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Impact of Polyhouse on Production Potential of Bitter Gourd in Off-season

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Abstract: In Bangladesh, the bitter gourd, which is a vegetable, is a wonderful source of magnesium, folate, zinc, phosphorus, and vitamins B1, B2, and B3. It also contains a high level of dietary fiber. From December 2020 to April 2021, an experiment was carried out in the field laboratory of Bangladesh Agricultural University, Mymensingh, to determine how the polyhouse and the local environment affected the growth and yield of bitter gourd during the off-season. It was a factorial experiment using RCBD (Randomized Completely Block Design), in which Factor A represented the impact of a polyhouse and Factor B represented the influence of the environment on the development and yield of bitter gourd during the off-season. Results showed that photochemically active radiation decreased within the polyhouse compared to the open area outside. In terms of soil temperature, soil moisture, and air temperature, a reverse trend was seen. In comparison to an open field during the winter, the polyhouse had higher air, soil, and soil moisture temperatures. Compared to plants cultivated in open fields, bitter gourd plants planted in poly houses had longer stems, more branches, blooms, and higher reproductive efficiency, which led to more fruit setting plants-1 and a higher fruit yield. Additionally, the fruit size in the polyhouse was greater than it was in the open field situation. In comparison to open fields, the fruit output of bitter gourd was approximately 2.5 times higher in polyhouses, which will be helpful to meet up the nutritional demand in the off-season.

Keywords: Bitter gourd; Growth; Polyhouse; Yield.

INTRODUCTION

In Bangladesh, the bitter gourd (Momordica charantia L.) is one of the most significant and widely grown vegetables. The bitter gourd is a tropical vegetable that grows quickly. A relatively less expensive source of vitamins and minerals is bitter gourd. The fruit is regarded as a tonic, stomachic, stimulant, emetic, antibilious, laxative, and alternate in Ayurvedic medicine. According to Dhalla et al. (1991), the fruit is beneficial for treating gout, rheumatism, subacute canes of the spleen, and liver illness. The bitter gourd has a substance called charantin that is used to treat diabetes by lowering blood sugar levels (Lottikar et al., 1976).

Bitter gourd is temperature loving crop. Bitter gourd production is hampered in winter season due to cool weather. In a polyhouse, one may partially regulate the microclimate, which has a significant impact on plant development and growth. In temperate climates, polyhouses are used to effectively raise fruits, vegetables, and flowers. It makes it simple for light or short-wave radiation to enter and traps the long-wave radiation that is emitted. As a result, the polyhouse's interior air temperature rises. Thus, the inside of a polyhouse become warmer in winter season (Montero and Anton, 2003) which is favorable for bitter gourd cultivation in winter. Around the world, more than fifty nations have employed polyhouse technology to grow crops. It's just recently that this technology has been used in India to produce vegetables. Fresh vegetables are consistently in high demand throughout the entire year.

Many vegetables can only be cultivated in one season and cannot be grown in the following season. The alternative is polyhouse farming, which makes it easier for them to produce during the off-season. Consequently, the polyhouse setting might open up new opportunities for the industrial production of high-value crops. However, the viability of this technology and its impact on the production of bitter gourds in Bangladesh's agro-ecological settings are not well understood. Plant growth and productivity are governed by phenological development (Awal and Ikeda, 2003). Temperature has a significant impact on the phonological growth and productivity of crop plants. High temperatures promote the growth and development of plants. Cultivation of vegetables under polyhouse in off-season of a crop is economically suitable as reported by many workers (Baytorun et al., 1999; Arora et al., 2002; Kang and Sidhu, 2005 and Aberkain et al., 2006). Hi-tech Glasshouse technology involves significant upfront costs and high production costs. Due to the substantial capital investment required, small and medium farmers cannot afford such technology. Therefore, for nursery growing and off-season vegetable production, low cost, locally accessible materials like bamboo and UVS translucent polythene have been shown to be successful. The production of vegetables like tomato, sweet pepper, broccoli, okra etc. has resulted into higher yield under polyhouse in off-season which fetched premium prices in the market. Thus, this simple low-cost polyhouse can prove quite useful for small and marginal farmers who want to take nursery and off-season vegetable production as agri-business.

