T\(_2\) (Vermicompost 4 t ha\(^{-1}\) + Soil test based 50% NPK) along with High-Density Polyethylene (HDP; 15 micron) vacuum pack at cold storage condition (4\(^\circ\) C with RH 90-95%) up to maximum 26.33 and 27.25 days in the year of 2019-20 and 2020-21 respectively which is less than the nutrients 1.50%, 3.58%, 5.41% and 4.65% respectively in fresh broccoli curds as mentioned in table 4 in the year of 2019-2020 and 4.04%, 7.36%, 9.89% and 9.20% respectively less than the nutrients in fresh broccoli curds as mentioned in table 5 in the year of 2020-2021.
Table 6. Effects of pre-harvest application of organic and inorganic nutrient sources and storage condition along with each level of storage materials on nutrients content in broccoli curd at maximum shelf life stage (2019-2020).

A) Using Low -Density Polyethylene (LDP; 35 micron) bag.

| Treatment | Nutrients content | Nutrients content |
|-----------|-------------------|-------------------|
|           | Dry Matter (%)    | Protein(g) | CHO (g) | Vitamin c (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) | Dry Matter (%) | Protein (g) | CHO (g) | Vitamin c (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) |
| T1        | 9.05c             | 2.56a       | 2.69c   | 61.43c          | 46.15c              | 21.57c            | 9.25c            | 2.59a       | 2.75c   | 63.27c          | 49.34c              | 22.78c     |
| T2        | 15.03a            | 2.03c       | 5.03a   | 81.45a          | 66.47a              | 39.25a            | 16.05a           | 2.11c       | 5.19a   | 83.58a          | 67.42a              | 39.35a     |
| T3        | 12.11b            | 2.41ab      | 3.85b   | 72.26b          | 58.36b              | 33.27ab           | 12.93b           | 2.44ab      | 3.87b   | 74.86b          | 60.33b              | 33.78ab    |
| T4        | 10.95bc           | 2.26bc      | 3.19bc  | 70.34b          | 55.83b              | 31.53b            | 11.75bc          | 2.36bc      | 3.31bc  | 72.51b          | 58.21b              | 31.81b     |
| T5        | 10.33bc           | 2.15bc      | 2.91c   | 68.29bc         | 55.77b              | 29.55bc           | 11.03bc          | 2.23bc      | 3.05bc  | 70.19bc         | 58.79b              | 30.83b     |
| LSD (P=0.05) | 0.52         | 1.79       | 0.24    | 0.27            | 0.20                | 0.43              | 0.26             | 0.31       | 0.21    | 0.24            | 0.44                | 0.49       |

B) Using High -Density Polyethylene (HDP; 15 micron) vacuum pack.

| Treatment | Nutrients content | Nutrients content |
|-----------|-------------------|-------------------|
|           | Dry Matter (%)    | Protein(g) | CHO (g) | Vitamin c (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) | Dry Matter (%) | Protein (g) | CHO (g) | Vitamin c (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) |
| T1        | 9.25c             | 2.61a       | 2.73c   | 63.31c          | 49.25c              | 23.36c            | 10.41c           | 2.63a       | 2.79c   | 66.25           | 52.36c              | 25.53c     |
| T2        | 15.13a            | 2.09c       | 5.14a   | 83.26a          | 68.23a              | 39.47a            | 16.31a           | 2.14c       | 5.25a   | 86.33           | 70.27a              | 41.66a     |
| T3        | 12.26b            | 2.46ab      | 3.93b   | 74.37b          | 60.56b              | 34.35ab           | 13.38b           | 2.49ab      | 4.01b   | 77.65           | 63.23b              | 36.41ab    |
| T4        | 11.07bc           | 2.32bc      | 3.31bc  | 72.14b          | 58.37b              | 32.36b            | 12.28bc          | 2.36abc     | 3.39bc  | 75.36           | 61.16b              | 34.52b     |
| T5        | 10.64bc           | 2.23bc      | 3.05bc  | 70.33bc         | 58.63b              | 30.63b            | 12.09bc          | 2.29bc      | 3.21bc  | 75.12           | 61.77b              | 33.56b     |
| LSD (P=0.05) | 0.60         | 2.20       | 0.22    | 0.27            | 0.33                | 0.54              | 0.65             | 0.22       | 0.22    | 0.26            | 0.47                | 0.57       |

