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PRE-HARVEST APPLICATION OF INORGANIC SOURCES OF NUTRIENT ON YIELD AND SHELF LIFE OF BROCCOLI

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ABSTRACT

A study was conducted at Chanchra, Sadar Upazila, Jashore, Bangladesh during Rabi seasons of 2019-20 and 2020-21 to evaluate pre-harvest treatments of inorganic nutrient sources on yield and shelf life of broccoli following Randomized Complete Block Design (RCBD) with three replications and six treatments which were; T_1 = soil test based 50% NPK with blanket dose, T_2 = soil test based 75% NPK with blanket dose, T_3 = soil test based 100% NPK with blanket dose, T_4 = soil test based 125% NPK with blanket dose, T_5 = local farmers practice (N_{138} P_{75} K_{94} S_{27} Zn_5 kg ha^{-1}),T_6 = control.Completely Randomized Design (CRD) was designed to determine the shelf life of broccoli with three replications considering three factors; (i) pre-harvest treatments of inorganic sources of nutrient; (ii) storage materials at room temperature and (iii) storage materials at cold storage condition.Findings revealed that the effects of different inorganic sources of nutrients significantly influenced on yield and shelf life of broccoli. The treatment T_3 (soil test based 100% NPK with blanket dose) resulted in better marketable curd yield with maximum gross returns, net returns and Benefit Cost Ratio (BCR) as compared to other treatments.The treatment T_1 (soil test based 50% dose of NPK with blanket dose) recorded the maximum shelf life of 6.57 daysand 6.83 days at room temperature (14-24^{0}C with RH 60-65%) and 23.65 days and 24.25 days at cold storage (4^{0}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.

Keywords: Broccoli, Growth, Yield, Pre-harvest, Shelf life, Yield

INTRODUCTION

Broccoli is one of the most important high value and nutrient rich vegetables under Cole crops belongs to the family Brassicaceae. Broccoli has a reputation as a supper

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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 (Cartea et al., 2008; Faller and Fialho, 2009; Yvette, 2012). Broccoli is also considered a low Glycemic Index (GI=10) wonder food for diabetics (Nagraj et al., 2020). Global production of broccoli was 27 million tons in 2019. Out of these, 73% broccoli production accounted by China and India. The rest of production was supplemented by USA, Mexico, Spain, Italy, Turkey, Bangladesh, Poland and France (FAOSTAT, 2020). Farmers of Bangladesh are very much interested to produce and extent broccoli for its high value.

Nutrient management plays a key role in influencing the productivity and quality of any crop. Broccoli is highly responsive to nitrogen, phosphorus and potassium in its growth and yield. Nitrogen is inextricably linked with the vegetative growth of broccoli which plays an important role in maximizing the yield of broccoli up to a certain limit. But if more nitrogen is used than the optimum rate, the desired yield of broccoli will be reduced and it may have a negative effect on the quality and preservation of broccoli (Abu, 2021). Similarly, phosphorus is another important macronutrient that also affects the growth and productivity of cauliflower and broccoli (Sonia et al., 2020). In the same way, potassium also plays a vital role in physiological activity; growth and yield balance of broccoli (Zaki et al., 2015). Adequate potassium supply ensures optimum shelf life and more marketable crops with less moisture loss during storage. Considering the above-mentioned review, it is essential to recommend a dose of inorganic sources of nutrients for increasing yield, quality and shelf life of broccoli.

