

**EVALUATION OF CAPSICUM HYBRIDS UNDER
PROTECTED CONDITION**

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**EVALUATION OF CAPSICUM HYBRIDS UNDER
PROTECTED CONDITION**

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IN

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BY

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CERTIFICATE

This is to certify that the thesis entitled "**EVALUATION OF CAPSICUM HYBRIDS UNDER PROTECTED CONDITION**" submitted by **Mr. MANOJ B. V.**, for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **HORTICULTURE** to the University of Agricultural Sciences, Dharwad is a record of research work done by him during the period of his study in this university under my guidance and the thesis has not been previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

**Dharwad
July, 2016**

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CONTENTS

Sl. No.	Chapters particulars
	CERTIFICATE
	ACKNOWLEDGEMENT
	LIST OF TABLES
	LIST OF FIGURES
	LIST OF PLATES
	LIST OF APPENDICES
1.	INTRODUCTION
2.	REVIEW OF LITERATURE
	2.1 Performance of capsicum hybrids under protected cultivation
	2.2 Quality of capsicum
	2.3 Influence of different growing environment on productivity and quality of the produce
	2.3 Cost economics
3	MATERIAL AND METHODS
	3.1 Experimental Details
	3.2 Experimental Procedure
	3.3 Characters of capsicum hybrids
	3.4 Observations
	3.5 Economics
	3.6 Statistical analysis
4.	EXPERIMENTAL RESULTS
	4.1 Vegetative parameters of capsicum hybrids
	4.2 Reproductive parameters of capsicum hybrids
	4.3 Quality parameters
	4.4 Yield parameters
	4.5 Economics
5.	DISCUSSION
	5.1 Vegetative growth parameters of capsicum hybrids
	5.2 Reproductive parameters of capsicum hybrids
6.	SUMMARY AND CONCLUSIONS
	REFERENCES
	APPENDICES

LIST OF TABLES

Table No.	Title
1.	Plant height of capsicum hybrids at different stages of crop growth under polyhouse condition
2.	Number of leaves of capsicum hybrids at different stages of crop growth under polyhouse condition
3.	Number of primary and secondary branches per plant of capsicum hybrids recorded under polyhouse conditions
4.	Days taken for first flower initiation and fruit harvest of different capsicum hybrids in polyhouse
5.	Number of flowers per plant, number of fruits per plant and per cent fruit set of capsicum hybrids grown under polyhouse condition
6.	Fruit weight and fruit volume of capsicum hybrids grown in protected condition
7.	Shelf life and pericarp thickness of capsicum hybrids grow in polyhouse
8.	TSS, vitamin – C, moisture content and dietary fibre of capsicum hybrids grown under polyhouse condition
9.	Yield per plant, yield per meter square and yield per hectare of capsicum hybrids grown under polyhouse condition
10.	Cost of cultivation and B:C ratio per hectare of capsicum hybrids grown in polyhouse for one crop (6 months)
11.	Summary of observations recorded under vegetative, reproductive and quality parameters

LIST OF FIGURES

Figure No.	Title
1.	Plant height of capsicum hybrids at different stages of crop growth under polyhouse condition
2.	Number of leaves of capsicum hybrids at different stages of crop growth under Polyhouse condition
3.	Number of primary and secondary branches of capsicum hybrids grown under polyhouse condition
4.	Days taken for first flower initiation and fruit harvest of different capsicum hybrids grown under polyhouse condition
5.	Number of flowers per plant and number of fruits per plant of capsicum hybrids grown under polyhouse condition
6a.	Fruit weight of capsicum hybrids grown under protected condition
6b.	Fruit volume of capsicum hybrids grown under protected condition
7.	Shelf life of capsicum hybrids grown under polyhouse condition
8.	Vitamin – C of capsicum hybrids grown under polyhouse condition
9.	TSS and dietary fibre of capsicum hybrids grown under polyhouse condition
10.	Yield per plant, yield per meter square and yield per hectare of capsicum hybrids grown under polyhouse condition

