Standardization of Production Technology for Cucumber (*Cucumis sativus* L.) under Protected Cultivation

खीरा (*कुकुमिस सटाइवस* एल.) के उत्पादन की तकनीकी का संरक्षित प्रक्षेत्र में मानकीकरण

AVINASH PARASHAR

Thesis

Master of Science in Agriculture

(Horticulture)

उत्तमा वृत्तिस्तु कृषिकर्मैव

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DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE
SWAMI KESHWANAND RAJASTHAN AGRICULTURAL UNIVERSITY BIKANER

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Thesis

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the degree of

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(Horticulture)

BY

AVINASH PARASHAR

2011

Swami Keshwanand Rajasthan Agricultural University, Bikaner

College of Agriculture, Bikaner

CERTIFICATE – I

Dated: 08 / 09 / 2011

This is to certify that **Mr. Avinash Parashar** has successfully completed the Comprehensive Examination held on 26 / 03 / 2011 as required under the regulation for the degree of **Master of Science** in **Agriculture (Horticulture).**

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This is to certify that the thesis entitled ***"Standardization of Production Technology for Cucumber (Cucumis sativus L.) under Protected Cultivation"*** *submitted for the degree of* ***Master of Science in Agriculture*** *the subject of* ***Horticulture*** *embodies bonafide research work carried out by* ***Mr. Avinash Parashar*** *under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged. The draft of the thesis was also approved by advisory committee on 17 / 08 / 2011.*

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Chapter-1

INTRODUCTION

Cucumber *(Cucumis sativus* L.) belonging to family cucurbitaceae is one of the important vegetable crops from nutritional as well as economic point of view. It is a warm season vegetable grown throughout the world under tropical and sub-tropical conditions. It is said to be the native of Northern India *(*Pursglove*,* 1969). The fruit of cucumber is said to have cooling effect, prevent constipation, checks jaundice and indigestion *(*Nandkarni*, 1927).* Besides, the seed of cucumber is used in *Ayurvedic* preparations and raw fruits are also being used in cosmetic preparations. It is reported that oil extracted from seed is good for brain and body. Nutritively 100 g of edible portion of cucumber contains 96.3 g moisture, *2.5* g carbohydrates, 0.4 g protein, 0.1 g fat, 0.3 g minerals, 10 mg calcium, 0.4 g fiber and traces of vitamin C and iron. It is eaten raw with salt and bell pepper or as a component of salad and pickles. The pulp of the fruit is used for making mash cakes. In Rajasthan, the estimated area under this crop is around 3093 hectares with total production of about 10142 metric tonnes (Anonymous, *2008).* The major cucumber growing pockets in Rajasthan are Bharatpur, Alwar, Bhilwara, Jaipur, Tonk, Dholpur and Sawai Madhopur districts.

It is grown throughout the year in Southern states of India. In plains of Northern India, it is grown during summer and rainy seasons. However, it is grown commercially throughout the country. Production of cucumber in India is mainly restricted to its open field cultivation. Nevertheless, biotic and abiotic stresses are the main factors responsible for low yield and poor quality under open field cultivation. Particularly, rainy season crop is always affected by pests and diseases, resulting into low productivity and poor quality of fruits.

India, being a vast country with diverse and extreme agro-climatic conditions, the protected vegetable cultivation technology can be utilized for the year round production of high value quality vegetable crops, with high yield. By protected cultivation, high water and nutrient use efficiencies can be achieved. Increasing photosynthetic efficiency and reduction in transpiratory losses are added advantages of protected cultivation. Both these are of vital role for healthy and luxuriant growth of crop plant. This technology is highly suitable for farmers in periurban areas of the country, especially in Northern plains of India. But protected cultivation requires careful planning and attention including selection of crops, varieties, suitable production technology like spacing, time of planting, water and nutrient management and plant protection to produce economic yield of better quality. Singh *et al*.(2005) suggested that Hasan and Sarig cultivars of cucumber are ideal for cultivation during summer and rainy season, while Muhasun, Isatis, Dinar, Nun 9729, Nun 3019 and Kian can be grown successfully in winter season. They also recommended that 60 cm row to row and 30 cm plant to plant spacing is optimum for cultivation of cucumber under protected condition.

Moreover, parthenocarpic and gynoecious cucumber cultivars increase the potentiality to bear fruit load by the vines in controlled environments resulting in a high harvest index. Plants exhibiting a high harvest index can be grown in limited space in a growth chamber.

Besides, the cultivar and plant geometry, cucumber requires a constant water supply along with fertilizer application to achieve high quality yield. In general, zero energy poly house cucumbers are fertigated through drip system of irrigation according to the crop growth and season of cultivation. Sato *et al.* (2004) observed that the savings in nitrogenous fertilizers by drip irrigation were 28 to 34 per cent over the conventional method of fertilizer application.

Agro shade net a perforated plastic material is used to cut down the solar radiation so as to protect leaves from wilting and scorching. These net are available in three colors i.e. black, green, and white and in different shading intensities ranging from 25 to 75 per cent.

Insect proof net house and agro shade net house are available in different intensities of perforation, ranging from 25 to 60 mesh. Net of 40 and higher mesh are effective means to control entry of most flying insects and to save the crop from viral infestation.

Considering all these aspects, an experiment entitled "Standardization of production technology for cucumber (*Cucumis sativus* L.) under protected cultivation" was conducted at Central Institute of Arid Horticulture, Bikaner and Department of Horticulture, College of Agriculture, Bikaner, with the following objectives :

1. To identify the suitable structure for protected cultivation.
2. To find out the suitable cultivar for protected cultivation.
3. To assess the economic feasibility.

Chapter-2

REVIEW OF LITERATURE

The literature pertaining to the **"Standardization of production technology for cucumber (*Cucumis sativus* L.) under protected cultivation"** are reviewed as under in suitable heads.

2.1 Effect of environments on yield and quality parameters

More *et al.* (1990) reported that cucumber variety 'Poinset' gave a yield of 1.70 kg/plant under poly house as compared to less yield in open conditions, during winter months under North Indian conditions due to low temperatures

Abou-Hadid *et al.* (1994) worked on the soil less culture of *Capsicum annuum* cv. Delphine F_1 in controlled greenhouse conditions using the nutrient film technique (NFT) and rock wool between January and September 1991. Plants grown in NFT produced higher total yields than those in rock wool (4.47 and 3.93 kg/plant, respectively). There was no difference in plant height and leaf number. NFT was more profitable than rock wool, largely due to the extra cost of the rock wool slaps.

Gomez and Hernandez (1994) conducted a comparative study among capsicum cultivars planted on 2nd June in greenhouse condition. They were assessed for flowering dates, beginning of cropping and full cropping, yield in each of four harvests and total yield, and percentage of fruits in four different weight groups. Cultivars Vidi and Elisa gave the higher total yields (30, 030 and 30, 468 kg/ha, respectively), almost twice as high as for cv. Fiuco (16,268 kg/ha) in the first harvest; in this harvest Elisa and Fiuco yielded 6738 and 3417 kg/ha, respectively.

Lange and Combark (1997) reported that, with the use of plastic in August and September harvesting commenced two weeks earlier and higher yield (76t/ha) was obtained in watermelon, compared to uncovered plants (49t/ha).

Ruiz and Romero (1998) stated the effect of rates of N (KNO_3,at 2.5,5,10,20 or 40g/m^2) on yield and quality of greenhouse cucumber cultivar Bunex. Fruits from the 10 and 20g/m^2 treatments were the best for human consumption and economic profit.

Singh *et al.* (1998) reported that structure should be also able to retain the temperature for longer period besides being simple and easily manageable so that even a lay man can built and manage it without any difficulty. The entire feature may not be accommodated in one type of greenhouse.

Singh *et al.* (1998) studied that a prefabricated metal structure of convenient size is installed and polyethylene film is covered over it. This structure is not recommended at all for the region because of poor temperature retention, low crop yield and high installation cost.

Singh and Dhaulakhandi (1998) concluded that the structure does not require much skill in its construction and management. Its cost is lowest among all other greenhouse and being an underground structure heat loss is minimal and temperature retention is high.

Zhao *et al.* (1998) stated that Luhuanggua-11 was the most suitable cultivar of cucumber for protected cultivation. Broeck *et al.* (1999) evaluated eleven cucumber cultivars in a greenhouse condition. Highest crop yield was obtained for BS 19-59 (17.637 kg m^{-2}, 45.21 fruits m^{-2}), while BSK 19-63 obtained the longest fruits on stems (33.8 cm) and LD 97-71-04 obtained the longest fruits on branches (36.6 cm).

Dwivedi and Singh (1999) reported that trench type greenhouse are Leh recommend trench type of greenhouse was suitable in Ladakh hills. This study was conduct by field research laboratory, Leh.

Siwek and Capecka (1999) reported that the vegetative growth was maximum in plants grown in the tunnel where the thermal conditions were best. Early and total marketable yields were highest under the Poly Ethylene tunnel for all cultivars of cucumber. Yield under the Poly Propylene cover were lower but exceeded those in the open field several fold. Yields were highest from Othello which was slightly earlier than Marinda. Gracius variety was reach to early maturity and could not achieve full fruiting potential until late July. There were non significant differences in fruit chemical composition between cultivars. Dry weights and sugar contents were lower under tunnels.

Jeevansab (2000) reported that highest and significant fresh fruit yield (30.5 t/ha) was obtained under poly house followed by open condition (12 t/ha). Similarly capsicum fruits obtained from poly house had a higher ascorbic acid and total soluble solids (TSS) compared to fruits of open field.

Megharaja (2000) reported that Capsicum fruits grown under greenhouse condition were recorded significantly higher TSS and total chlorophyll content (3.24% and 17.54 mg/100 g) as compared to fruits from open condition (1.44 % and 11.36 mg / 100 g respectively).

Megharaja (2000) recorded significantly higher plant height (94.36 cm) number of branches (31.94) and total number of fruits (12.08) in capsicum under poly house condition compared to plants grown under open condition (45.33 cm, 14.25 and 5.43, respectively).

Singh *et al.* (2000) reported that the polythene is also covered by an additional or woolen or cotton sheet because polythene film during night reduce the heat loss during winter. Strong wind does not affect polyethylene cover much and it is long lasting. This structure is therefore, being recommended as a most suitable greenhouse for the region.

Ganesan and Subashini (2001) conducted an experiment on tomato and revealed that the yield of tomato (2985.84 g/plant) grown under the poly house was comparatively better than that grown in open condition (819.94 g/plant) and the increase was nearly 3½ times higher in fruit yield.

Nagalakshmi *et al*. (2001) studied biometric and yield characters in capsicum cv. Green Gold and tomato cv. S-41 raised under greenhouse and open field condition and concluded that there was four fold increased in yield of capsicum (80 t/ha) and two fold increase in tomato (98.5 t/ha) under greenhouse condition as compared to open field condition.

Sriharsha (2001) recorded the highest tomato yield of 35.27 t ha^{-1} in medium cost poly house followed by low cost poly house (31.98 t/ha) and least under open field condition (24.38 t ha^{-}).

Waterer (2002) studied potential benefits of bell pepper by using transparent row covers installed at transplanting and removed as growing conditions improved to promote warm season climate in regions of cool growing season. They were found that the higher duration of row covers other than cool season which exposed crop to higher temperature had reduced growth and yield and also required additional labour and occasionally exacerbated problems with weeds and pests.

Takte *et al.* (2003) reported that unlike plastic film, shade nets can also be used for protection of valuable crops against excess sunlight, cold wind, frost and insect / birds. Ventilation played an important role in crop production under controlled conditions. Which was provided naturally or mechanically to create optimum condition for crop growth.

Ganesan (2003) conducted a study to compare naturally ventilated greenhouse and open field conditions for their effect on yield and quality of fruits of tomato and found that greenhouse with ventilation gaps in four side walls had significantly higher total sugar, reducing sugar, protein and nitrogen content. The lycopene content and chlorophyll content was not much affected compared to open field conditions.

Basavaraja *et al.* (2003) reported that, the higher yields obtained from the poly house might be due to the favorable air temperature, optimum relative humidity and light intensity present in poly house having exhaust fan and cooling system, which had helped in getting good vegetative and reproductive characters in capsicum and okra which in turn resulted in higher economic yield. The interaction effects between growing environment and nutrients were found to be significant both for capsicum and okra indicating the positive and favorable influence of these two characters on yield and growth parameters.

Ganesan (2003) conducted a study to compare naturally ventilated greenhouse and open field conditions for their effect on yield (2145.21g fruits/plant) and quality of fruits of tomato and they were found that greenhouse with ventilation gaps in four side walls had significantly higher total sugar, reducing sugar, protein and nitrogen content. The lycopene content and chlorophyll content was not much affected compared to open field conditions.

Singh *et al.* (2003) observed that the higher productivity of tomato (93.2 t/ha) and capsicum (76.4 t/ha) inside greenhouse was mainly because of higher temperature (4-9^{0}C) obtained during month of December to February and high rate of utilization of carbon dioxide inside greenhouse and its peculiar characters of capsicum like medium height, lateral spreading and fruit set at comparatively lower temperature. Microclimate inside greenhouse during winter months was mainly responsible for better yield due to their beneficial effects of flowering and fruiting.

Fernandez *et al.* (2004) evaluated greenhouse cucumber variety Tropico F_1 grown on perlite substrate or in a hydroponic system during the winter and summer seasons. NFT- grown fruits had darker and greener skin colour than the perlite grown fruits. Fruits grown during winter had darker and dull green skin colour, and were of better quality than fruits grown in spring. Fruit weight and diameter gradually increased during winter, but decreased after the third harvest during spring. The length of NFT and perlite grown fruits significantly varied only during some particular harvest dates during winter. However, perlite grown fruits were larger during spring than winter. Skin colour was found to be the best index of fruit quality in cucumber, although acidity and firmness can also be used to monitor quality particularly during spring.

Singh, (2004) reported that utility of greenhouse for raising virus free healthy seedling of various vegetables during rainy and post rainy season and for raising off season nursery of cucurbits during peak winter month for off season production of these crop may be very successful and can be adopted as a commercial venture by the farmers and unemployed agriculture graduate of our country in major vegetable growing pockets and specially in peri- urban area of the country.

Sanwal *et al*. (2004) reported that tomato varieties gave better yield under poly house condition as compared to open field condition.

Parks *el al.* (2004) observed the yield and fruit quality of mini cucumbers *(Cucumis sativus* cv. Tandora) using different substrates in a run-to-waste system in a greenhouse experiment. There was no significant effect of substrate on dry weight, number of fruits, average weight per cucumber and on the fruit quality measurements. However, differences were observed in colour, deformation, crush strength and dry matter between harvests.

Singh *et al.* (2004) reported that plastic low tunnel technology is a simple, suitable and profitable technology for off season cultivation of cucurbits during the winter season in north plains of the country.

Marsic *et al.* (2005) observed that the highest marketable yield among the salad tomatoes was obtained with ‘Stormy F_1 (4.05 kg per plant) and among the processing tomatoes with ‘Hypeel 108 F_1 (4.7 kg per plant) and ‘Centurion F_1 (4.1 kg per plant). Those cultivars had some good quality characteristics, important for their application (firmness, redness of skin, thickness of pericarp and succulence) in low tunnel production.