C) Treated with 2% egg shell powder solution.

| Treatment | Nutrients content | Nutrients content |
|-----------|-------------------|-------------------|
|           | Dry Matter (%)    | Protein(g) | CHO (g) | Vitamin c (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) | Dry Matter (%) | Protein (g) | CHO (g) | Vitamin c (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) |
| T1        | 8.75c             | 2.51a       | 2.61c   | 59.92c          | 43.56c              | 19.46c            | 9.09c            | 2.57a       | 2.69c   | 61.35c          | 47.16c              | 20.45c     |
| T2        | 13.63a            | 1.95c       | 4.93a   | 79.36a          | 64.13a              | 36.37ab           | 15.75a           | 2.08c       | 5.05a   | 81.36a          | 65.75a              | 37.52a     |
| T3        | 10.25b            | 2.36bc      | 3.75b   | 70.15b          | 56.21b              | 31.16b            | 12.27b           | 2.41ab      | 3.75b   | 72.73b          | 58.47b              | 31.73ab    |
| T4        | 10.47bc           | 2.18bc      | 3.03bc  | 68.27b          | 52.47b              | 29.37b            | 11.15bc          | 2.24bc      | 3.17bc  | 70.25b          | 56.35b              | 29.64b     |
| T5        | 9.65bc            | 2.07c       | 2.81c   | 66.35bc         | 52.33b              | 26.45b            | 10.83bc          | 2.17bc      | 2.95bc  | 68.36bc         | 56.76b              | 28.58b     |
| LSD (P=0.05) | 0.02         | 1.22       | 0.24    | 0.27            | 0.18                | 0.37              | 0.30             | 0.24       | 0.24    | 0.26            | 0.37                | 0.40       |
D) Treated with 2% ascorbic acid solution.

| Treatment   | Dry Matter (%) | Protein (g) | CHO (g) | Vitamin c (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) | Nutrients content at room temp. (14-24°C with RH 60-65%) |
|-------------|----------------|-------------|---------|---------------------|------------------------|-----------------|--------------------------------------------------------|
| T<sub>1</sub> | 8.71c          | 2.49a       | 2.55c   | 56.44c              | 40.25c                 | 18.33c         |
| T<sub>2</sub> | 13.47a         | 1.91c       | 4.75a   | 76.29a              | 62.17a                 | 35.25a         |
| T<sub>3</sub> | 10.04b         | 2.33ab      | 3.61b   | 67.13b              | 54.13b                 | 30.13ab        |
| T<sub>4</sub> | 10.33b         | 2.13bc      | 2.94bc  | 63.22b              | 49.56b                 | 28.31b         |
| T<sub>5</sub> | 9.53bc         | 2.03c       | 2.67c   | 63.46bc             | 49.75b                 | 25.37b         |
| LSD (P=0.05) | 0.03           | 0.97        | 0.31    | 0.29                | 0.11                   | 0.37           |

| Treatment   | Dry Matter (%) | Protein (g) | CHO (g) | Vitamin c (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) | Nutrients content at cold storage (4°C with RH 90-95%) |
|-------------|----------------|-------------|---------|---------------------|------------------------|-----------------|-------------------------------------------------------|
| T<sub>1</sub> | 9.01c          | 2.55a       | 2.63c   | 58.81c              | 44.91c                 | 18.11c         |
| T<sub>2</sub> | 15.63a         | 2.05c       | 4.95a   | 79.21a              | 63.92a                 | 35.72a         |
| T<sub>3</sub> | 12.17b         | 2.36ab      | 3.67b   | 70.48b              | 56.33b                 | 29.63ab        |
| T<sub>4</sub> | 11.03bc        | 2.18bc      | 3.05bc  | 67.92b              | 54.14b                 | 27.44b         |
| T<sub>5</sub> | 10.75bc        | 2.11bc      | 2.88bc  | 65.91bc             | 54.55b                 | 26.33b         |
| LSD (P=0.05) | 0.31           | 2.05        | 0.26    | 0.23                | 0.32                   | 0.33           |

E) Control (at open place).