LIST OF PLATES

Plate No.	Title
1.	General view of experimental plot
2a.	Different capsicum hybrids : In bearing stage
2b.	Different capsicum hybrids : In bearing stage
2c.	Different capsicum hybrids : In bearing stage
3a.	Morphological features of capsicum hybrids under study
3b.	Morphological features of capsicum hybrids under study
4.	Pooled harvesting of different capsicum hybrids

LIST OF APPENDICES

Appendix No.	Title
I.	Mean monthly meteorological data during (2015-2016) crop growth period at Hi-tech Horticulture Unit, Saidapur farm, MARS, Dharwad
II.	Calculation of detailed cost of cultivation of capsicum hybrids under protected structure (one hectare) for one crop

1. INTRODUCTION

The genus capsicum belongs to family Solanaceae a widely distributed and cultivated one in tropical regions of the world (Dapgan, 2002). The capsicum (*Capsicum annuum* L. var. *grossum*; 2n=24) is commonly known as bell pepper or green pepper or sweet pepper. It is relatively non-pungent or less pungent with thick flesh and it is the world's second most important vegetable after tomato. Capsicum is native to Central and South America and Brazil is considered as a secondary centre of diversity (Mongkolporn and Taylor, 2011). It is cultivated in most parts of the world, in temperate regions of Central and South America, European countries, tropical and subtropical regions of Asian continent mainly India and China.

Asia is the biggest producing region in the world. China is the leading country which produces approximately 1.10 lakh tons followed by India (Anon., 2015). India contributes one fourth of the world production of capsicum with an average annual production of 172 thousand tons from an area of 30 thousand hectare. In India, capsicum is extensively cultivated in Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Himachal Pradesh and hilly areas of Uttar Pradesh. Karnataka stands first with an area of about 3.89 thousand hectare with a production of about 53.01 thousand tons (Anon., 2015).

In India, capsicum is grown for its mature fruits and is widely used in stuffing and baking. It is also used in salad and soup preparation. Capsicum fruits are known to have high nutritional values, they contain various vitamins A, C, E, B₁ and B₂ (3131 IU, 127.7 mg, 1.58 mg, 0.085 mg and 0.054 mg, respectively for every 100 g), biological pigments (Lycopene and Xanthophyll), dietary fibre (1.8 g/100 g) and several essential minerals. It is a good source of potassium (211 mg/100 g), phosphorus (26 mg/100 g), magnesium (12 mg/100 g) and calcium (7 mg/100 g). Every 100 g of edible portion of capsicum contains 31 k cal of energy, 0.99 g of protein, 6.03 g of carbohydrate and 0.99 g of fat (USDA National Nutrient Data Base). Anon., (2014)

Therefore, capsicum consumption is increasing and may represent an important source of vitamins for world populations. The antioxidant vitamin-C (Ascorbic acid) and E (Alpha-tocopherol) and pro-vitamin-A (Carotene), which prevents cancer and cardiovascular human diseases, are present in high concentrations in various bell pepper types (Kurubetta, 2008).

Capsicum is a cool season crop, but protected cultivation enables to grow capsicum round the year, where temperature and relative humidity can be manipulated. This crop requires day temperature of 25-30 °C and night temperature of 18-20 °C with relative humidity of 75 to 80 per cent. If temperature exceeds 35°C or falls below 12 °C, fruit setting will be affected.

It has attained a status of high value crop in India in the recent years and occupies a pride place among vegetables in Indian cuisine, because of its delicate taste and pleasant flavour coupled with rich content of ascorbic acid and other vitamins and minerals. The mature fruits (green, red and yellow) of sweet pepper are eaten raw or widely used in stuffing, baking, pizza and burger preparations (Elio, 1998).

