

A Study on Sustainable Cultivation of Broccoli in a Naturally Ventilated Greenhouse in Warm and Humid Climatic Condition

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ABSTRACT: The suitability of a low-tech naturally ventilated greenhouse was evaluated for cultivation of broccoli in warm and humid climate i.e. in coastal Odisha, Bhubaneswar, Odisha, India because of its increasing demand among the consumers. The cultivation of this vegetable was tried in winter days of the year 2013-14. It was observed that the crop yield was more in the greenhouse as compared to the open field condition. The greenhouse with shade net was observed to be a suitable protected condition for better plant growth and higher yield compared to without shade net for less variation in temperature due to partial elimination of incoming solar radiation by the shade net during day hours and prevention of the radiative losses to the cold night sky thus maintaining a better heat distribution inside the greenhouse. The yield of broccoli per square meter of the cultivated area in the greenhouse was found to be 2.9 times more than open field condition. The small and marginal farmers of Odisha will be able to grow broccoli and other high value vegetables in such type of naturally ventilated greenhouse which would be quite remunerative and enhance their livelihood sustainably through higher market price due to the greater demands and higher nutritive values.

Key words: Greenhouse, solar energy, broccoli, vegetable cultivation, shade net.

INTRODUCTION

Cultivation of crops is mainly climate dependent in normal conditions. Hence, all vegetables have their own seasons in which they can be grown. But with the introduction of green house technology (Nelson, 1985), farmers can be able to grow various vegetables during off season to fetch a good market value. The increasing demand of the highly nutritious and protein rich vegetable like broccoli throughout the year in the big cities can be met by growing the crop in a partially controlled environment and low cost greenhouse. The favorable environment in the greenhouse not only enhances the productivity but also creates a good market of fresh vegetable during the off-seasons by providing the maximum returns to the growers. The ideal period for the cultivation of broccoli is from September to mid December in the moderate temperature range of 25-30 °C (Anonymous 2010). As there are many small and marginal farmers in Odisha, hence the suitability of a low-tech naturally ventilated greenhouse was evaluated for cultivation

of broccoli in coastal Orissa because of its high demand during pre-summer period. The cultivation of this vegetable was tried in winter days of the year 2013 with three dates of sowing under both open field and greenhouse condition to evaluate and compare its different growth parameters, yield and yield attributing characters and to harvest during pre-summer period as an off season vegetable. Looking into the demands of broccoli during off-season and importance of maintaining suitable temperature inside the greenhouse for the growth of broccoli, experiments were conducted under greenhouse and open field conditions with the objective of comparing the growth and yield of broccoli both inside greenhouse and in open field condition

MATERIALS AND METHODS

Experimental Site

A semi circular shaped greenhouse (Fig. 1) covering the floor space of 4 m x 12 m (48 sq m) oriented in

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East-West direction (Singh and Tiwari 2000) was used for study. The greenhouse was covered with ultra violet (UV) low density polyethylene (LDPE) film of 200 micron thickness. The greenhouse was covered with a netlon make shade net of 50 per cent as a shading device (Sharma 1998) as and when required. The experimental greenhouse is located in the Central Farm of Orissa University of Agriculture and Technology, Bhubaneswar and experimental

observations were taken during the year 2013-14. The place is situated at 20°15'N latitude and 85°52'E longitude with an elevation of 25.9 m above the mean sea level and nearly 64 km west of the Bay of Bengal and coming under the warm and humid climatic condition. The mean air temperature varies from 25 to 37.17 °C in summer, 24.53 to 32.72 °C in rainy and 14.88 to 28.33 °C in winter seasons. The photograph of experimental greenhouse is shown in Fig. 2.