| Treatment   | Dry Matter (%) | Protein (g) | CHO (g) | Vitamin c (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) | Nutrients content at room temp. (14-24°C with RH 60-65%) |
|-------------|----------------|-------------|---------|---------------------|------------------------|-----------------|--------------------------------------------------------|
| T<sub>1</sub> | 6.75c          | 2.43a       | 2.35c   | 53.52c              | 38.17c                 | 16.46c         |
| T<sub>2</sub> | 11.23a         | 1.75bc      | 4.47a   | 74.13a              | 60.21a                 | 33.33a         |
| T<sub>3</sub> | 8.16b          | 2.18ab      | 3.49b   | 65.27b              | 51.33b                 | 28.35ab        |
| T<sub>4</sub> | 8.56b          | 1.35c       | 2.76bc  | 63.20b              | 46.47b                 | 26.61b         |
| T<sub>5</sub> | 8.14b          | 1.95ab      | 2.53c   | 60.73bc             | 46.63b                 | 23.44b         |
| LSD (P=0.05) | 0.06           | 1.46        | 0.86    | 0.22                | 0.10                   | 0.37           |

| Treatment   | Dry Matter (%) | Protein (g) | CHO (g) | Vitamin c (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) | Nutrients content at cold storage (4°C with RH 90-95%) |
|-------------|----------------|-------------|---------|---------------------|------------------------|-----------------|-------------------------------------------------------|
| T<sub>1</sub> | 7.71c          | 2.51a       | 2.56b   | 56.48c              | 42.35c                 | 15.72c         |
| T<sub>2</sub> | 14.51a         | 1.81c       | 4.75a   | 77.34a              | 61.72a                 | 33.67a         |
| T<sub>3</sub> | 11.25b         | 2.25ab      | 3.47b   | 68.31b              | 54.01b                 | 27.46ab        |
| T<sub>4</sub> | 10.46b         | 2.10b       | 3.93b   | 65.67b              | 51.69b                 | 25.19b         |
| T<sub>5</sub> | 9.48bc         | 2.03bc      | 2.74b   | 63.62bc             | 52.04b                 | 23.97b         |
| LSD (P=0.05) | 0.37           | 0.27        | 0.49    | 0.36                | 0.20                   | 0.28           |

Note: Means in the column followed by different letter(s) differed significantly by DMRT at (P=0.05) level of significance. Here, T<sub>1</sub> = Soil test based 100% NPK, T<sub>2</sub> = Vermicompost 1 t ha<sup>-1</sup> + Soil test based 50% NPK, T<sub>3</sub> = Vermicompost 2 t ha<sup>-1</sup> + 100% NPK, T<sub>4</sub> = Trichocompost 2 t ha<sup>-1</sup> + 100% NPK, T<sub>5</sub> = FYM 6 t ha<sup>-1</sup> + 100% NPK.
### Table 7. Effects of pre-harvest application of organic and inorganic nutrient sources and storage condition along with each level of storage materials on nutrients content in broccoli curd at maximum shelf life stage (2020-2021).

#### A) Using Low-Density Polyethylene (LDP; 35 micron) bag.

| Treatment | Nutrients content | Nutrients content |
|-----------|-------------------|-------------------|
|           | Dry Matter (%)    | Protein (g)       | CHO (g) | Vitamin C (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) |
|           |                   |                   |         |                    |                     |                |
| LDP       | At room temp. (14-24°C with RH 60-65%) | | | | | |
| T<sub>1</sub> | 8.95c | 2.49a | 2.66c | 60.13c | 46.85c | 22.07c |
| T<sub>2</sub> | 14.83a | 2.01b | 5.19a | 82.26a | 67.23a | 39.25a |
| T<sub>3</sub> | 11.91b | 2.33a | 3.81b | 70.32b | 60.15b | 33.13ab |
| T<sub>4</sub> | 10.63bc | 2.21ab | 2.37c | 70.25b | 57.26b | 30.67b |
| T<sub>5</sub> | 9.69bc | 1.51c | 3.05bc | 68.39b | 54.30b | 28.25bc |
| LSD (P=0.05) | 0.46 | 0.04 | 0.07 | 0.14 | 0.17 | 0.34 |