With the increase in population, the demand for the crop has been increasing day by day and the traditional varieties due to their inherent low yield potential would not be fulfilling the demand. On the other hand, hybrids have not only shown a potential to fulfill the demand, but also opened the export avenues as they had an edge over traditional varieties in terms of yield, uniformity, early maturity, tolerance to biotic and abiotic stresses and better quality (Arya, 1999).

Greenhouse bell pepper cultivars are hybrids that have bell-shaped or blocky-type fruits with varied colours. While green is the most favoured colour in bell peppers, red and yellow are also preferred with higher price in fresh market. Such hybrids are characterized for high productivity and quality traits. Commercial hybrids show superiority of marketable fruit yield and fruit quality over the open pollinated cultivars.

The traditionally grown green capsicum, depending upon variety and season, usually yields 20-40 tons per hectare in about 4-5 months. In greenhouse, the crop duration of green and coloured capsicums is about 7 -10 months and yields about 80-100 t ha⁻¹.

Despite its economic importance, growers are not in a position to produce good quality capsicum with high productivity due to various biotic (pest and diseases), abiotic (rainfall, temperature, relative humidity and light intensity) and crop factors (flower and fruit drop), which ultimately affects the crop productivity adversely (Ochigbo and Harris, 1989). The concept of protected condition of bell pepper has slowly been mingling with changing trend in vegetable production owing to increasing demand in variety, taste and quantity by Indian army, tourist, floating population as well as locals themselves. So, it becomes imperative to grow bell pepper under protected condition usually in greenhouse in this region and real potential can well be exploited using greenhouse technology (Kanwar *et al.*, 2014). Hence, to obtain a good quality produce and production during off season, there is a need to cultivate capsicum under protected conditions such as greenhouse or polyhouse or shade net.

Protected cultivation technology ideally suits to horticultural crops mostly vegetables and floriculture crops. In protected cultivation the crops are protected from excessive sunlight by providing uniform shade that result in better yield. These structures will also act as a barrier against heavy rains, hail-storms and other natural calamities. It provides protection against insects, diseases, birds and helps in reducing the loss of water through evaporation. These technologies are being utilized all over the world to produce vegetables but the level and extent of their use may be different among different countries. Of late, the farmers of India are realizing the importance of protected cultivation of vegetable crops. India has entered into the era of greenhouse vegetables cultivation more recently.

Depending on the region, climate and crop-growing season, greenhouse can be a means to economically maintain a warm environment during cool seasons, utilized for year round off-season production of high value with low volume vegetables to protect plants from rain, wind and high solar radiation. In addition, these structures facilitate the utilization of nutrients from soil for longer duration (Singh *et al.*, 2005).

Growing of capsicum under polyhouse has been reported to give high productivity of good quality produce in developed countries and several hybrids have been developed recently. Hence, there is a need to evaluate their performance under naturally ventilated polyhouse conditions for getting higher productivity of excellent quality under Indian conditions.

Capsicum is one such vegetable which befits into cultivation under protection to increase the production and yield. There are several capsicum varieties and hybrids available and being cultivated by farmers on commercial scale under open field condition. Hence, there is a need to evaluate various commercial capsicum hybrids for recommending its cultivation under greenhouse condition. Therefore, present study was conducted with an objective to evaluate technical feasibility of protected technology and suitable hybrids for obtaining maximum yield, economic gain and to minimize biotic and abiotic stresses for capsicum crop. This study was undertaken with the following objectives.

- i. To study the performance of different capsicum hybrids under protected cultivation for growth and yield.
- ii. To study the quality of capsicum grown under naturally ventilated polyhouse.
- iii. To work out the cost economics of different hybrids grown under polyhouse.

2. REVIEW OF LITERATURE

Capsicum is one of the most important nutritious and highly remunerative vegetable crops grown mainly for its green fruits. It is difficult to obtain higher yields of good quality fruits throughout the year under open conditions in most parts of India, as it is delicate crop. Cultivation of bell pepper is possible even during the off-season under protected structures. Newly evolved and superior type of varieties or hybrids of crops needs to be assessed for their optimum performance under protected structures. The literature pertaining to the evaluation of capsicum and other such vegetables which suit cultivation under protected structures is reviewed hereunder.