Arora *et al.* (2005) screened the hybrid capsicum (Alankar and Callifornia Wonder) for fruit yield and quality when grown under green house. They observed that capsicum hybrid Alankar gave maximum number of fruits (24 fruits/plant) and fruit yield (255.7q/ha^{-1}) whereas least was observed in Callifornia Wonder. Arora *et al*. (2005) also studied the performance of different tomato hybrids under greenhouse condition and reported that hybrid NP-5002 gave significantly higher total fruit yield (596.1 q/ha).

Hemavathi *et al*. (2005) conducted a trial on integrated nutrient management in cultivation of coloured capsicum cv. Orobelle under naturally ventilated green house. They observed that application of 25% of nitrogen through pongamia cake + 75% recommended dose of fertilizer + FYM @ 25 tonnes/ha^{-1} + Azotobactor @ 5 g/plant is most ideal for profitable cultivation of Orobelle under green house condition

Kumar and Kohli (2005) conducted an experiment on capsicum production in naturally ventilated poly house in mid hills of Himachal Pradesh. They observed that comprising (soil : FYM/compost : sand (2:1:1)as growing media, water soluble fertilizer @150kg/ ha^{-1} NPK and use of black polythene as mulch) recorded maximum yield (1243.30 g/plant 9.95 kg/m^2) with average fruit weight (69.93 g). The quality of produce was also higher in comparison to open field conditions.

Mantur *et al.* (2005) assessed the productivity of capsicum grown under shade house as influenced by nutrition and planting geometry. They observed that application of 50% inorganic +50% organic nutrients recorded significantly higher average fruit weight (86.81g) and fruit yield/plant (750.54g).

Munshi and Kumar (2005) conducted an experiment on evaluation of varieties and standardization of planting time for all season production of capsicum under low cost poly house. They observed that Pusa Deepti was the best for low cost poly house cultivation as they showed the highest yield (417q/ $ha^{1)}$ during winter season. Similar set of experiment was also conducted under open field condition to compare the performance. The seed of capsicum grown under open condition either did not germinate or their seedling died.

Pandey *et al*. (2005) compared the performance of capsicum lines under glass house, poly house and open field condition and noted that plant height, length and width of fruit and yield were significantly higher in greenhouse structures than in open field condition.

Srivastava *et al*. (2005) studied the effect of varieties, crop geometry, and canopy management in capsicum (hybrid Indra) in naturally ventilated poly house. They observed that average fruit weight was the highest when individual plants were tailored to have only two shoots with planting done at the widest spacing. The maximum yield (6.14kg/m^2) was obtained when planting done at the narrowest spacing and plants were allowed to have full canopy development, i.e. without any pruning treatment (8.02kg/m^2).

Hazarika and Phookan (2005) recorded quality parameter of different tomato cultivars under poly house and reported that no single cultivar was found to be excellent in qualitative parameter. However, Pusa Ruby and Arka Shreshta recorded the maximum TSS content, whereas the maximum ascorbic acid was recorded in DRD-8014 cultivar.

Rai *et al*. (2005) studied the change in colour and texture of capsicum fruits under poly house and open field condition and concluded that Arun F_1 grown under poly house condition had maximum shelf life.

Tohamy *et al*. (2006) conducted an experiment on pepper and found that additional foliar application of nutrients especially by phosphorus, calcium and potassium can improve growth and yield of pepper plants under protected cultivation.

Gomez-Lopez *et al*. (2006) reported that cucumber fruits grown in a glass house during the winter had a darker and dull green skin colour, and showed better quality than during the spring. In general, fruit quality at harvest in spring was lower than the winter, due to flesh whitening.

Pandey *et al*. (2006) conducted a participatory study in participation with farmers to compare different open pollinated and hybrid varieties of tomato under plastic house condition and found that hybrid gave higher yield potential than open pollinated varieties.

Singh *et al.* (2006) reported that protected cultivation of vegetable offer distinct advances of quality, productivity and favourable market price to growers. Vegetable growers can substantially increase their income by protected cultivation of vegetables in off season.

Singh and Kumar (2006) studies and found that in Northern Plains of Indian low cost naturally ventilated green house can be used efficiently & economically for year round cucumber cultivation.

Pandey *et al.* (2006) observed that under plastic house conditions, tomato fruit set after flowering was the highest in NSITH-162 (93.9%) and the lowest in Avinash-2 (83.1%). NSITH-162 produced the highest marketable fruit yield (89.05 t/ha) and Avinash-2 produced the lowest (51.98 t/ha) and hybrid varieties NSITH-162 and LTH-61 had more yield potentiality than open pollinated variety BL-410 and Avinash-2 .

Pandey *et al*. (2007) studied performance of capsicum varieties under greenhouse and open field condition. They concluded that different capsicum varieties gave higher yield under greenhouse condition as compared to open field condition.

Mantur and Patil (2008) conducted an experiment to found influence of spacing and pruning on yield of tomato grown under shade house. They found higher fruit yield per plant for higher spacing whereas lower spacing produced higher yield per m^2. It was also found the pruning treatment was helpful in significantly higher yield.

Thangam and Thamburaj (2008) conducted a study to compare performance of tomato varieties and hybrids in agro shade net and open field condition. They found that higher plant height, dry matter production and highest mean fruit weight and delayed flowering and more number of days to first harvest were observed under shade net house in variety Avinash- 2.

Demirtas and Ayas (2009) conducted experiment on pepper under green house conditions with irrigation treatment. They observed that effect of irrigation level on the yield, fruit length, diameter and weight, dry matter ratio was significant.

Kurubetta and Patil (2009) conducted an experiment on capsicum hybrids viz., Orobelle, Bombey and Indra under naturally ventilated poly house (NVP), naturally ventilated shadow hall, shadehouse with misting and shadehouse without misting during summer. The hybrid Indra recorded significantly earliest flower initiation (35.42 days), lower time taken for first harvesting (86.00 day) and higher per cent fruit set (45.45) as compared to other two hybrids. The quality parameters like fruit weight (160.00 g), fruit volume (320cc), rind thickness (0.91 cm) and shelf life (8.62 days) also found significantly maximum under naturally ventilated poly house than under naturally ventilated shadowhall.

Singh *et al.* (2010) conducted an experiment on the capsicum under naturally ventilated poly house. They reported that maximum fruit yield (63.2 t ha^{-1}) was obtained under the poly house condition at the irrigation level of 0.75 Epan as compared to non poly house crop (open condition) with check basin irrigation system (25.9 t ha^{-1}).

Panigrahi et al. (2010) conducted an experiment with green house and open field condition on capsicum annum cv. California Wonder. The germination percentage (52.47%) growth characters, like plant height, number of primary branches, number of leaves, number of fruits per plant, length of fruits and girth of fruits found significantly better under green house as compared to open field condition (37.32%). Under protected environment the yield was two times more (5.18 kg/m^2) as compared to open field condition (2.46 kg/m^2).

2.2 Effect of environments on physiological parameters

Xiaolei and Zhifeng (2004) concluded that a reasonable leaf area index (LAI) is critical to maintain high photosynthetic rates and yield. To optimize

LAI for greenhouse cucumber, variety Luhuanggua No.10 was taken in a plastic greenhouse and designed 4 treatments by keeping 7, 10, 13 and 16 fully-expanded leaves counting from the top. No leaves were removed from plants serving as controls. The number of leaves kept was negatively correlated with the average photosynthetic rate of a single plant among the treatments. When the number of leaves kept was less than 13, the LAI was less than 3. In this case, although the average photosynthetic rate of a single leaf was high, the assimilation rate of the whole plant was low, which led to fruit aborting and low yield. However, when the number of leaves kept was more than 16, LAI was more than 3.5 which also resulted in low assimilation rate for the whole plant and low yield. It was concluded that vines with 13-16 leaves each would have a LAI between 3 and 3.5, which would capture more solar radiation, maintain an optimal assimilation rate for the whole plant, and have a higher yield. The changes of photosynthetic rate for a single leaf and the whole plant, fruit set, yield per vine and per unit leaf area were characterized.

Kaukoranta and Huttunen (2008) evaluated that a radiation use efficiency (RUE) model was used for computing the expected direct yield increase from the cooling due to longer duration of high CO_2 concentration in the cooled greenhouse. In the summer months, the RUE model predicts 15 to 23% higher yield for the cooled greenhouse than in the uncooled greenhouse where temperature and humidity were controlled by ventilation and fogging.

Jiheng *et al.* (2009) reported that to improve the ability of predicting the yields of greenhouse cucumber, a model for fruit growth of greenhouse cucumber was developed based on the effects of temperature and radiation on fruit growth by using production of thermal and PAR (TEP) as prediction index. The prediction accuracy of the TEP-based model was 12.21% higher than that of GDD. The model can give a satisfactory prediction of fresh fruit weight on different axils. The model is applicable and can provide theoretical basis and decision support for the production of greenhouse cucumber.

Huang *et al.* (2011) concluded that cucumber plants were either self-grafted or grafted onto two salt-tolerant pumpkin rootstocks Chaojiquanwang (*Cucurbita moschata* Duch), and Figleaf Gourd (*Cucurbita ficifolia* Bouche).

Plants were grown hydroponically in 0, 30, 60, or 90 mm NaCl for 16 days in greenhouse. Salinity induced a smaller decrease in plant shoot dry mass, leaf area, net photosynthetic rate, and stomatal conductance in the two rootstock-grafted plants compared to the self-grafted plants. In addition, a significant increase in intercellular CO_2 concentration, as well as a significant decrease in the initial and total ribulose-1,5-bisphosphate carboxylase/oxygenase activities were observed only in the self-grafted plants under 90 mm NaCl treatment.

Yiping *et al.* (2011) observed that under greenhouse temperature control, CO_2 enrichment reduced greenhouse energy consumption in a greater degree in the south than in the north and higher altitude regions. With the two temperature control strategies, the variation of energy consumption per unit yield of greenhouse cucumber was less than 8%, but with temperature control strategy II and CO_2 enrichment, it could be reduced up to 29%-67% (from the north and higher altitude regions to the south).

2.3 Effect of cultivars

Shalaby and Hussein (1994) observed that the F_1 and F_2 plants of cucumber cv. "Katia k 2744" did not significantly differ in respect of total marketable yield under unheated plastic houses at Egypt, however, the F_1 plants significantly surpassed the F_2 in the early yield. In respect of fruit quality (weight, length, shape index and colour), both F_1 and F_2 plants did not significantly differ.

Dimitrov and Kanazirska (1995) conducted trial on glass house cucumber with 3 cultivars planted at 1.2, 1.6 or 2.0/m^2 and observed that increasing density stimulated plant growth. There was a high positive correlation between density and stem and leaf development. Increasing plant density from 1.2 to 2.0/m^2 increased the early yield of cv. `Sandra' by 26.5-40.8 percent and total yield by 16.7-17.4 percent; of cv. *'Sofia'* by 29.9-32.1 percent and 1.6-13.0 percent, respectively; and of cv. 'Mustang' by 16.7-17.5 percent and 1.6-13.0 percent, respectively. Planting density did not significantly affect the percentage of deformed fruits.

Etman (1995) conducted an experiment in unheated fiber glass greenhouse, over two growing seasons, to study the response of "Sahara" parthenocarpic cucumber to plant spacings of 25, 35 and 45cm, with one or two plants per hill. Yield per unit area ($1m^2$) increased as the spacing among plants declined to 25cm and also, with increasing number of plants per hill to two plants per hill. The increase in yield was positively associated with fruit number. Increasing plant density decreased plant height, number of leaves per plant, yield and fruit number per plant. Significant correlation coefficients were found among the studied cucumber traits on unit area basis or per plant.

Al-Harbi *et al.* (1996) reported that in the controlled greenhouse all four cucumber cultivars had almost similar vegetative growth characters, but cv. Sahara proved to be superior to the other cultivars in total yield expressed as fruit number and weight per plant. No significant differences were observed in total yield among the other cultivars.

Hochmuth and Leon (1996) evaluated twelve seedless cucumber cultivars in two seasons in a double layer polyethylene covered greenhouse. Total marketable yield in the fall trial ranged from 11.5 lb per plant for `Aramon' to 15.2 lb per plant for `Kalunga', whereas total marketable yield in the spring trial ranged from 16.1 lb per plant for `Discover' to 19.7 lb per plant for `Marianna'. No significant differences were detected for early yield (first three harvests) in either trial.

MA De Hua *et al.* (1997) reported that `Jinyou-1' (F_1 hybrid) was an early maturing-cucumber in protected cultivation which gave yield of around 90 t/ha.

Muhammad *el al.* (1998) studied the relative performance of eleven parthenocarpic cucumber hybrids (Dala, Belcanto, Bellando, Safa, Mubis, Taha, Luna, Pigal, Maram, Dina and Nibal) under ordinary plastic tunnels during the spring and autumn seasons. For spring cultivation Taha, Luna and Dala were found to be best, yielding 5.58, 4.48 and 4.17 kg m^{-2}, respectively. The cultivars found promising during the autumn season were eg. Data, Mubis and Luna which yielded 2.48, 2.30 and 2.24 kg m^{-2}, respectively.

Wang *et al.* (1999) stated that a cucumber cultivar 'Jinyou No.2' is an early maturing, high yielding and highly resistant to downy mildew, powdery mildew and Fusarium wilt under solar greenhouse cultivation during winter and spring season. It takes about 70 days from sowing to first harvest with a total yield of 82.5 t/h and the average fruit weight was 200g.

Shaw *et al.* (2000) evaluated six Beit Alpha cucumber cultivars and three Dutch-type cultivars over three seasons in a double layer polyethylene-covered greenhouse with passive ventilation. All six Beit Alpha cultivars produced more early and total marketable yield in all seasons than the Dutch cultivars. Total marketable fruit among all Beit Alpha cultivars were greater in the spring than in the fall. The Beit Alpha cultivar 'Alexander' produced high yield in all three seasons.

Pirog (2001) observed that greenhouse cucumber cultivars Rubin F_1 and Marinda F_1 differed with respect to yield. Significantly higher total (21.93 kg m^{-2}), marketable (21.39 kg m^{-2}) and first class (20.88 kg m^{-2}) yields were produced by Rubin F_1 than by Marinda F_1 (20.44, 20.02 and 19.46 kg m^{-2}, respectively). The higher rate of the first class yield growth, had cv. Rubin F_1. Mean mass of a Rubin F_1 cucumber was by about 20% higher than that of cv. Marinda F_1.

Cardoso (2002) evaluated four varieties (Branco coloniao, Caipira hortec, Premio and Rubi) and three hybrids (Caipira AG -221, Guarani AG-370 and Safira) of cucumber under protected cultivation at Sao manuel experimental farm during summer and winter seasons. `Safira' $F_1$ hybrid gave the highest yield during the summer (41.3 fruitsplant$^{-1}$), while 'Premio' $F_l$ hybrid had the lowest commercial yield (6.7 fruits plant$^{-l}$) during winter. It was concluded that `Safira' F_l hybrid was the best cultivar for the summer season, while in the winter all cultivars produced lowest yield.

Gao-Li Hong *et al.* (2002) reported that European Asian hybrids showed advantages in the vegetative and reproductive growth, resulting in strong growth, great vigour of root system and high yield. The European cultivars were superior to the Asian cultivars in their tolerance of low light intensity.

Peil and Lopez (2002) stated that increasing plant density decreased the total above ground biomass, the number of fruits and fruit biomass production per plant in cucumber grown under greenhouse condition. Similarly, Gebologlu and Saglam (2002) studied the effects or different plant spacings within row and mulching materials on the yield and quality of pickling cucumber during summer and autumn seasons. They found that transparent PE mulching materials and 20 cm plant spacing within row combination resulted in the highest yield.