| Treatment | Nutrients content | Nutrients content |
|-----------|-------------------|-------------------|
|           | Dry Matter (%)    | Protein (g)       | CHO (g) | Vitamin C (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) |
|           |                   |                   |         |                    |                     |                |
| LDP       | At cold storage (4°C with RH 90-95%) | | | | | |
| T<sub>1</sub> | 9.13c | 2.53a | 2.71c | 62.56c | 49.73c | 23.15c |
| T<sub>2</sub> | 15.03a | 2.07c | 5.26a | 84.13a | 69.46a | 40.73a |
| T<sub>3</sub> | 12.07b | 2.37ab | 3.93b | 75.47b | 62.25b | 34.26ab |
| T<sub>4</sub> | 10.80bc | 2.27abc | 2.45c | 72.55b | 59.13b | 32.53b |
| T<sub>5</sub> | 10.64bc | 2.14bc | 3.13bc | 70.56b | 56.76b | 30.47b |
| LSD (P=0.05) | 0.59 | 3.60 | 0.07 | 0.16 | 0.21 | 0.33 |

#### B) Using High-Density Polyethylene (HDP; 15 micron) vacuum pack.

| Treatment | Nutrients content | Nutrients content |
|-----------|-------------------|-------------------|
|           | Dry Matter (%)    | Protein (g)       | CHO (g) | Vitamin C (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) |
|           |                   |                   |         |                    |                     |                |
| HDP       | At room temp. (14-24°C with RH 60-65%) | | | | | |
| T<sub>1</sub> | 8.69b | 2.43a | 2.59c | 58.56c | 43.75c | 20.23c |
| T<sub>2</sub> | 13.45a | 1.91c | 5.03a | 80.13a | 65.36a | 37.46a |
| T<sub>3</sub> | 10.07b | 2.25ab | 3.75b | 71.25b | 58.21b | 31.25ab |
| T<sub>4</sub> | 9.57b | 2.13bc | 2.30c | 68.17b | 55.33b | 28.36b |
| T<sub>5</sub> | 9.06b | 1.44d | 2.93bc | 66.43b | 51.66b | 26.17bc |
| LSD (P=0.05) | 1.45 | 0.04 | 0.08 | 0.16 | 0.11 | 0.33 |

| Treatment | Nutrients content | Nutrients content |
|-----------|-------------------|-------------------|
|           | Dry Matter (%)    | Protein (g)       | CHO (g) | Vitamin C (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) |
|           |                   |                   |         |                    |                     |                |
| HDP       | At cold storage (4°C with RH 90-95%) | | | | | |
| T<sub>1</sub> | 9.15c | 2.49a | 2.67c | 66.85c | 34.73c | 20.15c |
| T<sub>2</sub> | 15.78a | 2.03c | 5.15a | 89.81a | 64.15a | 38.98a |
| T<sub>3</sub> | 12.26b | 2.33ab | 3.79b | 71.22b | 56.29b | 32.06b |
| T<sub>4</sub> | 11.13bc | 2.21abc | 3.13bc | 67.54b | 52.26b | 29.65b |
| T<sub>5</sub> | 10.77bc | 2.14bc | 3.03bc | 65.23b | 50.99b | 28.53b |
| LSD (P=0.05) | 0.28 | 4.26 | 0.18 | 0.11 | 0.13 | 0.17 |
D) Treated with 2% ascorbic acid solution.

| Treatment | Nutrients content at room temp. (14-24°C with RH 60-63%) | Nutrients content at cold storage (4°C with RH 90-95%) |
|-----------|--------------------------------------------------------|------------------------------------------------------|
|           | Dry Matter (%) | Protein (g) | CHO (g) | Vitamin c (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) | Dry Matter (%) | Protein (g) | CHO (g) | Vitamin c (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) |
| T1        | 8.65b          | 2.39a       | 2.56c   | 55.63c           | 41.47d                  | 18.55c             | 8.93c          | 2.43a       | 2.59c   | 55.25c           | 40.33c                  | 18.65c             |
| T2        | 13.37a         | 1.85c       | 4.96a   | 77.46a           | 63.13a                  | 35.47a             | 15.45a         | 1.95b       | 4.92a   | 79.33a           | 62.38a                  | 37.65a             |
| T3        | 10.04b         | 2.21ab      | 3.67b   | 68.23b           | 55.25b                  | 29.53ab            | 12.09b         | 2.23ab      | 3.67b   | 69.52b           | 54.06b                  | 30.56b             |
| T4        | 9.51b          | 2.08bc      | 2.17c   | 66.16b           | 50.13bc                 | 27.25b             | 10.91bc        | 2.09b       | 3.03bc  | 65.69b           | 49.91b                  | 28.05b             |
| T5        | 9.02b          | 1.37d       | 2.83bc  | 63.13b           | 46.37cd                 | 24.36bc            | 10.47bc        | 2.03b       | 2.83bc  | 63.33b           | 48.59b                  | 26.85b             |
| LSD (P=0.05) | 1.52         | 0.03       | 0.08    | 0.15             | 0.08                   | 0.37               | 0.32           | 3.09       | 0.25    | 0.07             | 0.10                   | 0.20                |