2.1 Performance of capsicum hybrids under protected cultivation

2.1.1 Capsicum

Gomez and Hernandez (1994) conducted a comparative study among capsicum cultivars planted on 2nd June. 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 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 (6,738 and 3,417 kg /ha, respectively).

Krishna Manohar (2002) reported that the hybrid Green Gold recorded significantly higher fruit set in both winter and summer (41.43 % and 36.61 %, respectively) followed by Indra (37.72 % and 33.42 %, respectively) while least was in Bharath (35.58 % and 30.68 %, respectively). The highest cumulative yield was obtained in hybrid Green Gold (10.69 kg/m²) than other genotypes. The fruits of the hybrid Green Gold had maximum breadth, weight, volume and rind thickness while length of the fruit was maximum in the hybrid Indra.

Kurubetta (2008) reported that the hybrid Indra recorded significantly earlier flower initiation (35.42 days), the time taken for first harvesting was lowest (86.00 days) and higher per cent of fruit set (45.45 %) as compared to Bomby and Orobelle hybrids.

Thangam *et al.* (2008) reported maximum yield per plant in Orobelle (1.29 kg/plant) followed by Swarna (1.27 kg/plant). Maximum fruit weight was highest in Swarna (110.40 g) followed by Orobelle (91.60 g).

Singh *et al.* (2010) reported that among the different hybrids, hybrid Tanvi produced maximum fruit diameter (7.50 cm), number of fruits per plant (51), individual fruit weight (65.85 g) and yield (19.86 kg/m²).

Kanwar and Sharma (2010) reported that the hybrid Bharath, BSS-519 and Spinx were best suited for greenhouse cultivation under the cold arid region. Hybrid Bharath was found to be high yielder (518.9 q/ha) closely followed by Super Gold (453 q/ha).

Vasant *et al.* (2011) revealed that two bell pepper varieties California Wonder and Gangavati Local did not differ much with respect to growth parameters like plant height, plant spread and number of branches. With respect to flowering, the performance of California Wonder was superior in terms of days taken from fruit set to harvest (32.98 days).

The variety California Wonder was included in the study with four protective structures (low height poly tunnel, poly tunnel with side open, poly tunnel with side closed and polyhouse) including control (open field). Protective structures had remarkable and significant influence on plant growth and yield of sweet pepper. The plants grown under protective structures had higher plant height compared to that of plants grown in open field. The highest individual fruit weight (65.2 g) was recorded from the plants grown under polyhouse condition while it was the lowest from open field grown plant (33.4 g). The maximum fruit yield per plant (334.0 g) was recorded from polyhouse, which was higher than that of plants grown under open field condition. The second highest yield was recorded from the plants of poly tunnel (212.5 g) (Halim and Islam, 2013).

Rajender and Shukla (2013) studied six hybrids of bell pepper (Orobelle, Bomby, Mahabharath, Tanvi, Tanvi Plus and US-26). Among six hybrids Tanvi (yellow-fruited) and Tanvi Plus (red-fruited) were the best yielders when compared to hybrids being grown by the farmers. Average plant height ranged from 100 to 160 cm, fruit weight ranged from 205 to 280 g per fruit and number of marketable fruits per plant varied from 11 to 23. Yield for the two best hybrids, *i.e.*, Tanvi and Tanvi Plus were 140.5 tons and 127.3 tons per hectare, respectively.

Laxmi *et al.* (2014) reported that the highest canopy width was found in White Erect (109.36 cm) followed by Kagaon and Round Black. Based on leaf characteristics, the longest pedicel was (3.76 cm) in White Erect and shortest in Utkalabha. The maximum leaf width was (5.51 cm) in White Erect followed by Chandanbati, Arka Suphala and Ghantamala-2.