There is a great possibility of increasing bitter gourd yield in off-season (winter season) under polyhouse (IARI, 2009) but this technique has not yet been used in Bangladesh. Therefore, the current experiment was carried out to compare the growth, yield attributes, and yield potentials of bitter gourd grown in polyhouse and open field, as well as to evaluate the microclimatic differences such as photo synthetically active radiation, air and soil temperature, and soil moisture inside and outside of polyhouse.

MATERIALS AND METHODS

Experimental site and climate

The experiment was conducted between 10 December 2020 and 28 April 2021 in the Field Laboratory, Department of Crop Botany, Bangladesh Agricultural University in Mymensingh. Geographically, the experimental location is situated 18 meters above sea level at 24075 N latitude and 90050 E longitude. The experimental field was a medium-high piece of land in the Old Bahmaputra Flood Plain's AEZ-9 that belonged to the Sonatola Soil Series of Grey Floodplain soil (FAO, 1988). It was a silty loam soil. The experimental field was located in a subtropical climate with considerable rainfall from May to September and little rain from October to March. March to October is the hot and rainy season, with temperatures varying from 15 to 250 C during the cold months of November to February.

Experimental treatments and design

The goal of the experiment was to determine how the polyhouse climate influenced bitter gourd plant growth and development during the off-season. The two environmental conditions used in the experiment are the open field condition and the polyhouse-created microclimate variation. Two blocks made up the experimental field. A block was chosen for polyhouse treatment, and a different block was chosen for open field treatment (control). The area was divided into three plots, each of which contained two pits and signified a replication, for the polyhouse block. The wide area was divided into three plots, each of which contained two pits and represented a replication of the previous plot. The size of the unit plot was 2.0 m x 2.0 m. Distances between block to block and row to row was 1.0 meter. Plant to plant distance was maintained at two meters. The pit size was 50 × 50 × 30 cm. Each unit plot contain two pits and distance between the pits was 2.0 m. The experiment in question used a hybrid bitter gourd seed.

Fertilizers and sowing of seeds

The fertilizer dosages were as follows: 3000 kg of cow dung, 150 kg of urea, 125 kg of triple super phosphate (TSP), and 100 kg ha-1 of muriate of potash (MP). During the last stage of land preparation, the entire amount of cow dung, TSP, MP, and half of urea were administered as a basal dose. Pit soil was fertilized with manure, and the pits were left open for two weeks prior to planting. The remaining urea was top-dressed at 30 and 60 days following germination in two equal portions, and the remaining TSP and MP were treated during pit preparation. On December 28, 2020, the seeds for bitter gourd were planted. In each pit, six seeds were inserted around 3–4 cm below the soil's surface. Seedlings were thinned after 15 days of germination so that pit-1 could grow and develop in proper ways.

Intercultural operations

Irrigations were done at 25 and 65 DAP. Weeding was done at 25, 55 and 70 DAP. However, seedlings were constantly being watched carefully. Throughout the cropping season, several intercultural procedures that were required for the plant's optimal growth and development were carried out. At flowering, few plants were affected by aphid. To control aphid, Malathion 57 EC was sprayed @ 25 L ha-1 at afternoon by using a sprayer. Rigon 60 EC was applied at 30 and 45 DAP for controlling red pumpkin beetle. To ensure optimal output, bamboo trailing was created as a technique of propping, allowing simple creeping and preventing the plant from lodging.

Parameters measured

Harvesting of fruits was started from 23rd January and continued until 28th April, 2021. Bitter gourd fruits were picked on the basis of horticultural maturity size, color and

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age. Due to the bitter gourds' quick growth and quick transition past the marketable stage, frequent plucking at intervals of five days was carried out during the harvesting period. The five days interval flowers count was recorded from days to flowering start until flowering ceased. The total number of flowers produced on every plant of the crop life was calculated from collected data. The ratio of total blooms to total fruits on a plant was computed, multiplied by 100, and expressed as a percentage. The five days interval fruits count was recorded from days to first harvest start until final harvest. The total number of fruits produced on every plant of the crop life was calculated from collected data.