E) Control.

| Treatment | Nutrients content at room temp. (14-24°C with RH 60-63%) | Nutrients content at cold storage (4°C with RH 90-95%) |
|-----------|--------------------------------------------------------|------------------------------------------------------|
|           | Dry Matter (%) | Protein (g) | CHO (g) | Vitamin c (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) | Dry Matter (%) | Protein (g) | CHO (g) | Vitamin c (mg/100g) | Antioxidants (mg/100g) | Phenol (mg/100g) |
| T1        | 6.77b          | 2.35a       | 2.49c   | 52.73c           | 39.43d                  | 17.23c             | 7.69c          | 2.38a       | 2.44c   | 54.33c           | 39.15c                  | 16.05c             |
| T2        | 11.16a         | 1.78c       | 4.63a   | 74.27a           | 61.25a                  | 33.46a             | 14.43a         | 1.83c       | 4.76a   | 78.58a           | 61.33a                  | 35.60a             |
| T3        | 8.10b          | 2.15ab      | 3.59b   | 65.75b           | 52.16b                  | 27.57ab            | 11.35b         | 2.19ab      | 3.45b   | 68.72b           | 52.06b                  | 28.33b             |
| T4        | 7.61b          | 2.04b       | 2.03c   | 64.14b           | 47.27bc                 | 25.35b             | 10.35b         | 2.07bc      | 2.87bc  | 64.82b           | 48.76b                  | 25.63b             |
| T5        | 7.56b          | 1.31d       | 2.71bc  | 60.36b           | 43.15cd                 | 22.70bc            | 9.53bc         | 2.01bc      | 2.77bc  | 62.43b           | 47.46b                  | 24.35b             |
| LSD (P=0.05) | 2.72         | 0.02       | 0.13    | 0.16             | 0.07                   | 0.49               | 0.28           | 1.99       | 0.29    | 0.07             | 0.10                   | 0.17                |

Note: Means in the column followed by different letter(s) differed significantly by DMRT at (P=0.05) level of significance. Here, T1 = Soil test based 100% NPK, T2 = Vermicompost + t ha⁻¹ + Soil test based 50% NPK, T3 = Vermicompost + 2 t ha⁻¹ + 100% NPK, T4 = FyM + 6 t ha⁻¹ + 100% NPK, T5 = Tricho-compost + 2 t ha⁻¹ + 100% NPK, T6 = Soil test based 100% NPK, T7 = Vermincompost + 2 t ha⁻¹ + 100% NPK.
Similarly, when broccoli curds stored at room temperature (14-24°C with RH 60-65%), the various nutrients viz. carbohydrates 5.14 g, 5.19 g, vitamin C 83.26 mg/100 g, 82.26 mg/100 g, antioxidants 68.23 mg/100 g, 67.23 mg/100 g, phenols 39.47 mg/100 g and 39.25 mg/100 g remain intact even after the broccoli curds were kept within High -Density Polyethylene (HDP; 15 micron) vacuum pack for a maximum 8.36 and 8.55 days in the same treatment which is less than the nutrients 5.56%, 7.01%, 8.16%, and 9.66% respectively in fresh broccoli curds as mentioned in table 4 in the year of 2019-2020 and 4.77%, 8.32%, 10.75% and 13.41% respectively less than the nutrients in fresh broccoli curds as mentioned in table 5 in the year of 2020-2021. This finding corroborates with Chinthgam and Banik [10]; Manisha and Rajkumari [26].