Clemencia and Sumagaysay (2015) stated that responses of bell pepper grown inside and outside plastic tunnel during wet and dry seasons manifested highly significant differences in the number of days to senescence, number of flowers, number of fruits, fruit size, fruit weight and fruit yield. Bell pepper grown inside plastic tunnel performed best in most parameters particularly when planted during wet season. Growing capsicum inside plastic tunnel both in wet and dry season recorded maximum plant height, longer growing period, more flowers and fruit production, bigger fruit size, higher yield and higher income.

Muhammad *et al.* (2015) revealed that among the hybrids *viz.*, Orobelle, Figaro, Green Beauty, Mighty and Capsitrano, it was Orobelle which ranked first regarding number of fruit per plant (43.7), fruit weight per plant (1.9 kg) and yield (51 t/ha), followed by Figaro (32.84, 1.72 kg, 48.57 t/ha) and Capsitrano (41.48, 1.70 kg, 45.90 t/ha, respectively). Mighty hybrid produced higher value for fruit length and fruit diameter (5.91 and 6.27 cm, respectively)

Sagar *et al.* (2015) revealed that among the varieties, Mekong emerged as superior in terms of more number of fruits (10.24), fruit weight (65.50 g) and yield (670.76 g/plant and 18.11 t/ha) while maximum beta carotene and vitamin-C were recorded in the variety California Wonder (0.071 µg/100 g fresh fruits, 154.80 mg/100 g fresh fruits, respectively).

2.1.2 Other vegetables

Savie *et al.* (1990) studied the performance of two tomato cultivar Merit and Havister in greenhouse and obtained higher fruit yield (86.02 t/ha) in Havister as compared to Merit (74.39 t/ha).

Pitam Chandra *et al.* (2000) found that hybrid Naveen performed better as compared to Pusa Hybrid-2 under greenhouse. The hybrid Naveen gave a yield of 11.05 kg/m² and 3.98 kg/plant, as compared to Pusa Hybrid-2 (9.86 kg/m² and 3.55 kg/plant).

Azeem (2011) reported significant increases in the marketable yield per unit area between 5.37 to 6.77 kg per m² in greenhouse cultivated cucumbers. The cucumbers so harvested were of higher quality (no insect damage) and were sold at premium prices during the whole production cycle.

The observation recorded for hybrids showed that To-ind- Hyb/3, TH-12 and G-600 were found maximum yielding genotypes under nethouse. These genotypes yield more because of maximum number of fruits per plant. It was also observed that genotypes under nethouse yield more as comparison to open field condition because of early yield and more number of pickings (Cheema *et al.*, 2013).

Nagre (2013) reported that, the Module 7 *i.e.*, soil : compost : sand as substrate, 20 kPa irrigation regime, basal dose of 50 kg/ha NPK with straight fertilizers + fertigation at 250:250:250 kg/ha NPK with straight fertilizers, black polythene mulch and variety SH-7711 recorded significantly maximum number of clusters per plant (17.89), number of fruits per cluster (6.44), number of fruits per plant (88.44) and the fruit yield per plant (6.70 kg) and therefore found to be best package for higher production of tomato in naturally ventilated greenhouse.

Twelve tomato hybrids were obtained from public and private sectors and grown under polyhouse conditions. The analysis of variance revealed significant variation among the hybrids for all the characters. Ample variability was observed for vegetative characters as obvious from the wide range obtained for the different characters. Indam 9802 was the earliest to flower (26.27 days) among the hybrids. Tomato F₁ T-30 had the potential of setting maximum fruits per plant (35.66) followed by Tomato F₁ Queen (35.55). Indam 9802 recorded the maximum yield of (1,444.40 g) followed by Tomato F₁ T-30 (1,412.22 g) and have the potential to be cultivated under protected conditions of Kerala. A wide range of variation was observed for the biochemical constituents of the fruits. Polyhouse tomatoes had better colour and appearance than those from the open field. It has been observed that polyhouse grown tomatoes have potential for better performance and higher fruit yield than open field conditions. (Lekshmi and Celine, 2015).