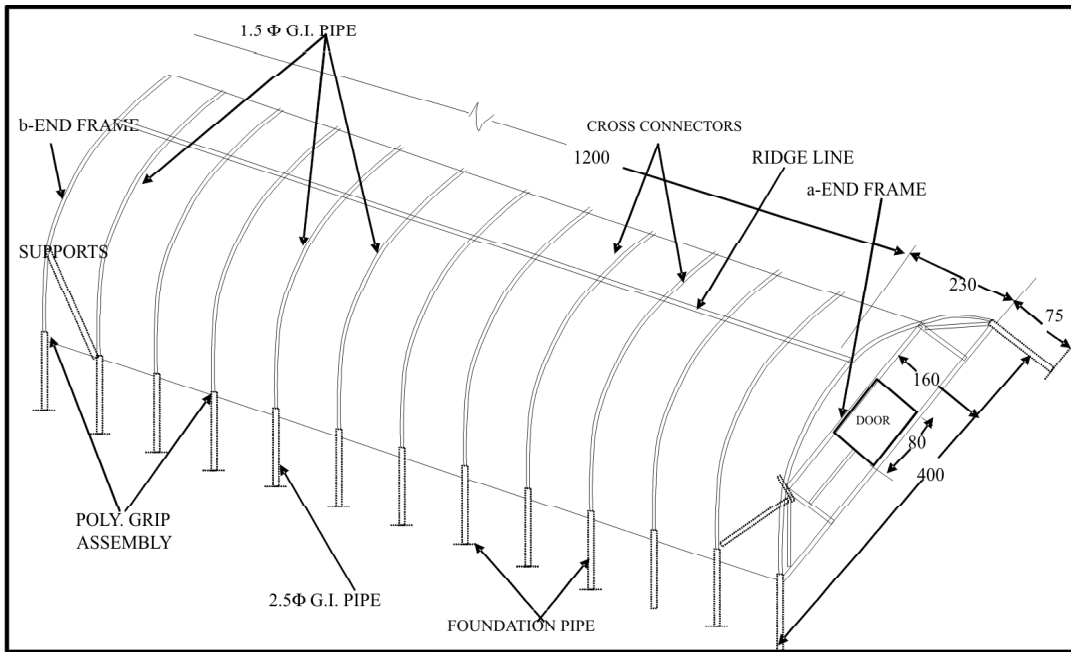


Figure 1: Semi cylindrical greenhouse (all dimensions in cm)



Figure 2: Photograph of experimental greenhouse

EXPERIMENTAL DESIGN

The experiment was laid out in a Complete Randomized Design (CRD) with six different treatment combinations of factor A and factor B in four replications (Das, 2010). The details of layout are shown below.

Greenhouse (G_1)		Sowing date	Open field (G_2)	
R_1	R_3	S_1	R_1	R_3
R_2	R_4		R_2	R_4
R_4	R_1	S_2	R_4	R_1
R_2	R_3		R_2	R_3
R_3	R_4	S_3	R_3	R_4
R_1	R_2		R_1	R_2

Layout for broccoli plantings

Size of the greenhouse: 12m x 4m	<i>Factor A: Growing condition</i> G_1 : Naturally ventilated greenhouse
Single plot size: 1.80m x 1.96m	G_2 : Open field as control
Number of plants/plot: 15	<i>Factor B: Date of planting</i>
Spacing: 0.4 m x 0.6m (plant to plant/row to row)	S_1 : 02-09-2013
Variety Pusa broccoli KTS-1	S_2 : 21-09-2013
	S_3 : 12-10-2013

RESULTS AND DISCUSSION

Germination and growth of Seedlings

It was noticed that the seeds were germinated after 4 and 10 days of sowing for inside and outside of the greenhouse respectively. The seedlings in the greenhouse were more healthy and lush green in comparison to the outside seedlings. It was observed that the height of the seedlings in the greenhouse was 4-6 cm more than that of the outside seedlings after 20 days of sowing due to the good environmental conditions. The seedlings were ready for transplantation after 20 days and 30 days of sowing for the inside and outside greenhouse respectively. But the seedlings of inside greenhouse were taken for both inside and outside transplantation to keep the planting date same for the study. The cause of delay in readiness of the outside seedlings for transplantation was due to the low temperature range of 20-28 °C in the ambient condition than that of the inside temperature of 25-32 °C.