Cardoso and Silva (2003) evaluated twelve cucumber hybrids in summer and 14 in autumn winter for their performance under protected cultivation at Brazil. The highest yielding hybrids in summer were 'Tsuyataro' (25.4 fruits plant^{-1}) and Rensei (25.3 fruits plant^{-1}). The highest yielding in autumn winter were `Nikkey' (26.8 fruits plant^{-1}) and 'Top Green' (23.4 fruits plant^{-1}). However, higher yield was obtained in autumn-winter sowing than in summer.

Hochmuth *et al.* (2004) conducted a greenhouse experiment during the winter season to evaluate the yield and fruit quality at harvest and during storage of 12 cucumber cultivars and observed that cv. 4419, Alamir, General, LDCB-845 and Manar were the highest yielding cultivars ranged from 1.3-2.6 kg plant^{-1} while, cv. Tenor produced the lowest yield.

Yildirim and Guvenc (2004) studied to explore a suitable intercrop with cucumber *(Cucumis sativus* L.) for proper utilization of interspace and resources under greenhouse conditions. No significant differences were found among cropping systems in terms of fruit length, fruit diameter, fruit weight and fruits per plant in both years. However, inter cropping increased significantly the cucumber-equivalent yield compared to sole cropping. The results showed that inter cropped cucumber with Cos lettuce, leaf lettuce or Frenchbean had some yield advantage and a higher area-based productivity than when grown alone.

Siwek and Lipowiecka (2004) reported that the `Marinda F_1' cucumber resulted highest yield in plastic tunnels where soil was mulched with coloured or black polyethylene film. The lowest yield was produced by crops shaded directly with perforated film.

Alsadon *et al.* (2004) reported significant differences among cultivars in fruit growth traits especially yield and its components. Highest values for fruit weight, early and total yield were recorded in 'Copra' followed by 'Alia' and 'Alasil', respectively.

According to Korol (2005), the parthenocarpic cucumber hybrid variety `Kurazh' is suitable for both outdoor and protected cultivation not only as a spring-summer crop but also as a winter – spring crop. Singh *et al.* (2005) stated that `Hasan' and 'Sarig' cultivars of cucumber are ideal for summer and rainy season under protected cultivation, while, 'Muhasan', 'Isatis', 'Dinar', 'Nun 9729', 'Nun 3019' and `Kian' were successfully grown during winter season.

Biryukova and Maslovskaya (2006) reviewed two new parthenocarpic cucumber hybrids of which, the medium – early F_1 hybrid `Vityaz' had a yield of 14-15 kg $m^{-2}$, with medium height, dark green leaves, and has oval to cylindrical cucumbers of 12-14 cm in length. Whereas, `Zhukovskii' (medium early F_1) had a yield of 15-17 kg m^{-2}, has dark green leaves and produces short cucumbers of 10-12 cm in length under protected cultivation.

Guncan *et al.* (2006) carried out an experiment to determine possibilities of cultivating organic cucumber under greenhouse conditions. They observed that spring growing season seems to be more appropriate for organic cucumber production in greenhouse conditions in Izmir. Total yield was determined as 16.46 kg m^{-2} in spring season as compared to 5.33 kg m^{-2} in autumn production period.

Maniutiu *et al.* (2006) recorded that the greenhouse cucumber cultivation at 28,000 plants per hectare on peat substrate resulted in an increase of about 29.3 percent early yield and 23.4 percent total yield as compared to control (cultivation on wheat straw and manure at 16,000 plants per hectare).

El-Aidy *et al.* (2007) carried out an experiment to study the influence of growing season on yields of two cucumber F_1 hybrids in protected cultivation. Two seasons were tested, the first was the winter season and the second was the early summer season. Likewise, the dates of transplanting of cucumber under plastic houses were 10^{th} October in the winter season and second February in the early summer season in both years. They concluded that the early summer season caused a highly significant increase in early and total fruit yield (as weight and number of fruits) when compared with the winter season in both the years.

Guo *et al.* (2008) conducted the two year greenhouse cucumber experiments to investigate seasonal effects on fruit yield with different fertilizer management. Seasonal effects were much greater than fertilizer effects. Winter-spring (WS) cucumber was attained higher fruit yields and N uptake than autumn-winter (AW) cucumber due to lower cumulative air temperatures during fruit maturation in the AW season.

The best quality cucumbers were obtained in the cultivation period between April and August, due to the optimum climatic conditions for that species in greenhouse cultivation. Low intensity of irradiation during spring time was a significant cause of much lower yielding as compared to summer and autumn cultivations (Wolska *et al.,* 2008).

Yiping *et al.* (2011) observed that distribution of energy consumption per unit yield of greenhouse crops is essential information for assessing the risk of greenhouse investment and optimizing greenhouse climate control in different regions. In order to predict the energy consumption per unit yield of greenhouse crops, a Venlo type greenhouse and cucumber crop were used in this study. The results showed that energy consumption per unit yield of greenhouse cucumber was increased from the south to the north and higher altitude regions.

Bisht *et al.* (2011) reported that twelve characters were studied in eleven open pollinated varieties/hybrids of cucumber. Significant differences among the genotypes were observed for all the characters except internodal length. Phenotypic coefficient of variation and genotypic coefficient of variation were found high for number of fruits per plant. Highest heritability in broad sense was recorded for number of fruits per plant and number of nodes on main shoot. High heritability coupled with high genetic advance as per cent of mean was observed for yield and number of primary branches per plant which indicated that these characters are more reliable for effective selection.

2.4 Economics of the treatments

Granges and Leger (1989) found that by increasing the plant density of capsicum from normal level of three plants per m^2 to six plants per m^2, yield was found to increase by 80 per cent and gross returns by 50 per cent under greenhouse conditions.

Gaye *et al.* (1992) reported that economic analysis made in capsicum with three plant spacing (30 X 30, 45 x 30 and 65 x 30 cm) under naturally ventilated greenhouse conditions and open field cultivation revealed that though wider spacing of 65 x 30 cm gave relatively lower yield due to lower plant population but excellent quality fruits were obtained. Medium spacing of 45 x 30 cm gave the highest net returns of Rs. 21,018/ 100m^2/year and higher cost benefit ratio of 1:2.60 because of excellent quality fruits fetching relatively good price (Rs.20/kg) as compared to those from open field conditions (Rs.2560/ 100m^2/ year) with least cost benefit ratio of 1: 1.65 (@ of Rs. 16/kg)

Khan (1995) reported that though greenhouse cultivation resulted in higher returns by producing higher yields of good quality produce, its initial investments and maintenance costs were much higher than natural or traditional cultivation methods.

Engyndenyz (2000) concluded the costs and returns of organic cucumber production in a 12x32m greenhouse in Menderes, Turkey and developed a production budget for growers. Total costs of organic, greenhouse cucumber production were determined to be 1334 dollars. According to study, net return per square meter was determined to be 0.98 dollars for organic greenhouse cucumbers and net return per kilogram was calculated to be 0.07 dollars. But, production and market risks both affect profitability and economic viability of organically grown vegetables.

Engindeniz and Tuzel (2003) observed that this study aimed to evaluate the economic feasibility of growing organic tomatoes (in 2000-01) and cucumbers (in the spring of 2001) under farmer's conditions in Izmir province of Turkey. According to the results, net profit per square and net profit per kg were determined to be $1.5 and $0.2 for organic greenhouse tomatoes. However, net profit per square and net profit per kg were determined to be $1.3 and $0.1 for organic greenhouse cucumbers.

Natarajan *et al.* (2005) studied standardization of production package to improve growth, yield, and economics of sweet pepper under poly house condition. They observed that the package consisting soil: FYM: coir pith (2:1:1) as @ 50:50:50 kg/ ha^{-1} with straight fertilizers and fertigation of NPK @150:150:150 kg/ha^{-1} with water soluble fertilizers and with black polyethylene mulching proved its superiority over other packages. The package also recorded the highest yield of 149 to 144tonnes per hectare with benefit.

Singh and Kumar (2006) conducted an experiment at the Indo-Israel project of the Indian Agricultural Research Institute, New Delhi under which two types of naturally ventilated greenhouses were evaluated for their techno-economic feasibility for year round cucumber cultivation. The first crop of parthenocarpic cucumber (Var. Hasan) was planted in the first week of August, the second crop in the first week of October (Var. Muhasan) and the third crop in the second week of February (Var. Sarig) in both the greenhouses and their cost of production and cost benefit ratio was calculated. The cost-benefit ratio of cucumber cultivation under the Israeli greenhouse system was worked out 1:1.13, where as the cost-benefit ratio for the Indian greenhouses was 1:2.06 under Delhi conditions of India. It is concluded that the low cost naturally ventilated greenhouses are more suitable and economical for year-round cucumber cultivation in the northern plains of India.

Cantliff *et al.* (2008) reported economic feasibility model that compares the costs and benefits associated with field-grown slicing cucumbers and the production of European-type greenhouse cucumber in Florida. Though greenhouse production requires a significantly larger capital investment (total cost: $391,922/acre) compared to field production (total costs: $5,620/acre), potential profits have been determined to be as much as 1,206 times greater for greenhouse produced cucumbers than the field (profits: $72,775 compared to $60/acre, respectively).

Shashidhara and Shivamurthy (2008) conducted an experiment and found that application of FYM @ 10 t /ha along with 100 percent RD resulted in significantly higher plant height (89.77cm) number of branches per hill (40.52), canopy spread (58.79m^3) and dry matter production (132 g/hill) in chilli and thus higher B:C ratio (2.81 & 2.83) as compared to other treatments.

Chapter-3

MATERIALS AND METHODS

A field experiment entitled "**Standardization of production technology for cucumber (*Cucumis sativus* L.) under protected cultivation"** was conducted at Central Institute of Arid Horticulture, Bikaner during *kharif season* 2010. The details of experiment techniques, materials used and methods/techniques adopted for treatment evaluation during the course of investigation are described in this chapter.

3.1 Experimental site and location

The experiment was conducted at Central Institute of Arid Horticulture, Bikaner, during the *kharif* 2010. Bikaner is situated at 28.01^0N latitude and 73.22^0E longitude at an altitude of 234.70 meters above mean sea level. According to “Agro-ecological region map” brought out by the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), it falls under Agro-ecological region No. 2 (MgE1) under Arid ecosystem (Hot Arid Eco-region with desert and Saline soil), which is characterized by deep, sandy and coarse loamy, desert soils with poor water holding capacity, hot and arid climate. Pan evapotranspiration in this region ranges between 1500-2000 mm. As per NARP, Bikaner falls in Agro-climatic zone Ic (Hyper Arid Partially Irrigated North Western Plain Zone). According to Planning Commission, it falls under Agro-climatic zone XIV (Western Dry Region) of India.

3.2 Climate and weather condition

Bikaner has dry hot arid climate and average annual rainfall is 250 mm. More than 80 per cent rainfall is received in the *kharif* season (July-September) by the South-West monsoon. During summers, the maximum temperature say go as high as 48^0C while in the winters it may fall as low as 0^0C. This region is prone to high wind velocity and soil erosion due to dust storms in summers. Occasionally frost is experienced in arid region during winter season.

The periodical mean weekly weather parameters for the period of the experimentation recorded from the Meteorological observatory of Agriculture Research station, Bikaner are presented in Appendices XVIII and XIX and depicted in Fig. 3.1 shows that the maximum and minimum temperature in poly house and shade net house remained more or less static up to 39^{th} and 40^{th} week of experimentation, respectively thereafter in poly house maximum and minimum temperature decreased at a slower rate whereas, shade net house the minimum temperature fell at a faster rate. Similarly, under poly house maximum relative humidity remained static whereas, under shade net house it fluctuated in an erratic manner throughout the crop growth. Likewise minimum relative humidity fluctuated erratically up to 40th and 41st week under poly house and shade net house, respectively. Thereafter, it decreased slowly under poly house and drastically under shade net house and reached to a minimum level of about 20 per cent at the end of experimentation. Under glass house condition the optimum temperature 28-34^{o}C and relative humidity 85-95 per cent was maintained throughout the experimentation for batter performance of cucumber. The maximum and minimum temperature of 38.4^{o}C and 16.8^{o} C were recorded on 40th and 49th week of experimentation, respectively in poly house whereas, in shade net house the maximum and minimum temperature of 41.1^{o} C and 8.2^{o} C, were recorded on 41st and 49th week.

3.3 Soil of experimental field

In order to know the physical and chemical properties of soil, samples were taken randomly from 0-15 cm depth from different spots of the experiment and a representative composite sample was prepared by mixing all these samples together. This composite sample was analyzed to determine the mechanical composition, physico-chemical properties, organic carbon and available N, P and K of the soil. The results of the analysis along with methods used are presented in Table 3.1.

Result of the physical and chemical analysis revealed that the soil of the experimental field was loamy sand in texture and slightly alkaline in reaction. The status of soil was poor in organic carbon and low in available nitrogen and medium in phosphorus but high in available potassium.

Table 3.1 : Physico-chemical characteristics of the experimental soil

Soil properties	Value at 0-15 cm depth	Methods of analysis with reference
A. Mechanical Composition		
Sand (%)	84.48	Hydrometer method (Bouyoucos , 1962)

Silt (%)	7.36	
Clay (%)	6.98	
Texture	loamy Sand	Triangular method (Brady, 1983)
B. Physical properties		
Bulk density (Mg m^{-3})	1.65	Method No. 38, USDA HandBook No. 60 (Richards, 1954)
Particle density (Mg m^{-3})	2.68	Method No. 39, USDA Handbook No. 60 (Richards, 1954)
Field Capacity (%)	8.35	Method No. 30, USDA Handbook No. 60 (Richards, 1954)
Porosity (%)	39.4	Method No. 40, USDA Handbook No. 60 (Richards, 1954)
C. Chemical properties		
Organic carbon (%)	0.08	Walkley and Black's rapid titration method (Jackson, 1973)
Available nitrogen (kg ha^{-1})	86.40	Alkaline $KMnO_4$ method (Subbiah and Asija, 1956)
Available phosphorus (P_2O_5 kg ha^{-1})	21.91	Olsen's method (Olsen et al., 1954)
Available potassium (K_2O kg ha^{-1})	234.00	Flame photometric Method (Jackson, 1973)
EC (dS m^{-1}) (1:2 soil water suspension at 25^0C)	0.15	Method No. 4 USDA Hand Book No.60 (Richards, 1954)
Soil pH (1:2 soil water suspension)	8.5	Method No. 21 b, USDA Hand Book No. 60 (Richards, 1954)

3.4 Experimental Details

The treatments for the experiment comprised of fifteen treatment combinations consisting of three design of protected structures and five cultivars of cucumber. The details of plan of work are given as follows:

A. Details of treatments with their notations

Treatments	Notations
(a) Design of protected structure	
1. Glass house	S_1
2. Poly house (naturally ventilated)	S_2
3. Agro shade net house (50% shade)	S_3
(b) Cultivars	
1. Isatish	V_1
2. Hilton	V_2
3. Alamgir-CT-180	V_3
4. Poona Khira	V_4
5. Himangi	V_5

(B) Treatment Combinations:

S. No.	Treatment combination of protected structure and varieties	Symbol
1.	Glass house + Isatish	S_1V_1
2.	Glass house + Hilton	S_1V_2
3	Glass house + Alamgir-CT-180	S_1V_3
4.	Glass house + Poona Khira	S_1V_4
5.	Glass house + Himangi	S_1V_5
6.	Poly house + Isatish	S_2V_1
7.	Poly house + Hilton	S_2V_2

8.	Poly house + Alamgir-CT-180	**S_2V_3**
9.	Poly house + Poona Khira	**S_2V_4**
10.	Poly house + Himangi	**S_2V_5**
11.	Agro shade net house (50% shade) + Isatish	**S_3V_1**
12.	Agro shade net house (50% shade) + Hilton	**S_3V_2**
13.	Agro shade net house(50% shade) + Alamgir-CT-180	**S_3V_3**
14.	Agro shade net house (50% shade) + Poona Khira	**S_3V_4**
15.	Agro shade net house (50% shade) + Himangi	**S_3V_5**

C Experimental details:

i.	Crop	-	Cucumber
ii.	Variety	-	Isatish, Hilton, Alamgir-CT-180, Poona Khira, and Himangi,
iii.	Season	-	*Kharif*, 2010
iv.	Replication	-	3
v.	No. of treatments	-	15
vi.	Experimental design	-	RBD
vii.	Spacing	-	60 cm X 60 cm

3.5 Raising of the nursery

For greenhouse cultivation of cucumber the seedlings were raised on soil-less media in plastic pro-trays having cells of 1.5” in size. A mixture of coco-peat, vermiculite and perlite was used @ 3:1:1 was used as media for raising seedlings. One seed was sown in each cell. Regular watering was done and plant protection measures were adopted as required. Nutrients were applied in the form of N:P:K (1:1:1) @ 1.4 per cent once a week through the fine sprinkler to maintain the uniformity in application of nutrients. The seedlings were ready for transplanting within 20 days.