Five exotic varieties of cucumber *viz.*, CU-2833, CU-5555, GR-102, CFMC-0036 and CFMC-0031 were compared with locally developed line "Kheera Local" during autumn 2012. Differences of mean yield and number of fruits were found significant among six varieties while emergence percentage was found non-significant. Exotic varieties produced early fruiting and gave more returns. However, CU-2833 and CU-5555 topped the list with 35.5 and 33.9 tons per hectare, respectively (Mudassar *et al.*, 2015).

2.2. Quality of capsicum

2.2.1 Capsicum

Buczowska (1990) studied the sweet capsicum cropping in unheated structures. Fruit production by five cultivars in glasshouse and in a plastic tunnel was investigated over three years. Temperature in the two structures were higher than in the open field during May-September and growing conditions, especially in the tunnel, were better. Annual weather conditions affected both yield and quality. The highest total yield and the highest percentage of marketable fruits were produced in both structures by the Czechoslovaks cultivar PCR. Fruit vitamin-C, carbohydrates and dry matter content varied with cultivars.

Mohamedien *et al.* (1991) reported that the cucumber cultivar Farid under polyhouse conditions gave maximum fruit weight (114.24 g), fruit length (15.69 cm), diameter (3.3 cm) and yield (75.07 kg/plot) as compared to other cultivars.

Rai *et al.* (1992) studied shelf life of six capsicum hybrids grown under protected and open field conditions along with one open pollinated variety. The shelf life of capsicum fruits harvested from polyhouse was more than that of fruits harvested from open conditions. The maximum shelf life of sixteen days was recorded in Arun F₁ growing in polyhouse, while it was only ten days in fruits produced in open condition.

Krishna Manohar (2002) indicated that among the hybrids, Green Gold recorded significantly higher mean yield and shelf life both during winter and summer (10.12 and 7.83 days, respectively) than other hybrids. In contrast to this they recorded lowest shelf life in hybrid Bharath (7.50 and 5.18 days, respectively).

Martinez *et al.* (2005) revealed that the vitamin-C content for green mature and breaker peppers stored at room temperature (20 °C) increased upto 10 days of storage, reaching similar values as those obtained for red peppers direct from the plant. However, stored red ripe peppers showed a significant loss in vitamin-C content, around 25 per cent. Refrigeration at 4 °C for upto 20 days did not change the ascorbic acid content, except for red peppers, which have showed losses around 15 per cent.

Nyanjage (2005) studied that the post-harvest performance of sweet pepper 'California Wonder' was tested under three different packages (open trays, non-perforated and perforated polyethylene bags) stored at temperatures of 4 °C, 6.5 °C and ambient (17 °C) for 25 days. Fruit weight loss was significantly lower at storage temperatures of 4 °C and 6.5 °C and non-perforated packaging. Skin green colour retention was significantly higher with fruits held at 4 °C and 6.5 °C on day 5 and at 6.5 °C on days 10 to 25 compared to ambient storage.

Kurubetta (2008) studied that among the hybrids, Bomby recorded significantly higher fruit weight (158.50 g), fruit volume (310.00 cc) and Indra recorded higher rind thickness (0.87 cm) and shelf life (8.60 days).

Evaluation of capsicum genotypes namely Bomby, Aishwarya, Bharath, Manhattan, Orobelle, Indira (hybrids), California Wonder, China Zohinger and Solan Bharpur (cultivars) was done for horticultural traits under polytunnels and open field conditions. Growth and fruit yield of capsicum was significantly superior in polytunnels in comparison to field conditions. Under polytunnels crop was advanced by 15-20 days and an extending crop period of 25-30 days was recorded in comparison to open field conditions. Increase in yield over open field condition was recorded (11.78 to 57.11 %). Hybrids performed better over open pollinated cultivars (Sanjeev *et al.*, 2009).