### 3.6. Shelf Life

The perusal of data in Table 8 and 9 revealed that effects of organic and inorganic sources of nutrient and storage condition along with each level of storage materials significantly influenced on shelf life of broccoli. Maximum shelf life 8.36 and 8.55 days were observed in the treatment T2 (Vermicompost + t ha⁻¹ + Soil test based 50% NPK) followed by T3 (Vermicompost 2 t ha⁻¹ +100% NPK) with 5.49 and 5.33 days, T4 (Tricho-compost 2 t ha⁻¹ +100% NPK) with 5.33 and 5.25 days, T5 (FYM 6 t ha⁻¹+100% NPK) with 5.17 and 5.27 days, and it were kept in High -Density Polyethylene (HDP; 15 micron) vacuum pack at room temperature (14-24°C with RH 60-65%) condition during the 2019-20 and 2021-21 respectively. Whereas, minimum shelf life 1.85 and 2.33 days were recorded in treatment T1 (Soil test based 100% NPK) at the same condition during the 2019-20 and 2021-21 respectively. In the same way, at cold storage (4°C with 90-95% RH) condition, maximum shelf life 26.33 and 27.25 days were observed in the treatment T2 (Vermicompost + t ha⁻¹ + Soil test based 50% NPK) followed by T3 (Vermicompost 2 t ha⁻¹ +100% NPK) with 23.43 and 22.33 days, T4 (Tricho-compost 2 t ha⁻¹ +100% NPK) with 23.43 and 21.56 days, T5 (FYM 6 t ha⁻¹+100% NPK) with 22.68 and 21.75 days, and it were kept in High -Density Polyethylene (HDP; 15 micron) vacuum pack during the 2019-20 and 2021-21 respectively. Whereas, minimum shelf life 12.29 and 12.33 days were recorded in treatment T1 (Soil test based 100% NPK) at cold storage (4°C with 90-95% RH) condition during the 2019-20 and 2021-21 respectively. This might be due to synergistic effects of organic and inorganic sources of nutrient influenced broccoli longevity through increased nutrients uptake by the plants and enhanced greater development of water conducting tissue which enhanced the shelf life of broccoli. These findings corroborates with the findings of Dhakal, et al. [27].

Maximum shelf life in both the storage conditions within High -Density Polyethylene (HDP; 15 micron) vacuum pack might be due to its sophisticated techniques which delayed and protected the physiological deterioration of broccoli curd. Within High -Density Polyethylene (HDP; 15 micron) vacuum pack having more control over the gas exchange with the surrounding air, the levels of CO₂ and O₂ around the produce might have further slowed down conversion of starch to sugars.

Curds stored in the cold conditions had maintained a greener color and at the same time no chilling injury symptoms, no decay incidence and no rot were observed there. In addition, storage at low temperature reduced the rate of respiration, and delayed senescence during storage of curds. Pre-harvest application of organic and inorganic sources of nutrients in broccoli production and better storage conditions including appropriate use of scientific storage materials like High -Density Polyethylene (HDP; 15 micron) vacuum pack might have protected the chlorophyll degradation and ethylene production. The synchronized effects of the said treatment also might have protected available moisture and minimize the rate of respiration along with strengthening the cell wall in the vegetative parts of broccoli which restricted the yellowing color and reduced weight loss. This might have maintained the shelf life and quality of broccoli. The findings of present investigation in respect of shelf life corroborate with the findings of broccoli [14].
The present findings indicate that based 100% NPK, Treatment T4 (Vermicompost +100% NPK) in the year of 2019-20 and 2020 respectively. Whereas, minimum gross returns of BDT 458550 and 453450 ha-1 were noted in treatment T6 (Vermicompost +100% NPK, T6 = Tricho-compost +100% NPK) in the year of 2019-20 and 2020-21 respectively. The present findings indicate that treatment T6 is the maximum profitable treatment for broccoli production which could generate maximum net income with maximum Benefit Cost Ratio (BCR). This finding corroborates with Shamsunnahar et al. [11]; Sharma, et al. [28].