3.6 Bed preparation

The raised beds were prepared about 60 cm above the ground level for the experimental purpose. Beds of l.2m x 3m size were prepared. Basal dose of FYM @ 2.5 kg per square meter was applied and thoroughly mixed in the soil one week before transplanting.

3.7 Transplanting

Three weeks old seedlings at 2-3 true leaf stage were transplanted at 60cm x 60cm according to the different treatment combinations. Transplanting was done in the evening thereafter watering was done.

3.8 Fertilizer application

The fertigation method was used to apply nitrogen, phosphorus and potassium in liquid form along with irrigation water as NPK was used 22 kg as per recommendation of the crop.

3.9 Trailing of plant

The plants were trained upwards so that the main stem was allowed to climb to the overhead wire along a polythene twine. Wires were fixed 8-9 feet above the ground. The twine of each plant was alternatively tied to the horizontal overhead wires running along with the length of rows. The base of the twine (string) was anchored loosely to the base of the stem with a non-slip noose. As the stem developed, it was trellised on the twine up to the height of horizontal wires (8-9 feet height) and then the vines were again turned downward direction.

3.9 Intercultural operations

First hoeing and weeding was done after 20 days of transplanting and second weeding was repeated after 25 days of first weeding in all the treatments to keep plots weed free.

3.10 Plant protection measures

To protect the crop from the attack of insect and pests like aphids, whiteflies and thrips, Imidacloprid (0.04%) was sprayed at twenty five days interval as a precautionary measure after transplanting. Besides, to protect the crop from fungal disease as *Fusurium* root rot, fungicide Mancozeb @ 2.0 gram/litre of water was sprayed at 15 days interval during the entire experimental period.

3.11 Harvesting

Fruits were harvested 40 to 45 days after anthesis when they were more or less cylindrical and well filled. Subsequent harvesting was done three times a week.

Table 3.4 : Details of operations for raising experimental crops

S. No.	Particulars	Date	Remarks
1.	Seed sowing in pro-tray	02.08.2010	Manually
2.	Preparation of bed in protected conditions	15.07.2010	Manually
3.	Layout of field	25.09.2009	Manually
4.	Transplanting	14.08.2010	Manually
5.	Trialing of plants	08.09.2010	Manually
6.	Weeding and hoeing	04.09.2010 01.10.2010 25.10.2010 15.11.2010	Manually
7.	Irrigation	On requirement	By drip irrigation
8.	Application of chemical fertilizers	30.08.2010 25.09.2010 20.10.2010	Through drip irrigation
9.	Plant protection measures	10.09.2010 06.10.2010	Though sprayer
10.	Harvesting	Starts from 10.11.2010 and repeated three time in week	Manually when fruit achieved proper size

Methodology Used for Recording Observations

To assess the impact of various treatments on growth, yield and quality of parthenocarpic cucumber grown under different protected structures, the following observations were recorded. The details of methodology adopted for recording data are as under:

A. Growth parameters

1. **Number of branches per vine:** The total numbers of branches in five randomly selected plants were counted periodically until the final harvesting completed from each plot and average number of branches per vine was calculated.

2. **Average length of vine:** Vine length of five randomly selected plants was measured with the help of meter scale from the base of the vine to its tip at the time of last picking and average length of vine was calculated and expressed in metre.
3. **No. of leaves per vine:** The total numbers of leaves in five randomly selected plants were counted periodically until the final harvesting of plant from each plot and average number of leaves per vine was calculated.
4. **Leaf area:** Five mature leaves from each tagged five plants were randomly selected and total leaf area of five leaves was measured with the help of Systronics leaf area meter and then average data was worked out.

B. Yield and yield attributes

1. **Days to first flowering:** The date of first flower bud initiation was recorded in each treatment then the numbers of days were counted from the date of transplanting.
2. **Number of pickings:** The total numbers of pickings in five randomly selected plants were counted periodically until the final harvesting of plant from each plot and average number of pickings per vine was calculated.
3. **Number of fruits per vine:** The number of fresh marketable fruits harvested from five randomly selected plants was recorded at each harvesting and average number of fruits per vine was calculated.
4. **Weight of fruits per vine (kg):** Mature fruits were harvested periodically in each treatment separately and the weight was recorded with the help of single pan balance. Then average total yield was calculated and expressed in kilogram per vine.
5. **Average fruit length (cm):** The length of five randomly selected fruits at marketable stage was measured from head end up to blossom scar by meter scale in each treatment then the average fruit length was calculated and expressed in centimeters.
6. **Average fruit girth (cm):** The fruit girth of five randomly selected plants was measured with the help of vernier calipers at the final stage of harvesting. The average values for each treatment were

then worked out and expressed in centimeters.

7. **Average fruit weight (g):** The weight of ten fresh fruits harvested from randomly selected five plants was taken during harvesting and average weight of fruit was calculated and expressed in grams per fruit.
8. **Yield per square metre (kg):** The yield of fruits per square meter was calculated by multiplying the average yield of fruits per vine with the number of plants per square meter and expressed in kilogram per square meter.
9. **Yield (t ha^{-1}):** The yield of fruits per hectare was calculated by multiplying the average yield of fruits per square meter and expressed in tonnes per hectare.

C. Physiological parameters

1. **Photosynthesis rate (at flowering time):** The photosynthetic rate was simultaneously measured for the attached and upper most fully expanded leaves using a portable open gas exchange system (Li6400). The photosynthetic photon flux density was maintained at 1,500 μ mol m^{-2} s^{-1} and the relative humidity was 60 per cent. The temperature of the leaf was 25^{o}C and the ambient CO_2 concentration was 370 μmol mol^{-1}, while measurements were taken.
2. **Transpiration rate:** The transpiration rate was simultaneously measured for the attached and uppermost fully expanded leaves using a portable open gas exchange system (Li6400). The photon flux density was maintained at 1,500 μ mol m^{-2} s^{-1} and the relative humidity was 60 per cent. The temperature of the leaf was 25^{o}C and the ambient CO_2 concentration was 370 μmol mol^{-1}, while measurements were taken.
3. **Chlorophyll content:** The total chlorophyll content in cucumber was determined at 45 days after transplanting, by taking 100 mg sample which was dipped in 5 ml of N, N-Di-methylformamide. It was stored in refrigerator for overnight and thereafter, this extracted was taken in a measuring cylinder and final volume was to be made to 10 ml by adding D. M. F. Reagent and absorbance was measured through spectrophotometer at 645 nm wave length. The total chlorophyll

content in mg g^{-1} was calculated by using the following formula (Arnon, 1949):

$$\text{Total chlorophyll (mg g}^{-1}\text{ fresh weight of tissue)} = [20.2(AV645) + 8.02(A663)] \times 1000 \times W$$

Where,

A = Absorbance at specific wave length

V = Final volume of extract (ml)

W =Fresh weight of tissue (g)

D. Quality parameters

1. Ascorbic acid content (mg/100 g fruit)

Reagents:

(i) Metaphosphoric acid (HPO_3) solution (3%)

(ii) Dye solution: 50 mg of 2, 4-dichlorophenol-indophenol was dissolved in approximately 150 ml of hot distilled water containing 42 mg of sodium bicarbonate. Then it was cooled and diluted and volume was made up to 200 ml with distilled water. Prepared solution was stored in brown bottle in a refrigerator at about 3°C, it was standardized every day and a fresh solution was prepared every week.

(iii) Standard ascorbic acid solution: 100 mg of L-ascorbic acid was dissolved in a small volume of 3 % metaphosphoric acid solution and make up to 100 ml with 3 % metaphosphoric acid (0.1 mg ascorbic acid per ml).

Procedure:

Standardization of dye: 5 ml of standard ascorbic acid solution was diluted with 5 ml of 3 % metaphosphoric acid. Titrated with dye solution till pink colour persists for 10 seconds and the dye factor was calculated (mg of ascorbic acid per ml of dye) which is as follows:

Dye factor (D.F.) = 0.5 / Titre

Preparation of sample and titration:

Ten mililitre sample was taken and volume was made up to 100 ml with 3 % metaphosphoric acid and it was filtered. Then 10 ml diluted sample was taken into a conical flask and titrated with the standard dye to a pink end-point.

$$\text{Ascorbic acid (mg/100g)} = \frac{e \times d \times b}{c \times a}$$

Where,

a = Titre x Dye factor

b = Volume made up

c = Volume of filtrate taken

d = weight or volume of sample taken

e = Average burette reading for sample

2. **Fiber content (%):** Crude fibre content was determined by the method of A.O.A.C. (1970). Representative ground fruit sample of two gram was refluxed with 1.25% H_2SO_4 washed & again refluxed with 1.25% NaOH for 30 minutes respectively the sample was dried, weighed (W_2) & ignited in muffle furnace (W_3). The loss in weight (W_2-W_3) was considered as crude fibre content & expressed on per cent basis using following relationship.

$$\text{Crude fiber} = \frac{W_3 - W_2}{W_1} \times 100$$

Where

W_1 = Initial wt. of sample

W_2 = Wt. of refluxed sample

W_3 = Wt. of ignited sample

3. **Calcium (mg/100g):** The fine grounded samples of tender fruits were used to determine the calcium content by using flame photometer (Bhargava and Ragupati, 1993)

4. **Phosphorus (mg/100g**): Phosphorus was determined on spectronic 20 by using Vanadomolybdo phosphoric yellow colour method in nitric acid (Jackson, 1973).

5. **Iron (mg/100g):-** Estimation of Fe in plant were determined by Atomic Absorption Spectrometer as suggested by Lindsay and Norvell (1978)

E. Economics of the treatments:-

1. **Net profit (\`ha^{-1}):** The economics of the treatment is the most important consideration for making any recommendation to the farmers for its wide adoption. For calculating economics of the treatment, the average treatment yield along with prevailing market rates for inputs and outputs were used. The net returns were calculated by subtracting the cost of cultivation for each treatment from return gained from economic yield.

   Gross returns (\`$ha^{-1}$) = Returns from fruit of cucumber (\` ha^{-1})

   Net returns (\` $ha^{-1}$) = Gross returns (\` ha^{-1}) – Total cost of cultivation (\` ha^{-1})

2. **B:C ratio:** Economics of cucumber production under poly house, shade net house and glass house condition was worked out by considering the present price of inputs and produce.

   $$\text{Benefit : Cost ratio} = \frac{\text{Net returns (` /ha)}}{\text{Cost of cultivation (` /ha)}}$$

3. **Statistical analysis:** In order to test the significance of variance in experimental data obtained for various treatment effects, data were statistically analyzed as per procedure described by Panse and Sukhatme (1985). The critical differences were calculated to assess the significance of treatment means wherever, the ‘F’ test was found significant at 5 per cent and 1 per cent level of significance.

Chapter-4

EXPERIMENTAL RESULTS

The result of the experiment entitled **"Standardization of production technology of cucumber (*Cucumis sativus* L.) under protected cultivation"** conducted during August, 2010 to January, 2011 at Central Institute of Arid Horticulture, Bikaner are presented in this chapter. The data on growth, yield and quality of cucumber pertaining to various criteria used for treatment evaluation were analyzed statistically to test their significance. The data analyses of variance have been presented in appendices at the end.

4.1 Growth Attributes

4.1.1 Number of branches per vine

The perusal of data in Table 4.1 and Appendix I revealed that the number of branches per vine was significantly influenced by different protected structures. The data show that maximum number of branches per vine were recorded in glass house structure (1.75) followed by poly house and net house 1.60 and 1.32, respectively. In the glass house No. of branches were recorded 32.57 and 21.21 per cent higher than the net house and poly house, respectively.

The data presented in Table 4.1 revealed that the number of branches per vine had significant difference in various cultivars during experimentation. On the basis of data analysis the highest numbers of branches were recorded in cultivar Isatish (1.73). However, Poona Khira (1.53), Alamgir-CT-180 (1.47) and Himangi (1.44) were found at par to each other. The per cent increase in number of branches was 20.14, 11.12, 6.25, and 2.08 per cent for Isatish, Hilton, Poona Khira and Alamgir-CT-180, respectively as compared to Himangi which recorded the minimum number of branches (1.44).

Table 4.1 : Effect of environments and varieties on No. of branches per vine

Treatments	No. of branches per vine
Environments	
Poly house	1.60
Net house	1.32
Glass house	1.75
S.Em.±	**0.03**
C.D. (5%)	**0.09**
Varieties	
ISATISH	1.73
HILTON	1.60
ALAMGIR-CT-180	1.47
POONA KHIRA	1.53
HIMANGI	1.44
S.Em.±	**0.04**
C.D. (5%)	**0.11**

4.1.2 Average length of vine

The data pertaining to effect of protected structures, cultivars and their interaction on average length of vine of cucumber during winter season are presented in Table 4.2 and analysis of variance in Appendix II.

The data presented in Table 4.2 indicated that the length of vine in cucumber was significantly influenced by various protected structures during experimentation. The data showed that maximum vine length was recorded in glass house (3.01m) than the poly house and net house with 2.84 m and 2.71 m, respectively. However, vine length under net house and poly house were at par to each other.

Table 4.2 : Effect of environments and varieties on average length of vine (m)

Environments	Varieties					Mean
	V_1	V_2	V_3	V_4	V_5	
Poly house	3.26	3.12	2.68	2.63	2.51	**2.84**
Net house	3.07	3.00	2.48	2.54	2.49	**2.71**
Glass house	3.44	3.26	3.25	2.80	2.29	**3.01**
Mean	**3.26**	**3.13**	**2.80**	**2.65**	**2.43**	

	Environments	Varieties	E x V
S. Em.±	**0.05**	**0.07**	**0.12**
C.D. (5%)	**0.15**	**0.10**	**0.34**

The data presented in Table 4.2 revealed that the vine length of cucumber was significantly influenced by various cultivars. On the basis of data analysis significantly maximum vine length was recorded in variety Isatish (3.26 m) while it was minimum in Himangi (2.43 m). The length of vine was higher by 34.15, 28.80,15.22 and 9.05 per cent in Isatish, Hilton, Alamgir-CT-180, and Poona Khira, respectively than Himangi. However, variety Isatish (3.26m) and Hilton (3.13 m) were at par to each other.