Abdullah *et al.* (2013) reported that among the three cultivars 'Lirica' F₁ yellow cultivar had large fruit size (heavier, longer, wider and thicker pericarp fruits). Mean while, 'Sondela' F₁ red cultivar exhibited superior fruit quality (Vitamin-C, titratable acidity, total soluble solids and total sugars).

Dargie *et al.* (2013) studied the effects of harvesting stages (0, 25, 50, 75 and 100 % fruit colourations) and storage durations (0, 1, 2, 3 and 4 weeks) on physico-chemical quality and shelf life of sweet pepper varieties (Telmo-Red and Velez-Yellow) under passive refrigeration system (PRS). Telmo variety showed significantly better -harvest quality and storability potential than Velez variety.

Jose *et al.* (2013) studied the influence of two production systems on post-harvest quality and shelf life of two green pepper hybrids (*Capsicum annuum* L.). Anaheim-types 'Cardon' (mild hot) and '118' (mid hot). In the first experiment, plants were grown in open-field, and in the second under greenhouse conditions (soil directly and soilless). From each production system, fifty freshly harvested fruits were picked and stored at 20 °C during 14 days. Fresh chilli pepper grown under hydroponic greenhouse conditions presented a better quality and shelf life (10 DAH) while those in open-field conditions showed a marketing limit of 5 DAH (Days After Harvest).

Studies conducted by Narayana Swamy *et al.* (2014) on capsicum indicated that fruit parameters such as fruit length, fruit volume, fruit wall thickness and number of locules per fruit recorded higher values in the hybrids *viz.*, Indra (10.42 cm, 313.36 cc, 1.05 cm and 4.00, respectively) and NS-280 (8.97 cm, 310.66 cc, 0.98 cm and 3.87, respectively). Average fruit weight was maximum in the hybrid Indra (124.70 g) followed by the hybrid NS-280 (115.31 g). With respect to quality parameters, high ascorbic acid content was recorded in the hybrid Angel (179.34 mg/100 g) and in the variety Arka Gaurav (170.85 mg/100 g).

Rahman *et al.* (2014) reported that capsicum fruits of BARI Misti Morich-1 were found suitable to harvest after 45 days of anthesis, when they attained length of (12.2 cm) diameter (8.8 cm) and weight (191 g). Moreover, fruits were crispier, glossy with attractive colour and flavour and had 58 mg per 100 g ascorbic acid at this maturity stage.

Sharma *et al.* (2014) reported that the highest ascorbic acid (103.2 mg/100 g) and acidity (0.384 %) was recorded in California Wonder and Manhattan, respectively. Shelf life of varieties was evaluated in the month of September in Individual Shrink Wrapping (ISW) and open conditions. All varieties could be stored for 20-30 days without losing much water and other quality parameters.

A study done by Vimlesh *et al.* (2015) revealed that for ascorbic acid content, Orobelle F₁ hybrid (111.97 mg/100 g) followed by Bomby F₁ hybrid (106.20 mg/100 g) were promising. Whereas, for capsaicin content, Bachata F₁ hybrid (0.038 %) and Indam Mamatha F₁ hybrid (0.056 %) were found were promising. Indam Mamatha F₁ hybrid (13.30 mg/100 g) had maximum chlorophyll content.

The hybrid Angel recorded significantly higher ascorbic acid content (179.34 mg/100 g) closely followed by the variety Arka Gaurav (170.85 mg/100 g). The capsaicin content was found meager (0.003 % to 0.010 %) in all the varieties and hybrids. Total carotenoid was high in the hybrid NS-280 (0.178 %) and in the variety Arka Basant (0.139 %) which produced red coloured fruits. High total soluble solids was recorded in the variety Arka Gaurav (8.37 °Brix) followed by the hybrid Angel (7.53 °Brix). Fruit wall thickness was observed maximum in the hybrid, Indra (1.05 cm) and in the variety Wonder (1.01 cm) and hence suitable for long distant transportation (Narayana Swamy *et al.*, 2015).