### Table 8. Shelf life (days) comparison of storage materials at each level of treatment under different storage condition (2019-20).

| Treatments | Storage materials | Shelf life (days) at room temperature (14-24°C with RH 60-65%) | Shelf life (days) at Cold Storage (4°C with RH 90-95%) |
|------------|-------------------|-------------------------------------------------------------|-----------------------------------------------------|
|            | LDP bag           | HDPE Vacuum pack 5% Egg shell power solution 9% Ascorbic acid solution Control | LDP bag HDPE Vacuum pack 5% Egg shell power solution 9% Ascorbic acid solution Control |
| T1         | 3.75ef 3.95e      | 2.42fg 2.33fg 1.85g | 15.81b 19.20a 14.45bc 13.83e 12.29d |
| T2         | 3.67f 3.86e      | 4.59fg 4.33g 3.59g | 21.70b 26.33a 19.59c 19.57c 14.87d |
| T3         | 4.60ef 5.49e    | 5.67fg 3.61h 2.33g | 20.20b 23.43a 17.17c 16.69c 13.87d |
| T4         | 4.37ef 5.33e    | 5.63fg 3.57i 2.30g | 20.16b 23.39a 17.13c 16.63c 13.79d |
| T5         | 4.25ef 5.17e    | 5.57fg 3.45j 2.25g | 19.42b 22.68a 16.41g 15.90e 12.73d |
| LSD(P=0.05) | 1.15e           | 0.20e           | 0.0000 |

Note: Means in the column followed by different letter(s) differed significantly by DMRT at (P=0.05) level of significance. Here, T1 = Soil test based 100% NPK, T2 = Vermicompost +1 t ha⁻¹ +Soil test based 50% NPK, T3 = Vermicompost +2 t ha⁻¹ +100% NPK, T4 = Tricho-compost +2 t ha⁻¹ +100% NPK, T5 = FYM +6 t ha⁻¹ +100% NPK.

### Table 9. Shelf life (days) comparison of storage materials at each level of treatment under different storage condition (2020-21).

| Treatment | Storage materials | Shelf life (days) at room temperature (14-24°C with RH 60-65%) | Shelf life (days) at Cold Storage (4°C with RH 90-95%) |
|-----------|-------------------|-------------------------------------------------------------|-----------------------------------------------------|
|           | LDP bag           | HDPE Vacuum pack 5% Egg shell power solution 9% Ascorbic acid solution Control | LDP bag HDPE Vacuum pack 5% Egg shell power solution 9% Ascorbic acid solution Control |
| T1        | 3.69g 4.33f       | 2.75h 2.37h 2.33h | 15.33b 18.75a 14.33c 13.25d 12.33e |
| T2        | 6.33g 8.55f      | 4.33h 4.25h 3.75i | 20.55b 27.25a 19.45c 18.33d 15.31e |
| T3        | 4.25f 5.33f      | 3.75h 3.25j 2.55j | 18.47b 22.33a 16.55c 15.75d 13.63e |
| T4        | 4.13g 5.25f      | 3.55h 3.17h 2.51i | 17.63b 21.56a 16.25c 15.47d 12.83e |
| T5        | 4.05g 5.27f      | 3.63gh 3.33h 2.35j | 17.53b 21.75a 16.31c 15.35d 13.33e |
| LSD(P=0.05) | 1.15e           | 0.20e           | 0.0000 |

Note: Means with the same letter are not significantly different. T1 = Soil test based 100% NPK, T2 = Vermicompost +1 t ha⁻¹ +Soil test based 50% NPK, T3 = Vermicompost +2 t ha⁻¹ +100% NPK, T4 = Tricho-compost +2 t ha⁻¹ +100% NPK, T5 = FYM +6 t ha⁻¹ +100% NPK.

### 3.7. Economic Consideration

Data enumerated in Table 10 and 11 revealed that maximum gross returns of BDT 458550 and 453450 ha⁻¹, net returns 334722 and 329622 ha⁻¹ with BCR 3.70 and 3.66 were observed in the treatment T6 (Vermicompost +2 t ha⁻¹ +100% NPK) in the year of 2019-20 and 2020-2021 respectively. Whereas, minimum gross returns of BDT 246450 and 243900 ha⁻¹, net returns 132620 and 130070 ha⁻³ with BCR 2.17 and 2.14 were noted in treatment T10 (FYM +3 t ha⁻¹+125% NPK) in the year of 2019-20 and 2020-21 respectively. The present findings indicate that treatment T6 is the maximum profitable treatment for broccoli production which could generate maximum net income with maximum Benefit Cost Ratio (BCR). This finding corroborates with Shamsunnahar [11]; Sharma, et al. [28].
Table 10. Economic consideration of broccoli production as influenced by pre-harvest application of organic and inorganic nutrient sources (2019-20).