Interaction between environments and varieties

A significant interaction between different structures and cultivars was observed in respect to average length of vine along with cultivars. The maximum vine length was recorded in glass house with cultivar Isatish (3.44 m). However, it was at par with poly house in same variety. Whereas, minimum length of vine was recorded in Himangi which were cultivated under net house condition (2.29 m).

4.1.3 Average number of leaves per vine

The perusal of data further revealed that number of leaves per vine in cucumber was not significantly affected by different protected structures.

The data presented in Table 4.3 reveals that the average number of leaves per vine in cucumber was significantly influenced by various cultivars during experimentation. On the basis of data analysis, the maximum number of leaves were recorded in cultivar Isatish (29.96) which was significantly higher compare to other cultivars. The minimum numbers of leaves per vine were recorded in Himangi (20.40). The percent increase in leaves per vine were 46.86, 24.50, 7.94 and 6.86 per cent in Isatish, Hilton, Alamgir-CT-180 and Poona Khira, respectively over Himangi. However, significant difference between three varieties Himangi (20.40), Poona Khira (21.80) and Alamgir-CT-180 (22.02) could not be observed.

4.1.4 Leaf area

The perusal of data in Table 4.3 and Appendix III revealed that the leaf area (cm^2) was significantly influenced by different protected structures. The data showed that maximum leaf area (cm^2) was recorded in glass house structure (448.37 cm^2) followed by poly house and net house 426.41 cm^2 and

404.15 cm^2 respectively. In glass house leaf area (cm^2) was recorded 10.90 and 5.50 per cent higher than the net house and poly house, respectively.

The data presented in Table 4.3 revealed that the leaf area (cm^2) had significant difference in some cultivars during experimentation. The highest leaf area (cm^2) was recorded in cultivar Hilton (449.71 cm^2). However, Poona Khira (416.29 cm^2), Alamgir-CT-180 (414.67 cm^2) and Himangi (405.76 cm^2) were found at par to each other. The per cent increase in leaf area was 10.88, 9.70, 2.60, 2.19 per cent for Hilton, Isatish, Poona Khira, Alamgir-CT-180, respectively as compared to Himangi which recorded the minimum leaf area (405.76 cm^2).

4.2 Yield and yield parameters

4.2.1 Number of pickings

The data presented in Table 4.4 and analysis of variance in Appendix IV explicit that number of pickings were significantly affected by different protected structures. The data showed that the significant maximum number of pickings were recorded in glass house condition (3.93) than the net house (3.31). The per cent increase in number of pickings under glass house and poly house were 18.73 and 7.85 per cent higher than the net house. However poly house and net house were found at par to each other.

Table 4.3 : Effect of environments and varieties on average No. of leaves per vine and leaf area

Treatments	Average No. of leaves per vine	Leaf area (cm^2)
Environments		
Poly house	24.17	426.41
Net house	23.04	404.15
Glass house	24.53	448.37
S.Em.±	**0.58**	**7.30**
C.D. (5%)	**NS**	**27.31**
Varieties		
ISATISH	29.96	445.47
HILTON	25.40	449.04
ALAMGIR-CT-180	22.02	414.67
POONA KHIRA	21.80	416.29
HIMANGI	20.40	405.76
S.Em.±	**0.75**	**9.43**
C.D. (5%)	**2.17**	**27.31**

The number of pickings were significantly affected by cultivars. The data presented in Table 4.4 showed that the highest number of pickings were found with Isatish (5.13) variety and it was at par with Hilton (4.80). The varieties recorded 110.24, 96.73, 21.32, 10.25 percent higher number of pickings in Isatish, Hilton, Alamgir-CT-180 and Poona Khira, respectively as compared to Himangi which observed the lowest number of pickings (2.69). However, Alamgir-CT-180 and Poona Khira were at par to each other.

4.2.2 Days to first flowering

It is explicit from data (Table 4.4 and Appendix IV) that day to first flowering was significantly influenced by various protected structures during experimentation. Among the various protected structures, the least number of days to first flowering was recorded in glass house (37.60) followed by poly house (38.68), however, found at par to each other. While maximum number of days required for first flowering recorded in net house (39.83)

It is evident from the data (Table 4.4) that day to first flowering was significantly affected by various cultivars during experimentation. Among the various cultivars, least number of days required for first flower initiation was recorded in cultivar Isatish (36.80) followed by Hilton (37.42). Whereas maximum numbers of days for first flowering were recorded in Alamgir-CT-180 (40.62). However, cultivar Hilton and Poona Khira were found at par to each other.

Table 4.4 : Effect of environments and varieties on No. of pickings and Days to first flowering

Treatments	No. of pickings	Days to first flowering
Environments		
Poly house	3.57	38.68
Net house	3.31	39.83
Glass house	3.93	37.60
S.Em.±	**0.17**	**0.56**
C.D. (5%)	**0.48**	**1.61**
Varieties		
ISATISH	5.13	36.80
HILTON	4.80	37.42
ALAMGIR-CT-180	2.96	40.62
POONA KHIRA	2.69	38.64
HIMANGI	2.44	40.02
S.Em.±	**0.21**	**0.72**
C.D. (5%)	**0.62**	**2.08**

4.2.3 Average fruit length

Data presented in Table 4.5 and analysis of variance in Appendix V Indicated that the fruit length of cucumber under different protected structures were significantly influenced. The maximum length of fruit was recorded under glass house (13.52 cm.) followed by poly house and net house 12.47 cm and 11.89 cm, respectively. However, there was no significant difference between poly house and net house.

The data presented in Table 4.5 revealed that the fruit length of cucumber was affected by different type of cultivars. The maximum fruit length was recorded in Isatish (14.57 cm) it was significantly higher than the Alamgir-CT-180 (11.98 cm), Poona Khira (12.10 cm) and Himangi (10.60 cm). However, any significant difference between Alamgir-CT-180 and Poona Khira could not be observed. In the varieties the per cent fruit length increase was 64.82, 60.08, 20.94, 19.37 percent higher in Isatish, Hilton, Poona Khira and Alamgir-CT-180, respectively than the Himangi which was recorded the lowest fruit length (10.60 cm).

4.2.4 Average fruit girth

The perusal of data presented in Table 4.5 and Appendix V revealed that the fruit girth of cucumber was significantly affected by different environments. On the basis of data analysis the fruit girth was found maximum in glass house (3.50 cm) than the poly house (3.30 cm) and net house (3.22 cm). The per cent increase in fruit length was higher in glass house by 8.6 and 4.96 per cent than net house and poly house, respectively. However, there was no significant difference between net house and poly house. The glass house and poly house were also at par to each other.

Table 4.5 : Effect of environments and varieties on average fruit length and average fruit girth

Treatments	Average fruit length (cm)	Average fruit girth (cm)
Environments		
Poly house	12.47	3.38
Net house	11.89	3.22
Glass house	13.52	3.50
S.Em.±	**0.28**	**0.07**
C.D. (5%)	**0.80**	**0.20**
Varieties		
ISATISH	14.57	4.17
HILTON	13.89	4.05
ALAMGIR-CT-180	11.98	3.02
POONA KHIRA	12.10	3.06
HIMANGI	10.60	2.53
S.Em.±	**0.36**	**0.09**
C.D. (5%)	**1.03**	**0.26**

It is depicted from the data presented in Table 4.5 that the effect of cultivar had significant effect on fruit girth of cucumber. The data showed that maximum fruit girth was observed in Isatish (4.17 cm) but it was at par to Hilton (4.05 cm). Further, variety Alamgir-CT-180 (3.02 cm) and Poona Khira (3.06) were also at par to each other and average fruit girth was recorded minimum in Himangi (2.53 cm). In variety Isatish, Hilton, Poona Khira and Alamgir-CT-180 the per cent increase was 64.82, 60.10, 20.95 and 19.37, respectively than Himangi which was attained the lowest fruit girth (2.53 cm)

4.2.5 Number of fruits per vine

Data presented in Table 4.6 and Appendix VI indicate that the number of fruits per vine of cucumber were significantly influenced by different protected structures. The significantly maximum number of fruits per vine were obtained from glass house (20.37) followed by poly house (19.25) than net house (17.32). The number of fruits per vine were 17.07 and 11.14 per cent higher in glass house than the net house and poly house, respectively.

A perusal of data presented in Table 4.6 further indicates that the different cultivars significantly influenced the number of fruits per vine. The maximum number of fruits per vine were recorded in Isatish (21.44) followed by Hilton (19.40) and minimum under Himangi (17.16). The number of fruits per vine was 24.94, 13.05, 10.49 and 4.66 per cent higher for Isatish, Hilton, Poona Khira and Alamgir-CT-180, respectively as compared to Himangi which was found to have lowest number of fruits per vine (17.16). However, Alamgir-CT-180 (17.96), Poona Khira (18.96) and Himangi (17.16) were at par to each other.

Table 4.6 : Effect of environments and varieties on No. of fruits per vine

Environments	Varieties					Mean
	V_1	V_2	V_3	V_4	V_5	
Poly house	21.40	18.60	18.20	19.27	18.80	**19.25**
Net house	19.27	18.33	16.47	17.47	15.07	**17.32**
Glass house	23.67	21.27	19.20	20.13	17.60	**20.37**
Mean	**21.44**	**19.40**	**17.96**	**18.96**	**17.16**	

	Environments	Varieties	E x V
S. Em.±	**0.22**	**0.28**	**0.49**
C.D. (5%)	**0.64**	**0.82**	**1.42**

Interaction between environments and varieties

A significant interaction between different environments and cultivars was observed in respect to number of fruit per vine. It was found that variety Isatish cultivated in glass house produced the highest number of fruits per vine (23.67). While minimum No. of fruits were found in net house with variety Hilton (15.07).

4.2.6 Weight of fruits per vine

The data on weight of fruits of cucumber as influenced by different structures are presented in Table 4.7 and Appendix VII. The significantly maximum fruit weight per vine was recorded in glass house (3.52 kg) followed by poly house (2.19 kg) while minimum recorded in net house (2.49 kg). The weight of fruits per vine was 41.36 and 28.11 per cent higher in glass house and poly house, respectively as compared to net house.

The data presented in Table 4.7 further showed that the maximum fruit weight per vine was recorded in Isatish (3.67 kg) followed by Hilton (3.33 kg). The weight of fruit per vine under Isatish, Hilton, Poona Khira and Alamgir-CT-180 were observed to be 51.65, 37.60, 26.60 and 18.60 per cent higher, respectively than Himangi (2.42 kg). However, cultivar Alamgir-CT-180 (2.87 kg) and Poona Khira (3.05 kg) were observed at par to each other.

Table 4.7 : Effect of environments & varieties on weight of fruits per vine (kg)

Environments	Varieties					Mean
	V_1	V_2	V_3	V_4	V_5	
Poly house	3.57	3.39	2.87	3.55	2.59	**3.19**
Net house	2.66	2.33	1.98	2.98	2.51	**2.49**
Glass house	4.77	4.28	3.76	2.62	2.17	**3.52**
Mean	**3.67**	**3.33**	**2.87**	**3.05**	**2.42**	

	Environments	Varieties	E x V
S. Em.±	**0.06**	**0.07**	**0.13**
C.D. (5%)	**0.17**	**0.22**	**0.38**

Interaction between environment and varieties

A significant interaction between different structures and cultivars was observed in respect to weight of fruits per vine. It was recorded that variety Isatish cultivated in glass house produced the maximum weight of fruits per vine (4.77 kg). While minimum yield was recorded in net house with variety Alamgir-CT-180 (1.98 kg).

4.2.7 Average fruit weight

The data on weight of fruit of cucumber as affected by different protected structures are presented in Table 4.8. The significantly highest fruit weight was observed in glass house (155.22 g) followed by poly house

(144.41g) than the net house (121.32 g). The weight of fruit was higher in glass house by 27.94 and 19.03 per cent as compared to net house and poly house, respectively. The average fruit weight in glass house was significantly higher over poly house and net house.

The perusal of data presented in Table 4.8 further showed that maximum fruit weight was recorded in Isatish cultivar (152.98 g) but it was at par to Hilton (150.56 g). Further Alamgir-CT-180 (135.22 g) and Poona Khira (138.29 g) were also at par to each other. However, the average fruit weight was minimum in Himangi (124.54 g). The per cent increase in weight of fruit was 22.84, 20.89, 11.04 and 8.58 per cent higher for Isatish, Hilton, Poona Khira and Alamgir-CT-180, respectively as compared to Himangi which was found the lowest fruit weight (124.54 g)

4.2.8 Yield per square metre (kg)

The data presented in Table 4.9 explicit that yield per square metre was significantly affected by different protected structures. The data showed that the significantly maximum yield per square metre was recorded in glass house condition (8.41 kg) while minimum in net house (5.67 kg). The per cent increase in yield per square metre in glass house and poly house was observed to be 48.32 and 33.33 per cent higher than the net house, respectively.

Table 4.8 : Effect of environments and varieties on average fruit weight

Treatments	Average fruit weight (g)
Environments	
Poly house	144.41
Net house	121.32
Glass house	155.22
S.Em.±	**3.69**
C.D. (5%)	**10.70**
Varieties	
ISATISH	152.98
HILTON	150.56
ALAMGIR-CT-180	135.22
POONA KHIRA	138.29
HIMANGI	124.54
S.Em.±	**4.77**
C.D. (5%)	**13.81**

The data presented in table 4.9 reveal that the yield per square metre of cucumber was significantly influenced by various cultivars. On the basis of data analysis the significantly maximum yield per square metre was recorded in variety Isatish (8.68 kg) while it was minimum in Himangi (5.90 kg). The per cent increase in yield per square metre was 47.12, 31.86, 20.00 and 12.20 per cent for Isatish, Hilton, Poona Khira and Alamgir-CT-180, respectively as compared to Himangi which recorded minimum yield per square metre (5.90 kg).

Table 4.9 : Effect of environments and varieties on yield per square metre (kg)

Environments	Varieties					Mean
	V_1	V_2	V_3	V_4	V_5	
Poly house	8.90	8.33	7.06	7.36	6.15	**7.56**
Net house	6.51	5.68	4.93	6.00	5.23	**5.67**
Glass house	10.62	9.34	7.87	7.88	6.32	**8.41**
Mean	**8.68**	**7.78**	**6.62**	**7.08**	**5.90**	

	Environments	Varieties	E x V
S.Em.±	**0.11**	**0.15**	**0.25**
C.D. (5%)	**0.33**	**0.42**	**0.73**

Interaction between environments and varieties

A significant interaction was observed between different type of structures and cultivars (Table 4.9) with respect to yield per square metre. The highest yield per square metre was found in variety Isatish cultivated under glass house condition (10.62 kg) followed by Hilton (9.34 kg). While minimum was found in Alamgir-CT-180 which was cultivated under net house condition (4.93 kg).

4.2.9 Fruit yield

The data on yield (t ha^{-1}) of cucumber as influenced by different structures are presented in Table 4.10 and analysis of variance in Appendix X The maximum yield (t ha^{-1}) was recorded in glass house (84.06 t ha^{-1}) and poly house (75.59 t ha^{-1}) while it was minimum in net house (56.72 t ha^{-1}). The yield (t ha^{-1}) was higher in glass house and poly house by 48.20 and 33.26 per cent, respectively than the net house.