Preservation capability of broccoli is comparatively poor than other Cole crops such as cauliflower. Yellowing is the main problem in post-harvest life of broccoli which leads to unmarketability due to consumer dislike (Chingtham and Banik, 2019). 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 (Shamsunnahar, 2016). Consequently, the storage longevity of broccoli is reduced spontaneously. In this circumstance, it is essential to improve post-harvest quality and extensionof the shelf life of the said crop. Packaging materials help not only to keep this vegetable from drying out but also to preserve nutritive value, flavour, texture and color (Raseetha et al., 2018). Polyethylene bag delayed color change due to synchronized effect of increased humidity and fluctuated atmosphere composition (Rao and Shivashankara, 2015). Vacuum pack with low temperature (storage at 4^0C with 95% RH) is the effective technique to maintain the shelf life of broccoli (Jadhav et al., 2018). The investigator opined that pre-harvest application of judicious inorganic sources of nutrients in broccoli production and also using low cost technology such as, Low- Density Polyethylene (LDP; 35 micron) bag, High -Density Polyethylene (HDP;15 micron) vacuum pack, 2% egg shell powder and 2% ascorbic acid solution at post-harvest stage to to maintain the shelf life of broccoli. Very few investigators studied partially but not in- depth on the above context. Considering above all, the investigator would like to take an in- depth study on pre-harvest application of inorganic sources of nutrient on yield and shelf life of broccoli.

MATERIALS AND METHODS

The field experiment was conducted in the Rabi seasons at Chanchra under SadarUpazila, Jashore, Bangladesh during the years 2019-20 and 2020-21. Randomized Complete Block Design (RCBD) had been followed including six treatments and three replications which were; T_1 = soil test based 50% NPK with blanket dose, T_2 = soil test based 75% NPK with blanket dose, T_3 = soil test based 100% NPK with blanket dose, T_4 = soil test based 125% NPK with blanket dose, T_5 = local farmers practice ($N_{138}P_{75}K_{94}S_{27}Zn_5$ kgha^{-1}), T_6 = control. The soil test based chemical fertilizers was $N_{115}P_{30}K_{75}S_{20}Zn_3B_1$ kgha^{-1}. The hybrid variety of broccoli "Green Crown" was used for conducting the field experiment as planting material. Before sowing on the nursery bed, seeds 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 3 m × 2 m 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, a TSP, Gypsum, Zinc sulphate (mono) and Boric acid had been used asbasal dose in the respective plots. Urea and MoP fertilizers were used as equal three splits at 15, 30 and 45 days after transplanting and mixed well with soil. Improved intercultural operations were done in all the experimental plots. The crop was irrigated and managed pests using biological methods meticulously. Broccoli curds were harvested before the buds opened on 29 January to 3 February 2020 during the first year and 24 to 29 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 ton per hectare were recorded taking five plants randomly from each experimental plot in each replication.

Design and methodology for shelf-life assessment of broccoli

To ascertain the shelf life for broccoli the following experimental design and methodology was followed as per the figure 1. The experiment was conducted in Completely Randomized Design (CRD) design, and it was carried out in triplicate.