Determination of soil moisture and temperature

Different mulched plots' variations in soil moisture during the crop's various growth phases were estimated by weighing and drying of the representative soil samples in oven at 80 0C for 72 hours (Gravimetric method). At a depth of 5 cm, in three-hour intervals between 9.00 am and 5.00 pm, the diurnal variation in soil temperature as affected by various mulches was monitored. In the second week of January and February 2022, the experimental sites' soil temperatures were measured on sunny days. A metal-cased soil thermometer was used to measure the soil's temperature.

Meteorological parameters

The Photo synthetically active radiation (PAR) was recorded on 15 January, 2021 at open field and polyhouse above the canopy with a portable quantum sensor (SKP 22000, UK) from 10:00 AM to 15:00 PM, every hour. Using a portable psychrometer (Testo 615, Germany), the air temperature was measured on January 15 and February 15, 2021, in an open field and a polyhouse at hourly intervals between 9.0 AM and 15.0 PM.

Statistical analysis

The statistical computer program MSTAT-C (Russell, 1986) was used to evaluate the acquired data using the analysis of variance (ANOVA) method and Duncan's Multiple Range Test (DMRT) to correct for mean differences.

RESULTS

Microclimatic conditions of polyhouse and open field

Photo synthetically active radiation (PAR) was measured on 15 January. Result revealed that incident PAR increased gradually from sunrise till 12.00 noon and thereafter decreased until sunset (Fig. 1A). Incident PAR was higher in open field than that of polyhouse. In polyhouse, PAR did not decline from 12.00 noon to 15.00 PM while PAR decline after 13.00 PM in open field. Lower PAR under polyhouse as compared to open space might be attributed for the interception of incoming radiation for the roof of polyhouse. Some part of radiation was also reflected by the roof of polyhouse which causes lowed PAR under polyhouse (Marcelis et al., 2006).

Air temperature was measured on 15 January 2021. The results showed that the air temperature was low in the morning and rose as the day progressed until 13:00 PM, after which it began to fall until 17:00 PM (Fig. 1B). The air inside the polyhouse was consistently 1- 20C warmer than the air outside. Short-wave radiation can easily enter polyhouses, whereas long-wave radiation is trapped as it leaves. As a result, the polyhouse's interior air temperature steadily rose as a result of the greenhouse effect (Saikia et al., 2001). As a result, a polyhouse's interior gets warmer and
warmer.

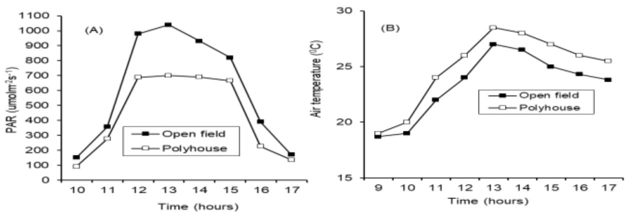

Figure 1. Diurnal trend of (A) Photosynthetically active radiation (PAR) and (B) Air temperature on 15 January 2021.

Soil temperature and moisture

Soil temperature was measured on 15 January 2021. The findings revealed that the soil temperature was low in the morning and gradually rose throughout the day until 13:00 PM, after which it began to fall until 17:00 PM (Fig. 2). 2-40C warmer soil was found inside the polyhouse than in the surrounding open area. Short-wave radiation can enter the polyhouse with ease, and long-wave radiation can only leave if it is trapped. The greenhouse effect had the effect of progressively raising the air temperature within the polyhouse (Saikia et al., 2001). In a polyhouse, the interior gets warmer and warmer as a result. As a result, the temperature of the soil was also greater under the polyhouse than in the open field (Montero and Anton,2003).

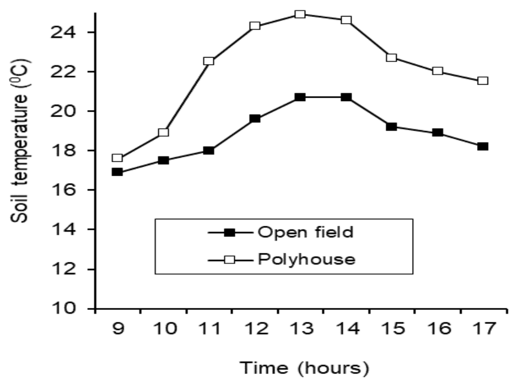

Figure 2. Diurnal trend of soil temperature with time in the polyhouse and the open field on 15 January 2021.