The data presented in Table 4.10 further show that the maximum yield (t ha^{-1}) was recorded in Isatish (86.78 t ha^{-1}) followed by Hilton (77.82 t ha^{-1}). The yield (t ha^{-1}) under Isatish, Hilton, Poona Khira and Alamgir-CT-180 were found 47.1, 31.8, , 20.0 and 12.2 per cent higher, respectively than the Himangi which recorded the minimum yield (59.01 t ha^{-1}).

Table 4.10 : Effect of environments and varieties on yield of cucumber (t ha^{-1})

Environments	Varieties					Mean
	V_1	V_2	V_3	V_4	V_5	
Poly house	88.97	83.27	70.60	73.63	61.47	**75.59**
Net house	65.13	56.83	49.27	60.03	52.33	**56.72**
Glass house	106.23	93.37	78.73	78.75	63.22	**84.06**
Mean	**86.78**	**77.82**	**66.20**	**70.81**	**59.01**	
	Environments		**Varieties**		**E x V**	
S.Em.±	**1.13**		**1.46**		**2.53**	
C.D. (5%)	**3.28**		**4.24**		**7.34**	

Interaction between environments & varieties

A significant interaction between different structures and cultivars (table 4.10) was observed in respect to yield (t ha^{-1}). It was found that the cultivar Isatish cultivated in glass house produced the maximum yield (106.23 tha^{-1}) followed by Hilton (93.37 tha^{-1}) under same structure. However, the yield of Isatish variety under poly house was recorded to be 88.97 tha^{-1}.

4.3 Physiological Parameters

4.3.1 Photosynthesis rate

The data on photosynthesis rate as affected by protected structures and cultivars of cucumber during winter season are presented in Table 4.11 and analysis of variance in Appendix XI

The photosynthesis rate was significantly influenced by different structures during the investigation. The data indicate that the maximum photosynthesis rate (12.83 µm $CO_2/m^2/s$**)** was observed in glass house followed by poly house and net house with 10.39 µm $CO_2/m^2/s$ and 8.58 µm $CO_2/m^2/s$, respectively. The percent increase in photosynthesis rate in glass house and poly house was by 49.53 and 21.10 per cent than net house, respectively.

It is explicit from the data (Table 4.11) that effect of cultivars had no significant influence on photosynthesis rate of cucumber in present study.

4.3.2 Transpiration rate

The data with regard to effect of protected structures and cultivars on transpiration rate of cucumber under during experimentation are presented in Table 4.11.

The perusal of data presented in Table 4.11 exhibit that structure had significant effect on transpiration rate in experimental study. The data showed that minimum transpiration rate was recorded in glass house (1.02 µm $H_2O/m^2/s$) which was significantly lowered over poly house and net house by 1.46 µm $H_2O/m^2/s$ and 1.57 µm $H_2O/m^2/s$, respectively. The per cent decrease in transpiration rate in glass house and poly house was by 57 and 47 per cent than net house, respectively.

It is explicit from the data (Table 4.11) that effect of cultivars had no significant influence on transpiration rate of cucumber in the experimentation.

4.3.3 Chlorophyll content

A perusal of data presented in Table 4.11 exhibited that the structure had significant effect on total chlorophyll content during the experimentation. As the data analysis showed that the maximum chlorophyll content was recorded in glass house (1.30 mg/g fresh weight) and minimum in net house (1.11 mg/g fresh weight). However, glass house (1.30mg/g fresh weight) and poly house (1.21 mg/g fresh weight) were found to be at par to each other. The per cent increases in chlorophyll content in glass house and poly house was by 17.12 and 9.01 per cent than the in net house, respectively.

It is evident from the data presented in table 4.11 that cultivars had no significant influence on chlorophyll content in the plant during experimentation.

Table 4.11 : Effect of environments and varieties on photosynthesis rate, transpiration rate and chlorophyll content

Treatments	Photosynthesis rate (μm $CO_2/m^2/S$)	Transpiration rate (μm $H_2O/m^2/S$)	Chlorophyll content (mg/g fresh weight)
Environments			
Poly house	10.39	1.46	1.21
Net house	8.58	1.57	1.11
Glass house	12.83	1.02	1.30
S.Em.±	**0.82**	**0.07**	**0.03**
C.D. (5%)	**2.37**	**0.21**	**0.09**
Varieties			
ISATISH	11.03	1.40	1.25
HILTON	11.04	1.38	1.26
ALAMGIR-CT-180	10.34	1.33	1.18
POONA KHIRA	10.38	1.35	1.20
HIMANGI	10.21	1.31	1.15
S.Em.±	**1.06**	**0.09**	**0.04**
C.D. (5%)	**NS**	**NS**	**NS**

NS = Non-significant

4.4 Quality parameters

4.4.1 Ascorbic acid content

The data regarding effect of protected structures and cultivars on ascorbic acid content (mg/100g) of cucumber are presented in Table 4.12.

The perusal of data presented in Table 4.12 indicate that the ascorbic acid content was not significantly influenced by various protected structures.

It is also clear from the data presented in Table 4.12 that the ascorbic acid content was significantly affected by various cultivars during the study. On the basis of data analysis the maximum ascorbic acid content was recorded in cultivar Isatish (6.37 mg/100g). The per cent increase in ascorbic acid content was 30, 24.48, 13.67 and 11.63 per cent for Isatish, Hilton, Poona Khira and Alamgir-CT-180, respectively as compared to Himangi which was recorded the lowest ascorbic acid content (4.90 mg/100g)

4.4.2 Fibre content

The data on the effect of structures and cultivars on fibre content (%) of cucumber are presented in Table 4.12.

The fibre content (%) was not significantly influenced by various structures during experimental study of cucumber. It is explicit from the data given in Table 4.12 that the effect of cultivars had significant influence on fibre content during the study. The data showed that the fibre content was minimum in Isatish (0.78 %) while maximum fibre content was recorded in cultivar Alamgir-CT-180 (1.24 %). The per cent decrease in fibre content with Isatish cultivar was recorded by 58.97, 33.33, 21.80, and 16.67 per cent for Alamgir-CT-180, Himangi, Poona Khira and Hilton, respectively.

Table 4.12 : Effect of environment and varieties on ascorbic acid and fiber content

Treatments	Ascorbic acid (mg/100g)	Fiber content (%)
Environments		
Poly house	5.76	0.98
Net house	5.50	0.97
Glass house	5.78	1.01
S.Em.±	**0.10**	**0.03**
C.D. (5%)	**NS**	**NS**
Varieties		
ISATISH	6.37	0.78
HILTON	6.10	0.91
ALAMGIR-CT-180	5.47	1.24
POONA KHIRA	5.57	0.95
HIMANGI	4.90	1.04
S.Em.±	**0.12**	**0.04**
C.D. (5%)	**0.36**	**0.11**

NS = Non-significant

4.4.3 Calcium content

The data basis the effect of structures and cultivars on calcium content in cucumber are presented in Table 4.13. A critical review of the data indicates that calcium content was not influenced significantly by different structures during experimentation.

A perusal data presented in Table 4.13 reveal that the cultivars had significant effect on calcium content in cucumber. According to data analysis maximum calcium content was obtained in cultivar Hilton (15.00 mg/100g) followed by Isatish (14.67 mg/100 g) and minimum in Alamgir-CT-180 (12.09 mg/100 g) which was statistically at par with Himangi (12.67 mg/100 g). However, variety Isatish and Poona Khira also was observed to be at par to each other by regarding 14.67 and 13.97 mg/100 g calcium content, respectively. Per cent increase in calcium content was 24.07, 20.84, 15.55 and 4.79 for Hilton, Isatish, Poona Khira, and Himangi, respectively as compared to Alamgir–CT-180 which recorded the lowest calcium content (12.09 mg/100 g).

4.4.4 Phosphorus content

The data with regarding to the effect of different protected structures and cultivars on phosphorus content in cucumber are presented in Table 4.13.

It is evident from the data (Table 4.13) that the effect of protected structures had not significant impact on phosphorus during the experimentation.

The data presented in Table 4.13 reveals that cultivars had significant influence on phosphorous content in fruits. The data exhibited that maximum phosphorous content was observed in cultivar Isatish (21.22 mg/g) which was also at par with Hilton (21.11 mg/100g) and Poona Khira (19.60mg/100g). The minimum phosphorus content was recorded in Himangi (17.91 mg/100g) which was at par with Alamgir-CT-180 (18.13 mg/100g). The per cent increase in phosphorus content was 18.43, 17.87, 9.44 and 1.23 per cent for Isatish, Hilton, Poona Khira and Alumgir-CT-180 varieties, respectively as compared to Himangi.

4.4.5 Iron content

The data regarding with protected structures and cultivars on Iron content of cucumber are presented in Table 4.13.

The perusal of the data presented in Table 4.13 reveal that the Iron content of cucumber was not affected significantly by different structures during the experimentation.

It is depicted from the data presented in Table 4.13 that the effect of cultivars had significant effect on Iron content. The data analysis depicted that the highest Iron content was recorded in cultivar Isatish (1.89 mg/100g) which was at par with Hilton (1.86 mg/100g). The minimum Iron content was recorded in Alamgir-CT-180 (1.41mg/100g) which was also at par with Himangi (1.42mg/100g). The per cent increase in Iron content was 34.04, 31.91, 20.57 and 0.71 per cent for Isatish, Hilton, Poona Khira and Himangi as compared to Alamgir-CT-180.

Table 4.13 : Effect of environments and varieties on calcium, phosphorus and Iron content

Treatments	Calcium (mg/100g)	Phosphorus (mg/100g)	Iron (mg/100g)
Environments			
Poly house	13.68	19.64	1.64
Net house	13.48	19.24	1.62
Glass house	13.88	19.91	1.70
S.Em.±	**0.36**	**0.41**	**0.05**
C.D. (5%)	**NS**	**NS**	**NS**
Varieties			
ISATISH	14.67	21.22	1.89
HILTON	15.00	21.11	1.86
ALAMGIR-CT-180	12.09	18.13	1.41
POONA KHIRA	13.97	19.60	1.70
HIMANGI	12.67	17.91	1.42
S.Em.±	**0.47**	**0.53**	**0.06**
C.D. (5%)	**1.36**	**1.54**	**0.18**

NS = Non-significant

4.5 Economics

4.5.1 Net return

Data presented in Table 4.14 showed that the net returns of cucumber were significantly influenced by different protected structures. The significantly maximum net returns were obtained from poly house (35821 ` per 500 sq m) followed by net house. The per cent increase under poly house was recorded to be 44.94 than net house while minimum net return was recorded under glass house ( - 3163 ` per 500 sq m).

A perusal of data presented in Table 4.14 further indicate that the different cultivars significantly influenced the net returns. The maximum net returns were recorded in Isatish (41049 ` per 500 sq m). It was significantly higher than the other cultivars. The per cent increase in net returns were 1009.73, 767.61, 198.65 and 109.01 per cent for Isatish, Hilton, Poona Khira and Alamgir-CT-180, respectively as compared to Himangi which recorded the lowest net returns (3699 ` per 500 sq m).

Table 4.14 : Effect of environments and varieties on net returns (` per 500 sq m)

Environments	Varieties					Mean
	V_1	V_2	V_3	V_4	V_5	
Poly house	56955	51255	24748	26884	19261	**35754**
Net house	38677	30377	14303	22240	17967	**24713**
Glass house	27513	14647	-15860	-15983	-26131	**-3163**
Mean	**41048**	**31982**	**7730**	**11045**	**3699**	

	Environments	Varieties	E x V
S.Em.±	**912.44**	**1177.95**	**2040.27**
C.D.(5%)	**2643.23**	**3412.39**	**5910.43**

Interaction between environments and varieties

A significant interaction between different structures and cultivars (Table 4.13) was recorded in respect to net returns. It was found that the cultivar Isatish grown in poly house fatched maximum net returns (56955 ` per 500 square metre) while minimum observed under glass house with Himangi cultivar (-15983 ` per 500 square metre) because no subsidy has been offered by the government agency for the glass house structure.

4.5.2 B : C ratio

The perusal of data presented in Table 4.15 revealed that the B:C ratio of cucumber was significantly affected by different structures. On the basis of data analysis B:C ratio was found maximum in poly house (2.18) followed by net house (2.01). While minimum B:C ratio was recorded in glass house (0.95). The per cent increase in B:C ratio was found maximum under poly house that is 129.47 and 111.58 per cent higher than glass house and net house, respectively.

It was depicted from the data presented in table 4.15 the effect of cultivars had significant effect on B:C ratio of cucumber. The statistical data showed that maximum B:C ratio was observed in Isatish (2.20) and minimum in Himangi (1.40). However, cultivar Himangi (1.40) and Alamgir-CT-180 (1.43) was at par to each other. The per cent increase in B:C ratio was 57.14, 41.43, 12.14 and 2.14 per cent for Isatish, Hilton, Poona Khira and Alamgir-CT-180, respectively as compared to Himangi.

Table 4.15 : Effect of environments and varieties on B:C ratio

Environments	Varieties					Mean
	V_1	V_2	V_3	V_4	V_5	
Poly house	2.78	2.60	1.88	1.95	1.72	**2.18**
Net house	2.46	2.15	1.63	1.98	1.84	**2.01**
Glass house	1.35	1.19	0.79	0.79	0.64	**0.95**
Mean	**2.20**	**1.98**	**1.43**	**1.57**	**1.40**	

Environments **Varieties** **E x V**

S.Em.±	**0.03**	**0.04**	**0.08**
C.D.(5%)	**0.10**	**0.13**	**0.22**

Interaction between environments and varieties

Significant interaction between different structures and cultivars (Table 4.15) was exhibited in respect to B:C ratio. It was found that the cultivar Isatish grown in the poly house condition recorded maximum B:C ratio (2.78) while minimum was recorded under glass house with cultivar Himangi (0.64).

Chapter-5

DISCUSSION

The result of investigation entitled **"Standardization of production technology for cucumber (*Cucumis sativus L.*) under protected cultivation"** showed significant variation in vegetative growth, flowering character, yield parameter, fruit quality and physiological parameters. Efforts have been made to discuss the significant findings of the experimental results in this chapter. Pertinent literatures of other workers have also been added in order to support the findings of present investigation.

5.1 Vegetative growth characteristic

It is evident from the data presented in the preceding chapter that various types of structures and cultivars had significant effect on vegetative growth parameters of cucumber like, number of branches, number of pickings, average length of vine (m), average number of leaves and leaf area (cm^2). As far as winter season was concerned various structures had significant influence on number of branches, number of pickings, average length of vine, average number of leaves and area of leaves. The maximum number of branches per vine (1.75), number of pickings (3.93), average length of vine (3.25 m), average number of leaves per vine (26.93) and leaf area (451.17 cm^2) were measured in glass house followed by poly house (Table 4.1, 4.2, 4.3). Among the various vegetative growth parameter leaf area is an important variable for most of the physiological processes involving light interception for photosynthesis and potential evapotranspiration. Moreover, the rate of photosynthesis increased with the increased in carbon dioxide supply up to a certain extent. It is ubiquitous that vegetative growth is directly influenced by the photosynthetic activity (Pandey and Sinha, 2007). Light is also responsible for effecting the rate of photosynthesis in various ways. Few of ultra violet light having shorter wave length apparently increased the photosynthetic rate (Pandey and Sinha, 2007). Temperature has little effect on the rate of the photosynthesis. However, very high and very low temperature range affects the photosynthesis rate adversely. As the light intensity, carbon dioxide concentration and temperature inside the glass house was optimum for the growth and development of cucumber. Whereas, in case of poly house short wave radiation transmitted in side and long radiation transferred out. Thereby increased the inside temperature and resulted in lesser growth and yield as compared to glass house.