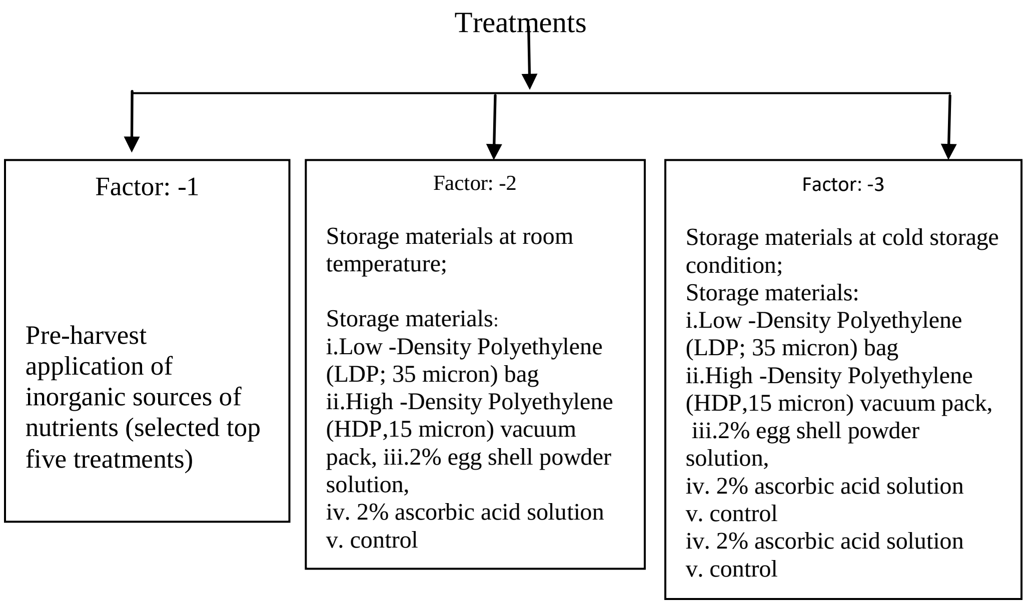

Figure 1. Flow chart of the details of the experimental design for shelf life assessment of broccoli.

In the case of shelf life assessment of broccoli, treatment wise matured broccoli curd from each replication had been collected and placed in the selective storage materials (Low -Density Polyethylene (LDP; 35 micron) bag, High -Density Polyethylene (HDP;15 micron) vacuum pack, treated with 2% egg shell powder solution for five minutes, treated with 2% ascorbic acid solution for five minutes and control both at room temperature and cold storage condition. The change of curd color (just started to yellowing) was observed by eye estimation and to ascertain the shelf life of broccoli using each selective storage materials both at room temperature and cold storage condition.

The recorded data of various characteristics 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. Benefit Cost Ratio (BCR) for each treatment under investigation had been calculated based on the present market prices of inputs and outputs in order to find out the maximum profitable treatment.

RESULTS AND DISCUSSION

Yield attributing characteristics and yield

The perusal of data in Table 1 revealed that significantly ($P \leq 0.05$) maximum curd length 17.25 and 17.09 cm, curd diameter 18.46 and 18.35 cm, marketable curd weight per plant 525.35 and 520.37 g and marketable curd yield 26.27 and 26.02 t ha^{-1} were recorded in treatment T_3 (soil test based 100% NPK with blanket dose) as compared to other treatments in the year of 2019-20 and 2020-21 respectively. Whereas, minimum curd length 8.14 and 8.05 cm, curd diameter 9.18 and 9.15 cm, marketable curd weight per plant 165.03 and 156.64 g and marketable curd yield 8.25 and 7.83 t ha^{-1}, respectively were noted in T_6 (control) in the year of 2019-20 and 2020-21, respectively. It was observed from the results that, marketable curd yield increased in treatment T_3 (soil test based 100% NPK with blanket dose) by 218.42%, 232.31% than controland 29.92%, 24.56% than local farmers practice (N_{138} P_{75} K_{94} S_{27} Zn_5 kg ha^{-1}) in the year of 2019-20 and 2020-21, respectively.This yield increased might have been the better performance on potential vegetative growth which influenced in the deposition of more amount of carbohydrates accumulation in curd and thereby increased the yield. The results of present investigation in concordance with the findings of Singh et al. (2015) in broccoli.

Table 1. Effects of pre-harvest application of inorganic sources of nutrients on yield attributes and yield of broccoli

Treatment	Curd length (cm)		Curd diameter (cm)		Marketable curd weight (g)		Marketable yield (t ha^{-1})	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	10.55bc	10.43bc	11.65bc	11.57bc	311.26bc	295.27bc	15.56bc	14.76bc
T_2	15.33ab	15.17ab	16.25ab	16.13ab	445.33ab	430.75ab	22.27ab	21.54ab
T_3	17.25a	17.09a	18.46a	18.35a	525.35a	520.37a	26.27a	26.02a
T_4	12.46abc	12.35abc	13.57bc	13.48abc	375.17b	365.53b	18.76b	18.28b
T_5	13.17abc	13.33abc	14.49ab	14.63ab	404.45ab	417.85ab	20.22ab	20.89ab
T_6	8.14c	8.05c	9.18c	9.15c	165.03c	156.64c	8.25c	7.83c
SEm ±	1.48	1.68	1.46	1.42	42.25	42.31	2.11	2.12
LSD (P=0.05)	1.4	3.7	1.8	2.9	2.3	3.1	2.3	3.1