Soil temperature was measured at 80, 100, 120 and 140 DAP (Table 1). Results showed that soil moisture

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decreased with time both in polyhouse and open field but the decrement was lesser in polyhouse than open field. The higher soil moisture percentage at all growth stages was recorded in polyhouse than in open field. This indicates that the polyhouse had a higher capacity to preserve water than an open field. According to Panday et al. (2004), polyhouse is known to considerably improve soil moisture in the 0–25 cm soil depth range, which corroborated the results of the current experiment.

Table 1. Effect of cultivation condition on soil moisture content at 10 cm depth in soil at different days after planting of bitter gourd field

Cultivation condition	Soil moisture content at different days after planting (DAP)			
	80 DAP	100 DAP	120 DAP	140 DAP
Open field	25.25	23.90	20.60 b	18.70 b
Polyhouse field	26.13	24.00	22.70 a	21.20 a
F-test	NS	NS	**	**
CV (%)	2.81	4.13	2.63	2.86

In a column, figures bearing same letter (s) do not differ significantly at P ≤0.05 by DMRT; Sig. = Significance; ** indicate significant at 1% level of probability; NS = Not significant.

Vegetative development

Number of vine plant-1 was measured from 70 to 180 DAP at 10 days interval (Fig. 3). Results revealed that vine number increased with age. The vine number plant-1 was significantly greater in polyhouse than open field. The experimental duration was December to May. In December to February, the air temperature was congenial in polyhouse due to increased air temperature than open field which enhance growth and development of bitter gourd plant and increased vine number in polyhouse compared to open field.

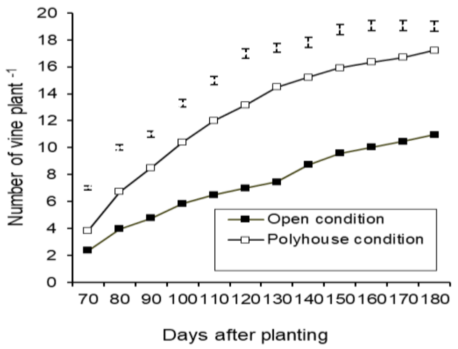

Figure 3. Vine production of bitter gourd at different days after planting under polyhouse and natural conditions. Vertical bars represent LSD (0.05).

Main vine length was measured from 70 to 180 DAP at 10 days interval and presented in (Fig. 4). Results showed that main vine increased with age. The main vine was significantly higher in polyhouse than in open field. The vine length was higher in polyhouse than open fields because of variation of temperature. The air temperature was higher and congenial than open field which enhance growth and development of bitter gourd plant and increased vine length in polyhouse compared to open field.

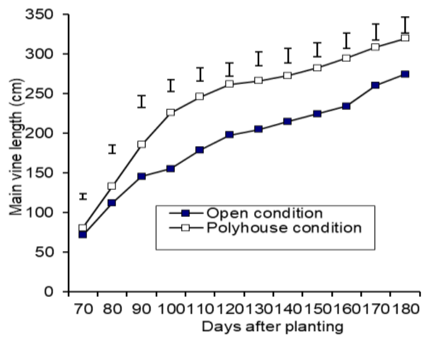

Figure 4. Variation in main vine length of bitter gourd at different days after planting under polyhouse and natural conditions. Vertical bars represent LSD (0.05)

Yield contributing characters and fruit yield

The effect of cultural condition on flower production of bitter gourd at different growth stages was significant (Table 2). Results further revealed that flower production was greater in plants grown under polyhouse than the plants grown under open field. However, the total flower production was higher and almost double in polyhouse condition (77.5 plant-1) as compared to open field condition (37.2 plants-1). The flower production was higher in polyhouse because of increased number of flowers bearing nodes (for increase number of branches and longer main stem and branches in polyhouse than open space) plant as compared to open space plant.