Similarly, Kwon and Chang (1996) reported that the length of the main stem before branching divergence was longest in chilli grown in glass house because of better environmental conditions. The glass house was the most favourable environment, the result of a high transmittance of solar radiation, suitable temperatures for plant assimilation, and other environmental factors. However, appropriate cultivation techniques are also needed for the high yields, to minimize the adverse effects of climate and soil.

The significant difference in vegetative growth parameters, such as number of leaves, number of branches, leaf area (cm^2) between cultivars may be due to varietal characteristic. Significant difference was observed among the cultivars for the vegetative growth characters by Al-Harbi *et al*. (1996) and Ramirez *et al*. (1988) in cucumber.

5.2 Flowering characteristic

As described in preceding paragraph that favourable environmental condition resulted in better vegetative growth and optimum photosynthesis. The glass house resulted in more assimilation of photosynthates and accelerated the flower initiation. Further, in cucumber the flowers appear on every node of the vine, therefore, increased vine length resulted in more flowering and ultimately more fruit set. The similar results have been found by Kwon and Chang (1996).

The data presented in Table 4.1 clearly showed that effect of cultivars significantly influenced the flowering characteristics. Among the different cultivars, minimum number of days required for flowering and early fruiting was recorded in Isatish. It has been reported that auxin can induce pistillate flower formation through its stimulation of ethylene production. An Auxin/IAA transcription factor was found to have higher expression in hermaphroditic flowers (Guo *et al* 2010).

5.3 Yield and yield attributes

Among the various yield attributing characters number of fruits per vine, weight of fruits per vine, average fruit length, average fruit girth, average fruit weight, yields per square meter and yield per hectare were recorded in the present investigation.

Yield attributes such as number of fruits per vine (19.17) weight of fruits per vine (2.52 kg) and average fruit length (13.52 cm) were recorded maximum in glass house. As higher chlorophyll content and maximum leaf area under glass house resulted in better vegetative growth which ultimately envisaged the plants to enter into the reproductive phase. As the length of vine was maximum under glass house which resulted in flower bud formation on each node, better fruit set, fruit development and fruit weight. In addition, micro climatic condition in glass house was also favourable for plant growth characteristic as well as for yield parameters. Similar effects were observed by Sezen *et al*. (2010) and Champugain *et al*. (2004).

Similarly, the early and total yield enhanced in pepper grown under glass house (Dasgum and Abak, 2003). It is well known that yield of vegetables under greenhouse condition depends on various factors such as variety, temperature, humidity, CO_2 concentration etc. Gucan *et al*. (2006) stated that the cucumber yield in unheated greenhouse was 8-10kg/m^2 and 11-12 kg/m^2 in autum and spring production period, respectively. The significant fruit length and fruit width in Capsicum was also reported in glass house (Pandey *et al*. 2005) . However, as the full season progressed, the average temperature was getting cooler and day length shorten which caused the fruit to take more days to attain a proper length (Kwon and Chan 1996).

In gynoecious varieties of cucumber under glass house condition resulted in higher level of auxin and lower level of ABA which ultimately favoured more fruit set and better development of fruit parthenocarpically. It has been reported that auxin can induce pistillate flower formation through its stimulation of ethylene production. (Guo *et al.,* 2010). The more fruit set per vine under glass house condition with more accumulation of food material in leaves and its transfer to developing fruits, which affected the fruit length and width and ultimately significant increase in fruit yield per plant and yield per square meter was observed as evident from the data (Chapagain *et al.,* 2004).

The data presented in table 4.3 revealed that the various cultivars showed significant increase in fruits per vine and average fruit weight of cucumber. Among different cultivars the maximum number of fruits per vine (20.44) and highest fruit weight (137.98 g) was obtained in cultivar Isatish. This might be due to the genetic features of the variety. The variety Isatish was better responsive to the temperature and humidity in protected structure so the yield was higher among other cultivars. Shaw *et al*., (2007) reported significant effect on marketable fruit number and weight per plant in greenhouse cucumber varieties. It is depicted from the data (Table 4.9, 4.10) that the effect of the cultivar had a significant effect on yield per square meter of cucumber in greenhouse.

The significantly higher yield was recorded in cultivar Isatish (7.17 kg/ square meter) followed by Hilton (6.28 kg per square meter). It might be due to the high vegetative growth such as vine length and high fruit set per cent, more number of fruits per vine. Increase in yield and quality of greenhouse cucumber cultivar also reported by Alsadan *et al*. (2004). The yield and quality improved by the optimum temperature (26-32^0 C), CO_2 concentration (300-1000ppm) and humidity (90%). The day and night temperature also affected significantly the production of cucumber (Singh, 2005).

Glass house performed better in relation to growth and yield of cucumber. However, overall yield under poly house and net house was towards lower side in comparison to the yield generally obtained under these structures. The probable reasons for this reduction were;

a) Poly house was naturally ventilated one and was not fan pad based.

b) There was no buffer zone (double door) and thus the crop was easily infested by pest and diseases.

c) Soil of poly house and net house was severally infected by nematodes.

d) The roof height of poly house was only three metre so the inside temperature was high.

5.4 Physiological Parameters

It is evident from the data presented in the preceding chapter that various type of structures and cultivars had significant effect on physiological parameter like photosynthetic rate (µm $CO_2/m^2/s$), transpiration rate (µm $H_2O/m^2/s$) and chlorophyll content (mg/g fresh weight) of cucumber under different type of structures.

As far as winter season concerned, effect of structure have a significant influence on photosynthetic rate (µm $CO_2/m^2/s$), transpiration rate (µm $H_2O/m^2/s$) and chlorophyll content (mg/g of fresh weight). The maximum photosynthetic rate (12.83 µm $CO_2/m^2/s$) and chlorophyll content (1.30 mg/g) was found in glass house. Whereas, minimum transpiration rate (1.01 µm $H_2O/m^2/s$) was found in glass house. The photosynthetic rate, transpiration rate and chlorophyll content are dependent on different factors such as CO_2 concentration, temperature, light intensity, humidity, air temperature etc. Carbon makes up about 40 per cent of the dry matter, weight of higher plant, therefore CO_2 concentration enrichment increased photosynthesis and plant productivity significantly. Increased CO_2 concentration in glass house (300-1000ppm) has been reported to increase photosynthesis and decreased stomatal conductance in most of the crop plant resulting in reduced transpiration rate per unit area of leaf and overall increase in water use efficiency (Dwivedi and Dwivedi, 2005). Reduced transpiration will alter the microclimate particularly, the selective humidity in immediate environment of plant which will have implication for other living organism sharing the same ecosystem with the plant.

5.5 Quality parameters

The data presented in table 4.6 revealed that the various cultivars had resulted in significant increase in vitamin C content (mg/100g), Fiber content (%), Calcium content (mg/100g), Phosphorus content (mg/100g), Iron content (mg/100g). Among different cultivars maximum vitamin C (6.37 mg/100g) and minimum fiber content (0.78 %) were found in cultivar Isatish. This might be due to genetic expression in the cucumber cultivar. The cucurbitacae is known to controlled by different genetic environment and hormonal factors. Fruit quality is also determined by the gene expression of a particular variety under favourable climatic condition in greenhouse (Manzano *et al.,* 2008). As discussed in section 5.4, auxin induced pistillate flower formation through its stimulation of ethylene production, therefore, number of female flower were measured and it has been reported that the ethylene has higher genetic expression in case of gynoecious line that’s why the improved of Isatish and Hilton variety under glass house. (Guo *et al.,* 2010)

5.6 Economics

The findings of the present studies reflected that the net returns were significantly affected by different types of structures. It is clear from the data that maximum net returns and B:C ratio can be obtained by the poly house structure with 35821 ` per 500 square metre and 2.18, respectively. Where as in case of cultivar the maximum net return and B:C ratio was found with Isatish (41049 ` per 500 square metre and 2.20, respectively). The similar economic results have been reported by Cantliff *et al.,* (2008). Protected cultivation of vegetable offer distinct advances of quality, productivity and favorable market price to growers in adverse climatic conditions. Vegetable growers can substantially increase their income by protected cultivation of vegetables in off season production (Singh *et al.,* 2006).

The construction cost of glass house was high and there was no subsidy. Whereas, in case of poly house and net house there was subsidy of 70 per cent and initial investment was less compared to glass house. Therefore, the net returns under the glass house was on negative side.

5.7 Interaction effect of environment and variety

The interaction effect of E x V on vegetative growth characteristic such as length of vine and No. of fruits, yield per square metre, weight of fruits per vine etc. were found to be significant (Appendix XVII).

Length of vine and No. of fruits, yield per square metre, weight of fruits per vine were found maximum in the glass house. As discussed earlier favourable environmental condition resulting in better vegetative growth such as vine length and No. of fruits, yield per square meter, weight of fruits per vine thereby increase the yield per square meter in the glass house due to favourable environmental condition. The varietal expressions were also positive under glass house and recorded maximum yield under glass house. Isatish (V_1) recorded 115.63 per cent higher yield followed by Hilton as compared to Alamgir-CT-180 (V_3) in net house.

Therefore, under the favourable environmental condition *i.e.* glass house followed by poly house with positive genetic expression of variety Isatish and Hilton. There was positive and additive effect on growth and yield attributes. This might be due to different genetic, environmental and hormonal factors. Fruit quality is also determined by the gene expression of a particular variety under favourable climatic condition in greenhouse (Manzano *et al.,* 2008).

Chapter-6

SUMMARY AND CONCLUSION

The experiment entitled **"Standardization of production technology for cucumber (*Cucumis sativus* L.) under protected cultivation"** was conducted during 2010-11 at Central Institute of Arid Horticulture, Bikaner. The results and discussion in the preceding chapter have been summarized as below

6.1 Effect of environments

6.1.1 Vegetative growth parameters

6.1.1.1 The growth parameter i.e. Number of branches (1.75), number of leaves per vine (26.93) and leaf area (451.12 cm^2) were observed maximum under glass house than the poly house and net house, respectively.

6.1.1.2 The average length of vine was found maximum under glass house (3.25 m) while minimum under net house (2.95).

6.1.2 Yield and yield attributes

6.1.2.1 The least number of days to flower initiation (37.60) and more number of pickings (3.93) were recorded under glass house structure followed by poly house and recorded minimum under net house.

6.1.2.2 The maximum average fruit length and fruit girth were recorded with glass house (13.52 cm and 3.50 cm, respectively) whereas, these were found minimum under net house (11.89 cm and 3.22 cm, respectively).

6.1.2.3 The maximum number of fruits per vine (19.17) and higher average weight of fruit (139.90 g) were recorded in glass house.

6.1.2.4 The yield per sq m and yield ha^{-1} were observed in glass house with 6.81 kg and 68.06 t ha^{-1}, respectively.

6.1.3 Physiological parameters

6.1.3.1 The photosynthetic rate was highest in the glass house (12.83 $H_2O/m^2/s$) while minimum in net house (8.58 $H_2O/m^2/s$).

6.1.3.2 The minimum transpiration rate was recorded in glass house (1.00 $H_2O/m^2/s$) and maximum in net house (1.57 $H_2O/m^2/s$).

6.1.3.3 The highest chlorophyll content was recorded under glass house condition (1.30 mg/g) while minimum under net house (1.11 mg/g).

6.1.4 Economics

6.1.4.1 The highest net returns was obtained in the poly house (35821 ` per 500 sq m).

6.1.4.2 The maximum B:C ratio was observed in poly house (2.18) and minimum in glass house (0.95).

6.2 Effect of cultivars

6.2.1 Vegetative growth parameters

6.2.1.1 The maximum number of branches (1.75) and average length of vine were recorded in Isatish cultivar where as minimum were observed in Himangi (1.44 and 2.43 m, respectively)

6.2.1.2 The maximum average No. of leaves per vine (29.96) and size of leaves (450.04 cm^2) were observed in Isatish and Hilton, respectively. While minimum in Himangi (20.40 and 429.09 cm^2, respectively).

6.2.2 Yield parameters

6.2.2.1 The least number of days to flower initiation (36.80) was found in Isatish variety while maximum in Alamgir-CT-180 (40.62)

6.2.2.2 The maximum number of pickings, average weight of fruit and more number of fruits were recorded in Isatish with 5.13, 139.92 g and 20.4, respectively.

6.2.2.3 The maximum average fruit length and average fruit girth were recorded in Isatish with 14.57 cm and 4.17 cm, respectively. While minimum in Himangi with 10.60 cm and 2.53 cm, respectively.

6.2.2.4 The yield per sq m and yield (t ha^{-1}) were observed in Isatish with 7.17 kg and 71.71 t/ha, respectively.

6.2.3 Quality parameters

6.2.3.1 The maximum vitamin C content was recorded in Isatish (6.37mg per 100 g) whereas, it was found minimum in Himangi (4.90 mg per 100 g).

6.2.3.2 The minimum fiber content was observed in Isatish (0.78%). However, cultivar Alamgir-CT-180 had maximum fiber content (1.24%).

6.2.3.3 The maximum calcium content was recorded in Hilton (15.00 mg per 100 g) followed by Isatish (14.67 mg per 100 g). However, it was minimum in Alamgir-CT-180 (12.09 mg per 100 g).

6.2.3.4 The phosphorus and iron content was found maximum in Isatish (21.22 mg/100 g and 1.89 mg/100 g, respectively).

6.2.4 Economics

6.2.4.1 The highest net returns was obtained from Isatish cultivar (41049 ` per 500 sq m) where as minimum in Himangi (3699 ` per 500 sq m).

6.2.4.2 The maximum B:C ratio was observed in Isatish (2.20) where as minimum in Himangi (1.40).

6.3 Interaction effect between environments and varieties

6.3.1 The variety Isatish grown under the glass house recorded highest vine length (3.44 m).

6.3.2 In interaction, highest yield per square meter and yield (t ha^{-1}) found under glass house in respect to the variety Isatish with 10.62 kg and 106.23 t ha^{-1}, respectively.

6.3.3 In combined effect of structures and varieties, the maximum net returns was obtained by the poly house in respect to the variety Isatish with 56955 ` per 500 sq m.

6.3.4 The maximum B:C (2.78) ratio was obtained in poly house with the cultivation of cultivar Isatish.

CONCLUSION

On the basis of results obtained in present investigation entitled, **"Standardization of production technology for cucumber (*Cucumis sativus L.*) under protected cultivation"** it may be concluded that during *kharif* season out of the three protected structures *viz*. glass house, poly house and net house, the poly house (naturally ventilated) was found to be statistically better to obtain the maximum B:C ratio (2.18) and net returns (35821 ` per 500 sq m).

The cultivar Isatish was found superior to obtained the good quality of fruits and it was also produced the higher net returns (41049 ` per 500 sq m) and B:C ratio (2.20).

Among different structures and varieties of cucumber studied in the present experiment, poly house responded economically better in respect to the variety Isatish with maximum yield (8.90 kg per sq m) hence proved to be suitable for this region with a net return of ` 56955 per 500 sq m and B:C ratio of 2.78. Further studies are required to satisfy the present findings.