| Treatment | Marketable Yield (t ha⁻¹) | Cost of production (BDT ha⁻¹) | Gross returns (BDT ha⁻¹) | Net returns (BDT ha⁻¹) | Benefit Cost ratio (BCR) |
|-----------|--------------------------|-------------------------------|--------------------------|------------------------|------------------------|
| T₁        | 24.52                    | 107370                        | 367800                   | 260430                 | 3.43                   |
| T₂        | 22.36                    | 136145                        | 335400                   | 199255                 | 2.46                   |
| T₃        | 30.57                    | 123828                        | 458550                   | 334722                 | 3.70                   |
| T₄        | 28.25                    | 128217                        | 423750                   | 295333                 | 3.30                   |
| T₅        | 26.28                    | 116148                        | 394200                   | 278052                 | 3.39                   |
| T₆        | 20.76                    | 144922                        | 311400                   | 166478                 | 2.15                   |
| T₇        | 19.59                    | 120783                        | 293850                   | 173067                 | 2.43                   |
| T₈        | 18.16                    | 117674                        | 272400                   | 154726                 | 2.51                   |
| T₉        | 17.56                    | 119866                        | 263400                   | 143534                 | 2.20                   |
| T₁₀       | 16.43                    | 113830                        | 246450                   | 132620                 | 2.17                   |

Table 11. Economic consideration of broccoli production as influenced by pre-harvest application of organic and inorganic nutrient sources (2020-21).

| Treatment | Marketable Yield (t ha⁻¹) | Cost of production (BDT ha⁻¹) | Gross returns (BDT ha⁻¹) | Net returns (BDT ha⁻¹) | Benefit Cost ratio (BCR) |
|-----------|--------------------------|-------------------------------|--------------------------|------------------------|------------------------|
| T₁        | 23.76                    | 107370                        | 356400                   | 249030                 | 3.32                   |
| T₂        | 21.67                    | 136145                        | 325050                   | 188905                 | 2.39                   |
| T₃        | 30.23                    | 123828                        | 453450                   | 329622                 | 3.66                   |
| T₄        | 28.15                    | 128217                        | 422250                   | 294033                 | 3.29                   |
| T₅        | 26.43                    | 116148                        | 396450                   | 280302                 | 3.41                   |
| T₆        | 20.54                    | 144922                        | 308100                   | 163178                 | 2.13                   |
| T₇        | 18.43                    | 120783                        | 291450                   | 170667                 | 2.41                   |
| T₈        | 17.86                    | 117674                        | 267900                   | 150226                 | 2.28                   |
| T₉        | 17.33                    | 119866                        | 259950                   | 140084                 | 2.17                   |
| T₁₀       | 16.26                    | 113830                        | 243900                   | 130070                 | 2.14                   |

Note: Sale rate of broccoli BDT 15/kg. Here, T₁ = Soil test based 100% NPK, T₂ = Vermicompost + 1 t ha⁻¹ + Soil test based 50% NPK, T₃ = Vermicompost 2 t ha⁻¹ + 100% NPK, T₄ = Tricho-compost + 2 t ha⁻¹ + 100% NPK, T₅ = FYM 3 t ha⁻¹ + 50% NPK, T₆ = FYM 4 t ha⁻¹ + 50% NPK, T₇ = FYM 5 t ha⁻¹ + 100% NPK, T₈ = Tricho-compost + 3 t ha⁻¹ + 100% NPK, T₉ = Tricho-compost + 3 t ha⁻¹ + 125% NPK, T₁₀ = FYM 3 t ha⁻¹ + 125% NPK.

4. CONCLUSION

The inference of the present investigation that Vermicompost 2 t ha⁻¹ + soil test based 100% NPK performed the best regarding higher yield, gross and net returns with maximum Benefit Cost Ratio (BCR) at grower's level. Simultaneously, broccoli produced through the application of Vermicompost + 1 t ha⁻¹ + Soil test based 50% NPK is the best for consumption and getting anticipated quality attributes of broccoli. In addition, combined use of Vermicompost + 1 t ha⁻¹ + Soil test based 50% NPK along with High-Density Polyethylene (HDP; 15 micron) vacuum pack is the significantly effective for maintaining the shelf life of broccoli both at room temperature (14-24°C with RH 60-65%) and at cold storage (4°C with RH 90-95%) condition.

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