Means with the same letter are not significantly different, Here, T_1 = soil test based 50% NPK with blanket dose, T_2 = soil test based 75% NPK with blanket dose, T_3 = soil test based 100% NPK with blanket dose, T_4 = soil test based 125% NPK with blanket dose, T_5 = local farmers practice ($N_{138}P_{75}K_{94}S_{27}Zn_5$ kgha^{-1}), T_6 = control

Shelf life of broccoli using low -density polyethylene (LDP; 35 micron) bag

The perusal of data in Table 2 and 3 revealed that treatment T_1 (soil test based 50% dose of NPK with blanket dose) recorded maximum shelf life 5.35 and 5.75 days at room temperature (14-24^{0}C with RH 60-65%) and 19.47 and 20.33 days at cold storage (4^0C with RH 90-95%) condition and minimum shelf life 2.35 and 2.33 days at room temperature (14-24^0C with RH 60-65%) and 12.34 and 12.73 days at cold storage (4^0 C with RH 90-95%) condition recorded in treatment T_4 (soil test based 125% NPK with blanket dose) using Low -Density Polyethylene (LDP; 35 micron) bag during the years of 2019-20 and 2020-21, respectively.

Shelf life of broccoli using high -density polyethylene (HDP; 15 micron) vacuum pack

The perusal of data in Table 2 and 3 revealed that treatment T_1 (soil test based 50% dose of NPK with blanket dose) recorded maximum shelf life 6.57 and, 6.83 days at room temperature (14-24^0C with RH 60-65%) and 23.65 days, 24.25 days at cold storage (4^0C with RH 90-95%) condition and minimum shelf life 3.38 days and 3.25 days at room temperature (14-24^0C with RH 60-65%) and 15.25 and 14.25 days at cold storage (4^0C with RH 90-95%) condition recorded in treatment T_4 (soil test based 125% NPK with blanket dose) using High -Density Polyethylene (HDP; 15 micron) vacuum pack during the years of 2019-20 and 2020-21, respectively.

Shelf life of broccoli when treated with 2% egg shell power solution

The perusal of data in Table 2 and 3 revealed that treatment T_1 (soil test based 50% dose of NPK with blanket dose) recorded maximum shelf life 3.53 and 3.67 days at room temperature (14-24^0C with RH 60-65%) and 15.75 and 15.33 days at cold storage (4^0C with RH 90-95%) condition and minimum shelf life 2.35 and 2.33 days at room temperature (14-24^0C with RH 60-65%) and 12.34 and 12.73 days at cold storage (4^0C with RH 90-95%) condition were recorded in treatment T_4 (soil test based 125% NPK with blanket dose) when broccoli was treated with 2% egg shell power solution during the years of 2019-20 and 2020-21, respectively.

Shelf life of broccoli when treated with 2% ascorbic acid solution

The perusal of data in Table 2 and 3 revealed that treatment T_1 (Soil test based 50% dose of NPK with blanket dose) recorded maximum shelf life 3.77 and 3.25 days at room temperature (14-24^0C with RH 60-65%) and 14.25 and 15.50 days at cold storage (4^0C with RH 90-95%) condition and minimum shelf life 1.85 and 1.75 days at room temperature (14-24^0C with RH 60-65%) and 10.45 and 11.23 days at cold storage (4^0C with RH 90-95%) condition were recorded in treatment T_4 (Soil test based 125% NPK with blanket dose) when broccoli was treated with 2% ascorbic acid solution during the years of 2019-20 and 2020-21, respectively.