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Standardization of production technology for cucumber (*Cucumis sativus* L.) under protected cultivation

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ABSTRACT

A field experiment was conducted to study the **"Standardization of production technology for cucumber (*Cucumis sativus* L.) under protected cultivation"** at Central Institute of Arid Horticulture, Beechwal, Bikaner during 2010-11. The experiment was laid out in Randomized Block Design with factorial concept comprised of three environments namely glass house, poly house and net house and five varieties (Isatish, Hilton, Alamgir-CT-180, Poona Khira, Himangi) of cucumber.

The results indicated a remarkable significant difference on all the vegetative growth parameters. The maximum vine length, number of leaves, number of branches and leaf area 3.01m, 24.53, 1.75 and 448.37 cm^2, respectively were found in glass house conditions as compared to minimum in net house condition. Among different varieties of cucumber maximum vine length (3.26 m), number of leaves (29.96), number of branches (1.73) and leaf area (449.71 cm^2) were recorded in variety Isatish against the minimum plant height (2.43 m), number of leaves (20.40), number of branches (1.44) and leaf area (405.76 cm^2) in variety Himangi.

The results revealed that the quality parameters like ascorbic acid, calcium content, phosphorus content, iron content were significantly affected by different varieties. Isatish recorded maximum values of physical and chemical fruit quality parameters such as ascorbic acid (6.37 mg/100g edible portion), calcium content (6.37 mg/100g edible portion), phosphorus content (6.37 mg/100g edible portion), iron content (6.37 mg/100g edible portion) against the minimum ascorbic acid (6.37 mg/100g edible portion), calcium content (6.37 mg/100g edible portion), phosphorus content (6.37 mg/100g edible portion), iron content (6.37 mg/100g edible portion) in variety Himangi .

Maximum yield per hectare (75.59 tha^{-1}), net returns (` 35821 per 500 $m^2$) with a B:C ratio of 2.18 was recorded in cucumber crop raised under naturally ventilated poly house condition. Among the varieties maximum yield per hectare (86.78 t/ha), net returns (` 41049 per 500 m^2) with a B:C ratio of 2.20 were recorded in variety Isatish. Whereas, the minimum yield per hectare (59.01 tha^{-1}),

net returns (` 3699 per 500 m^2) with a B:C ratio of 1.40 was recorded in variety Himangi**.**

From the above result it is clear that growing of cucumber plant under poly house and among the five varieties of cucumber, variety Isatish had been found to be most effective keeping into account the various parameters studied and net returns with higher B:C ratio per 500 square metre. Therefore, growing of cucumber variety Isatish under poly house can be suggested as one of the best treatments for obtaining higher yield with maximum net returns per 500 square metre (56955 `) area as well as better quality cucumber fruits to fetch higher price in the market.

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Appendix – I

Analysis of variance for Number of branches per vine and Number of pickings (MSS)

Source of variations	d.f.	No. of branches per vine
Replication	2	0.038
Environments (E)	2	0.705**
Varieties (V)	4	0.122**
E x V	8	0.022
Error	28	0.014

*   Significant at 5% level of significance and

** Significant at 1% level of significance

Appendix – II

Analysis of variance for average length of vine (MSS)

Source of variations	d.f.	average length of vine (m)
Replication	2	0.051
Environments (E)	2	0.327**
Varieties (V)	4	1.033**
E x V	8	0.102**
Error	28	0.042

*   Significant at 5% level of significance and

** Significant at 1% level of significance

Appendix – III

Analysis of variance for average Number of leaves per vine and leaf area (MSS)

Source of variations	d.f.	Average no. of leaves per vine	Leaf area (cm^2)
Replication	2	0.62	2664.4
Environments (E)	2	9.11	7335.1**
Varieties (V)	4	132.99**	3510.9**
E x V	8	11.18	36.8
Error	28	5.03	799.6

*   Significant at 5% level of significance and

** Significant at 1% level of significance

Appendix – IV

Analysis of variance for Number of pickings and Days to first flowering (MSS)

Source of variations	d.f.	No. of pickings	Days to first flowering
Replication	2	0.20	11.4
Environments (E)	2	1.48*	18.6*
Varieties (V)	4	14.34**	24.1**
E x V	8	0.85	1.4
Error	28	0.41	4.6

* Significant at 5% level of significance and

** Significant at 1% level of significance

Appendix – V

Analysis of variance for average fruit length and average fruit girth (MSS)

Source of variations	d.f.	Average fruit length (cm)	Average fruit girth (cm)
Replication	2	1.20	0.205
Environments (E)	2	10.17**	0.304*
Varieties (V)	4	22.87**	4.571**
E x V	8	0.18	0.011
Error	28	1.14	0.075

* Significant at 5% level of significance and

** Significant at 1% level of significance

Analysis of variance for Number of fruits per vine (MSS)

Source of variations	d.f.	No. of fruit per vine
Replication	2	0.4
Environments (E)	2	35.8**
Varieties (V)	4	23.9**
E x V	8	2.2**
Error	28	0.7

* Significant at 5% level of significance and

** Significant at 1% level of significance

Appendix – VII

Analysis of variance for weight of fruits per vine (MSS)

Source of variations	d.f.	Weight of fruit per vine (kg.)
Replication	2	0.166
Environments (E)	2	4.134**
Varieties (V)	4	1.989**
E x V	8	1.312**
Error	28	0.051

* Significant at 5% level of significance and

** Significant at 1% level of significance

Appendix – VIII

Analysis of variance for average fruit weight (MSS)

Source of variations	d.f.	Average fruit weight (g)
Replication	2	5.2
Environments (E)	2	4499.7**
Varieties (V)	4	1224.0**
E x V	8	440.1
Error	28	204.6

* Significant at 5% level of significance and

** Significant at 1% level of significance

Appendix – IX

Analysis of variance for yield per square (MSS)

Source of variations	d.f.	Yield per square meter (kg)
Replication	2	0.51
Environments (E)	2	29.38**
Varieties (V)	4	10.26**
E x V	8	1.21**
Error	28	0.19

* Significant at 5% level of significance and

** Significant at 1% level of significance

Appendix – X

Analysis of variance for yield of cucumber (MSS)

Source of variations	d.f.	Yield (tha^{-1})
Replication	2	51.5
Environments (E)	2	2938.3**
Varieties (V)	4	1026.2**
E x V	8	121.3**
Error	28	19.3

* Significant at 5% level of significance and

** Significant at 1% level of significance

Appendix – XI

Analysis of variance for photosynthesis rate, transpiration rate and chlorophyll content (MSS)

Source of variations	d.f.	Photosynthesis rate (µm $CO_2/m^2/S$)	Transpiration rate (µm $H_20/m^2/S$)	Chlorophyll content (mg/g fresh weight)
Replication	2	0.42	0.01	0.0237
Environments (E)	2	68.03**	1.27**	0.1320**
Varieties (V)	4	1.48	0.01	0.0186
E x V	8	22.49	0.15	0.0002
Error	28	10.04	0.08	0.0155

** Significant at 5% level of significance and

** Significant at 1% level of significance

Appendix – XII

Analysis of variance for ascorbic acid and fiber content (MSS)

Source of variations	d.f.	Ascorbic acid (mg/100g)	Fiber content (%)
Replication	2	0.37	0.016
Environments (E)	2	0.37	0.006
Varieties (V)	4	2.97**	0.271**
E x V	8	0.30	0.031
Error	28	0.14	0.013

* Significant at 5% level of significance and

** Significant at 1% level of significance

Appendix – XIII

Analysis of variance for calcium, phosphorus and iron (MSS)

Source of variations	d.f.	Calcium (mg/100g)	Phosphorus (mg/100g)	Iron (mg/100g)
Replication	2	3.20	6.49	0.039
Environments (E)	2	0.60	1.69	0.027
Varieties (V)	4	14.29**	22.32**	0.480**
E x V	8	3.60	4.74	0.076
Error	28	1.99	2.54	0.034

* Significant at 5% level of significance and

** Significant at 1% level of significance

Appendix – XIV

Analysis of variance for net return (MSS)

Source of variations	d.f.	Net return ` per 500 sq m
Replication	2	34651166.7
Environments (E)	2	6050546871.4**
Varieties (V)	4	2434235649.3**
E x V	8	155398227.2**
Error	28	12488131.0

* Significant at 5% level of significance and

** Significant at 1% level of significance

Appendix – XV

Analysis of variance for B:C ratio (MSS)

Source of variation	d.f.	B:C ratio
Replication	2	0.022
Environments (E)	2	6.696**
Varieties (V)	4	1.125**
E x V	8	0.057**
Error	28	0.017

*   Significant at 5% level of significance and

** Significant at 1% level of significance

Appendix – XVI

Common cost of cultivation of cucumber

S. No.	Particulars	Unit	Rate (` per unit)	Cost (`Per 500 m^2)
A.	**Labour cost**			
I	**Nursery**			
1	Nursery Preparation and sowing	1 Man days	135.00	**135.00**
2	Nursery management (one hour for 15 days)	2 Men days	135.00	**270.00**
II	**Main field**			
1	Land preparation	3 Men days	135.00	**405.00**
2	Transplanting	2 Men days	135.00	**270.00**
3	Manuring and fertilization	1 Man days	135.00	**135.00**
4	Intercultural operations (Hoeing, weeding, earthing up staking, pruning and irrigation)	8 Men days	135.00	**1080.00**
5	Spraying (insecticides and pesticides)	3 Men days	135.00	**405.00**
6	Training and trellising	4 Men days	135.00	**540.00**
7	Picking and harvesting	15 Men days	135.00	**2025.00**
	Total (A)			**5265.00**
B.	**Material inputs**			
1	Farm yard manure	12.5 q	50.00	**625.00**
2	Soil treatment (formaldehyde)	100 litre	20	**2000.00**
3	Fertilizer (19:19:19)	20 kg	80	**1600.00**
4	Insecticide, fungicide and nematicide			
(i)	Imedachlorprid 17.8 SL	100 ml	900/l	**90.00**
(ii)	Mencozeb 75% WP (Indofil M-45)	200 g	380	**76.00**
(iii)	Carbofuron (Furadon)	2 kg	80	**160.00**
5	Plastic ropes	5 kg	80	**400.00**
	Total (B)			**4951.00**
	Common cost of cultivation (Total A + B)			**10216.00**
C	**Treatment Cost**			
I	**Infra structure cost**			
1	Polyhouse/season		970	**13,472.00***
2	Shade net house / season		570	**7,917.00***
3	Glasshouse/season		4333	**60,181.00**
II	**Seed Cost**			
	Isatish		5945	**8,323.00**
	Hilton		5945	**8,323.00**
	Alamgir CT 180		3224	**4,514.00**
	Poona Khira		3323	**4,652.00**
	Himangi		2250	**3,150.00**

***Cost with 70 per cent subsidy

Appendix – XVII

Comparative cost of cultivation of various treatments (` Per 500 m^2)

Treatment	Gross cost (`/500 sq m)	Fruit yield (kg/500 sq m)	Gross return (`/500 sq m)	Net return (`/500 sq m)	B:C ratio
PV_1	32,011	4448.33	88967	56955	2.78
PV_2	32,011	4163.33	83267	51255	2.60
PV_3	28,202	3530.00	52950	24748	1.88
PV_4	28,340	3681.67	55225	26885	1.95
PV_5	26,838	3073.33	46100	19262	1.72
SV_1	26,456	3256.67	65133	38678	2.46
SV_2	26,456	2841.67	56833	30378	2.15
SV_3	22,646	2463.33	36950	14304	1.63
SV_4	22,785	3001.67	45025	22240	1.98
SV_5	21,283	2616.67	39250	17967	1.84
GV_1	78,720	5311.67	106233	27514	1.35
GV_2	78,720	4668.33	93367	14647	1.19
GV_3	74,910	3936.67	59050	-15860	0.79
GV_4	75,049	3937.67	59065	-15984	0.79
GV_5	73,547	3161.00	47415	-26132	0.64

Fruits of varieties Isatish (V_1) and Hilton (V_2) sold @ 15/kg

Fruits of varieties Alamgir-CT-180 (V_3), Poona Khira (V_4) and Himangi (V_5) sold @ 12/kg

Appendix – XVIII

Mean weekly weather parameters under naturally ventilated polyhouse during crop growing season (2010-11)

Standard meteorological week No.	Period		Temperature (^0C)		Relative humidity (%)	
	From	To	Max.	Min.	Max.	Min.
30	03.08.2010	10.08.2010	35.7	31.1	95	81
31	11.08.2010	18.08.2010	38.1	31.7	94	76
32	19.08.2010	26.08.2010	35.4	28.9	95	79
33	27.08.2010	03.09.2010	34.5	27.4	94	75
34	04.09.2010	11.09.2010	36.5	28.5	96	72
35	12.09.2010	19.09.2010	38.1	28	93	68
36	20.09.2010	27.09.2010	37.1	29.4	92	79
37	28.09.2010	05.10.2010	35.2	27.6	96	78
38	06.10.2010	13.10.2010	34.3	25.8	94	59
39	14.10.2010	21.10.2010	36.7	25.5	93	58
40	22.10.2010	29.10.2010	38.4	24.8	82	38
41	1.11.2010	7.11.2010	36.8	26.2	83	42
42	8.11.2010	14.11.2010	37.8	21.8	84	35
43	15.11.2010	21.11.2010	36.2	20.2	84	36
44	22.12.2010	28.11.2010	37.7	18.4	80	37
45	29.11.2010	5.12.2010	35.2	20.2	85	40

46	6.12.2010	12.12.2010	34.2	18.3	87	36
47	13.12.2010	19.12.2010	34.9	16.8	84	38
48	20.12.2010	26.12.2010	34	18.7	86	39
49	27.12.2010	2.01.2011	31.4	18.7	91	46

Appendix – XIX

Mean weekly weather parameters under Agro shade net house during crop growing season (2010-11)

Standard meteorological week No.	Period		Temperature (^0C)		Relative humidity (%)	
	From	To	Max.	Min.	Max.	Min.
30	03.08.2010	10.08.2010	38.0	29.3	71	48
31	11.08.2010	18.08.2010	38.6	29.4	66	40
32	19.08.2010	26.08.2010	41.1	30.9	60	38
33	27.08.2010	03.09.2010	35.0	28.0	83	56
34	04.09.2010	11.09.2010	35.7	27.4	83	60
35	12.09.2010	19.09.2010	37.0	28.2	79	47
36	20.09.2010	27.09.2010	35.2	26.9	87	56
37	28.09.2010	05.10.2010	35.2	27.2	76	50
38	06.10.2010	13.10.2010	38.4	27.5	80	43
39	14.10.2010	21.10.2010	36.2	26.2	82	54
40	22.10.2010	29.10.2010	33.3	25.3	90	64
41	1.11.2010	7.11.2010	31.5	16.1	62	28
42	8.11.2010	14.11.2010	32.1	16.5	65	30

43	15.11.2010	21.11.2010	31.5	16.1	62	28
44	22.12.2010	28.11.2010	32.1	16.5	65	30
45	29.11.2010	5.12.2010	29.7	17.5	90	40
46	6.12.2010	12.12.2010	27.2	11.9	79	27
47	13.12.2010	19.12.2010	26.6	8.8	66	16
48	20.12.2010	26.12.2010	23.9	9.2	68	24
49	27.12.2010	2.01.2011	24.2	8.2	65	22