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Table 2. Effect of cultivation condition on yield attributes of bitter gourd

Treatment	Flowers plant-1 (no)	Fruits plant-1 (no)	RE (%)	Fruit length (cm)	Fruit diameter (cm)	Single fruit weight (g)	Fruit weight plant-1 (kg)
Natural condition	37.4 b	20.2 b	57.1 b	14.38	4.00 b	51.56 b	0.88 b
Polyhouse condition	77.5 a	46.4 a	76.2 a	14.70	4.36 a	63.29 a	2.61 a
F-test	**	**	**	NS	*	**	**
CV (%)	16.3	21.1	15.9	3.22	4.62	5.30	16.7

NS = Not significant; *, ** indicate significant at 5% and 1% level of probability, respectively

The effect of cultural condition on fruit production in bitter gourd was significant (Fig. 5). Results revealed that fruit production increased with time till 140-150 DAP followed by a decline with age. Results further revealed that fruit production was greater in plants grown under polyhouse than open field grown plants at all growth stages. However, the total number of fruits plant-1 was higher and almost double in polyhouse condition (46.42 plant-1) compared to open field condition (20.19 plant-1). The fruit number was higher in polyhouse because of production of increased flowers plant-1 as well as reproductive efficiency (Table 2) compared to open field condition. Joshi and Srivastava, (2002) reported that fruit number was greater under polyhouse condition than open field condition that supported the experimental result.

The effect of cultivation condition on reproductive efficiency (RE) of bitter gourd was significant (Table 2). The RE was higher in polyhouse (76.2%) than open field (57.1%). The RE was higher in polyhouse because of less shedding flowers compared to open field condition due to congenial temperature was present there (Fig. 1). Fruit length had no significant influence by cultivation condition but fruit diameter was significantly influenced by cultivation condition (Table 2). The higher fruit length and diameter was recorded under polyhouse condition compared to open field condition. The single fruit weight was significantly greater in polyhouse as compared to open space due to increased fruit length and diameter. Pandey et al., (2004) observed that fruit size was higher in polyhouse as compared to open field condition.

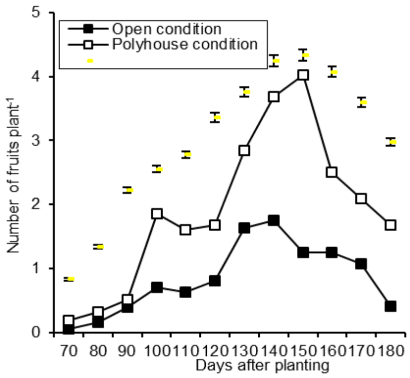

Figure 5. Effect of cultivation condition on fruit production and yield at different days after planting of bitter gourd.

Fruit yield plant^{-1}

Fruit yield plant-1 was significantly higher in polyhouse than in open space condition at all harvesting stages (Fig. 5). The fruit yield plant-1 increased till 140-150 DAP followed by a sharp decline. The fruit yield was higher in polyhouse might be due to increased number of fruits plant-1 and increase fruit size (Table 2). The higher fruit yield plant-1 was recorded in polyhouse (2.67 kg plant-1) as compared to open field condition (0.98 kg plant-1) due to increased production of fruits at all growth stages. The bitter gourd produced roughly 2.5 times as much fruit in a polyhouse as it did in an open field, making it more profitable to cultivate commercially during the off-season. Fruit yield increased under polyhouse compared to open field condition during off-season as reported by many workers workers (Paez et al., 2000; Saikia et al., 2001; Joshi and Srivastava, 2002; Cheema et al., 2004 and Singh et al., 2004).

CONCLUSION

From the results, it may be concluded that in the winter, which is the off-season for growing bitter gourds, microclimates such as air and soil temperature and soil moisture increased over open fields, providing a favorable environment for bitter gourd growth and development. As a result, bitter gourds were more able to flower and set fruit in polyhouses than in open fields, yielding 2.5 times more fruit, that will meet up the nutritional demand of bitter gourd in the off-season.

Conflict of Interest

There is no conflict of interest to declare.

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