Vegetative Growth

The height of broccoli plants was measured once in a week. The vegetative growth was not significant for the crop of inside greenhouse as compared to the outside in the initial stage. The outside plants grew faster and attained an average height of 48 cm with the maximum height of 70cm. During that period, the room temperature was varied from 16-33 °C whereas

the ambient temperature was raised from 20-30 °C. The outside condition was more favorable for promoting the vegetative growth of plants than that of the inside greenhouse. Also the greenhouse which was covered with the movable insulation during the day time created an unfavorable environment for photosynthesis process resulting in poor vegetative growth. The bud formation was also delayed by 10 days inside the greenhouse than the outside due to the same reason. When the movable insulation was no more used during the day time from 23-11-2013, the height of the inside plants was found to be increased but the growth of the outside plants remained almost constant after 3rd week of December due to the lower ambient temperature range of 15-23 °C. It was also observed that during the winter period the temperature of inside greenhouse was about 10-13 °C higher during the day time in comparison to the outside temperature due to the reduction of heat losses through shade net used in the greenhouse. The temperature of the inside greenhouse was 8 °C higher at night in December and January than the outside air temperature, due to the use of movable insulation at night. The average heights of the inside plants were observed to be 54 cm, 59 cm and 55 cm up to 20-03-2014 for the transplanting I, II and III respectively.

Head Formation and Yield

Head formation and the harvesting of broccoli were observed at 70-75 days and 90-100 days respectively after planting. The yield of the plants was almost 2.9 times more than the outside condition. In the present study, the total number of the broccoli plants inside the greenhouse was 150 in an area of 48 m². Similarly the total number of broccoli plants outside the greenhouses was 150 in the same area of 48 m². The mature heads of broccoli were harvested by a sharp knife when the bud clusters became compact. The central head was cut with about 10-12 cm of the stem. After cutting the central head of the plant, the growth of the lateral sprouts was promoted. The maximum number of the lateral sprouts was observed to be 5 for the inside plants as compared to 3 for the outside plants. During the head formation period, the temperature variation inside the greenhouse was maintained from 20 °C to 25 °C whereas the ambient temperature was found to be from 14 °C to 22 °C towards the 2nd week of January 2014 and as a result the yield became lower for the outside plants. The average yield per plant in the ground was noticed to be 502 gm and 138 gm respectively for the inside and the outside greenhouse. The average weight of heads

was observed to be 108 gm and 61 gm respectively for the inside and the outside greenhouse. Of course the weight of the healthiest heads was 330.3 gm and 225.5 gm for the inside and the outside greenhouse respectively. The total yield of broccoli was 41.69 kg (35 quintals/acre) and 14.61 kg (12 quintals/acre) respectively for the inside and the outside greenhouse for the same number of plants in an area of 48 m². After 20-03-2014, lateral heads were observed to be very small both from the outside and inside plants for which no yield were obtained.

CONCLUSIONS

On the basis of the above study, the following conclusions are drawn.

1. During peak sunny hours throughout the experimental period, the greenhouse air temperature inside the shade net was only 2 to 3 °C higher than the ambient air temperature and in the night hours, the inside air temperature is 4 to 7 °C higher than the ambient air temperature
2. The observed plant temperature inside the greenhouse with shade net during peak sunny hours is 1 to 2 °C lower than ambient air temperature and during night hours it is observed that, the plant temperature is 2 to 4 °C more than the ambient air temperature.
3. Natural ventilation was done (10 am to 4 pm) to keep the greenhouse air temperature within 3 to 4 °C lower than the ambient air temperature to make it suitable for the growth of the crops inside the greenhouse.
4. The variation of temperature is less in case of greenhouse with shade net than without

shade net due to partial elimination of incoming radiation during sunny hours and preservation of the radiative heat losses to the cold night sky for maintaining better heat distribution inside the greenhouse during night hours due to shade.

5. The yield of broccoli per square meter of the cultivated area in the greenhouse was found to be about 2.9 times more than open field condition irrespective of the date of plantings done for the present study.

Considering the yield, environmental parameters and cost of cultivation, a low cost naturally ventilated greenhouse with shade net is suitable for the cultivation of broccoli for higher yield compared to open field condition in coastal regions of Odisha.

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