Shelf life of broccoli in control

The perusal of data in Table 2 and 3 revealed that treatment T_1 (Soil test based 50% dose of NPK with blanket dose) recorded maximum shelf life 2.50 and 2.75 days at room temperature (14-24^0C with RH 60-65%) and 13.37 and 13.53 days at cold storage (4^0 C with RH 90-95%) condition and minimum shelf life 1.57 and 1.55 days at room temperature (14-24^0C with RH 60-65%) and 10.38 and 10.25 days at cold storage (4^0C with RH 90-95%) condition at open place were recorded in treatment T_4 (Soil test based 125% NPK with blanket dose) during the years of 2019-20 and 2020-21, respectively.

Maximum shelf life in both the storage conditions usingHigh- 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 CO_2 and O_2 around the produce might have further slowed down the 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 reduces the rate of respiration, and delayed senescence during storage of curds. Pre-harvest application of judicious inorganic sources of nutrients in broccoli production and better storage conditions along with appropriate use of scientific storage materials such as High- Density Polyethylene (HDP; 15 micron) vacuum pack might have protected the chlorophyll degradation and ethylene production. In addition, 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 reduces weight loss. This might have maintained the shelf life and quality of broccoli. The findings of present investigation in respect of shelf life corroborate the findings of Jadhav et al. (2018) in broccoli.

Table 2. Shelf life (days) comparison of treatment at each level ofstorage materials under different storage condition (2019-20)

Treatment	Shelf life(days) at room temperature (14-24°C with RH 60-65%)					Shelf life(days) at cold store (4°C with RH 90-95%)				
	storage materials					storage materials				
	LDPE Polyethylene bag	HDPE Vacuum pack	2% Egg shell power solution	2% Ascorbic acid solution	Control	LDPE Polyethylene bag	HDPE Vacuum pack	2% Egg shell power solution	2% Ascorbic acid solution	Control
T_1	5.35a	6.57a	3.53a	3.25a	2.50a	19.47a	23.65a	15.75a	15.50a	13.37a
T_2	4.19b	4.77b	2.71b	2.61b	2.21b	15.65b	18.41b	13.24b	13.16b	10.98b
T_3	3.27c	3.90c	2.55b	2.53b	2.11bc	13.49c	16.33c	12.53c	12.33c	10.66bc
T_4	2.35d	3.38d	1.85c	1.75c	1.57c	12.34d	15.25d	11.37d	11.23d	10.38c
T_5	2.39d	3.51c	2.53b	2.33b	1.75bc	12.37d	15.29d	11.55d	11.38d	10.75bc

Different letters within the same column in each treatment indicate a significant different ($P \leq 0.01$). Here, T_1 = Soil test based 50% NPK with blanket dose, T_2 = Soil test based 75% NPK with blanket dose, T_3 = Soil test based 100% NPK with blanket dose, T_4 = Soil test based 125% NPK with blanket dose, T_5 = Local Farmers Practice ($N_{138}P_{75}K_{94}S_{27}Zn_5$ kgha^{-1})

Table 3. Shelf life (days) comparison of storage materials at each level of treatment under different storage condition (2020-21)

Treatment	Shelf life(days) at room temperature (14-24°C with RH 60-65%)					Shelf life(days) at cold store (4°C with RH 90-95%)				
	storage materials					storage materials				
	LDPE Polyethylene bag	HDPE Vacuum pack	2% Egg shell power solution	2% Ascorbic acid solution	Control	LDPE Polyethylene bag	HDPE Vacuum pack	2% Egg shell power solution	2% Ascorbic acid solution	Control
T_1	5.75a	6.83a	3.67a	3.77a	2.75a	20.33a	24.25a	15.33a	14.25a	13.53a
T_2	3.83b	4.33b	2.75b	2.65b	2.25ab	15.75b	18.47b	13.57b	12.67b	11.49b
T_3	3.25bc	4.05b	2.63bc	2.57bc	2.13ab	14.33c	15.65c	12.33c	11.83c	10.53c
T_4	2.33d	3.25c	1.75c	1.85c	1.55b	12.73d	14.25d	11.25d	10.45d	10.25c
T_5	2.75cd	3.77bc	2.46bc	2.25bc	1.87b	12.85d	15.33c	11.73cd	11.15cd	10.33c

Different letters within the same column in each treatment indicate a significant different ($P \leq 0.01$). Here, T_1 = Soil test based 50% NPK with blanket dose, T_2 = Soil test based 75% NPK with blanket dose, T_3 = Soil test based 100% NPK with blanket dose, T_4 = Soil test based 125% NPK with blanket dose, T_5 = Local Farmers Practice ($N_{138}P_{75}K_{94}S_{27}Zn_5$ kgha^{-1})

Economic consideration

The perusal of data in Table 4 and 5 revealed that maximum gross return of BDT 394050 and 390300 ha^{-1}, maximum net return of BDT 286680 and 282382 ha^{-1} and Benefit Cost Ratio (BCR) with 3.67 and 3.62 were recorded in the treatment T_3 (soil test based 100% dose of NPK with blanket dose) in the year of 2019-20 and 2020-21, respectively.

Table 4. Economic analysis of broccoli production as influenced by different inorganic sources of nutrients (2019-2020)

Treatment	Marketable Yield (t ha^{-1})	Total cost of production (BDT ha^{-1})	Gross return (BDT ha^{-1})	Net return (BDT ha^{-1})	Benefit Cost ratio (BCR)
T_1	15.56	102130	233400	131270	2.29
T_2	22.27	104750	334050	229300	3.19
T_3	26.27	107370	394050	286680	3.67
T_4	18.76	109990	281400	171410	2.56
T_5	20.22	116243	303300	187057	2.61
T_6	8.25	88407	123750	35343	1.40

Table 5. Economic analysis of broccoli production as influenced bydifferent inorganic sources of nutrients (2020-2021)

Treatment	Marketable Yield t ha^{-1}	Total cost of production (BDT ha^{-1})	Gross returns (BDT ha^{-1})	Net returns (BDT ha^{-1})	Benefit Cost ratio (BCR)
T_1	14.76	102678	221400	118722	2.16
T_2	21.54	105300	323100	217800	3.07
T_3	26.02	107918	390300	282382	3.62
T_4	18.28	110552	274200	163648	2.48
T_5	20.89	115147	313350	198203	2.72
T_6	7.83	87858	117450	29592	1.34

Sale rate of broccoli @BDT 15Tk/kg

T_1 = soil test based 50% NPK with blanket dose, T_2 = soil test based 75% NPK with blanket dose, T_3 = soil test based 100% NPK with blanket dose, T_4 = soil test based 125% NPK with blanket dose, T_5 = local farmers practice ($N_{138}P_{75}K_{94}S_{27}Zn_5$ $kgha^{-1}$)

Whereas, minimum gross return of BDT 123750 and 117450 ha^{-1}, minimum net return of BDT 35343 and 29592 ha^{-1} and Benefit Cost Ratio (BCR) with 1.40 and 1.34 were noted in T_6 (control) in the year of 2019-20 and 2020-21, respectively. The present findings indicate that treatment T_3 (soil test based 100% dose of NPK with blanket dose) was the maximum profitable treatment for broccoli production which could generate maximum net income with maximum Benefit Cost Ratio (BCR) as compared to other treatments. The results of present investigation corroborate the finding of Sharma et al. (2018) in broccoli.

CONCLUSION

Growers or entrepreneurs might have applied soil test based 100% dose of NPK with blanket dose for commercial purpose and 50% dose of NPK for consumption and getting anticipated quality attributes of broccoli. In addition, combined use of soil test based 50% dose of NPK along with High- Density Polyethylene (HDP; 15 micron) vacuum pack has been considered as an effective technology for maintaining the shelf life of broccoli both at room temperature (14-24^{0}C with RH 60-65%) and at cold storage (4^{0}C with RH 90-95%) condition.

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