2.2.2 Other vegetables

The observations recorded in tomato for biochemical analysis showed that maximum lycopene content was found in hybrid G-600, in nethouse and open field condition. Maximum fruit acidity was found in hybrid ARTH-128 and TH-13 in nethouse and TH-23 in open field conditions. Maximum TSS content (3.91 °Brix) was recorded in G-600 in expand nethouse and Naveen recorded maximum TSS content (3.80 °Brix) in open field condition (Cheema *et al.*, 2013).

2.3 Influence of different growing environment on productivity and quality of the produce

2.3.1 Capsicum

Deli and Tiessen (1969) observed higher number of branches and flowers in low temperature exposed capsicum plants. The flowers and ovaries formed were very small in sweet pepper plants which were exposed to constant temperature of 25 °C and were largest when plants exposed to low temperature at four leaf stage.

Rylski (1972) reported that soil temperature below 10 °C retarded growth and development of chilli plants, while 17 °C was optimum and raising the temperature increased were shoot growth but root growth was retarded above 30 °C. Days to flowering were reduced from 87 to 65 under high temperature conditions.

Polowick and Sawahaney (1985) reported that, the low temperatures (18/15 °C) had more effect (negative response) on flowers and fruits of capsicum than intermediate (23/18 °C) temperatures.

Gosselin and Trudel (1986) observed maximum shoot dry weight and leaf area at root zone temperatures of 24 °C and 30 °C in pepper. While, maximum fruit weight and number occurred at 30 °C root zone temperature. Highest temperature (25 °C) range resulted in two week earlier harvest and improved fruit shape and firmness in tomato than at lowest constant temperature (Buitelaar and Janse, 1987).

Bakker *et al.* (1988) reported that yield of total and Class-1 fruits (kg/m²) in sweet pepper were greatest at daily mean temperature of 21-21.3 °C.

Hedge (1989) reported that in 3-year field trials with cultivars California Wonder, the plants receiving nitrogen at 0, 60, 120 or 180 kg/ha were irrigated. When the available soil moisture content (ASM) fell to 80, 60, 40 or 20 per cent, irrigation at 40 and 60 and ASM and nitrogen at 180 kg/ha gave the highest fruit yields (15 t/ha for the irrigation treatments and 18 t/ha for the Nitrogen rate).

Bhatt and Rao (1993) noticed higher net photosynthetic rate, growth rate and number of flowers in bell pepper at higher night temperatures. They further reported that at intermediate temperature, the number of four lobed fruits significantly increased and at low temperature the fruits obtained were short, blunt and unmarketable.

Chen *et al.* (1994) showed that sweet pepper (*Capsicum frutescens*) fruits exposed to chilling stress (0.1 °C) showed increased respiration rates and ethylene production. The relative conductivity of the pulp and membrane permeability increased with chilling duration. These metabolic changes occurred before visible signs of chilling injury became apparent. However, an altering temperature

treatment counteracted these changes and reduced the accumulation of alcohol, acetaldehyde and acetone, increased peroxidase and catalase activities, inhibited phenylalanine ammonia-lyase activity and reduced electrolyte leakage. The alternating temperature treatment was effective in reducing chilling injury in cold-stored sweet peppers.

Leonardi (1994) reported that maintaining temperature just above the minimum required for plant growth (about 16 °C until the end of vegetative growth and about 13 °C during flowering) increased yield and advanced the harvesting time of peppers.

2.3.2 Other Vegetables

Tomato

Gosselin and Trudel (1984) noticed a large increase in shoot dry weight, leaf area and fruit development in tomato with soil warming up to 24 °C.

Dekoning (1992) reported that total yield in tomato was significantly higher at the higher night temperature (18.6 °C) than at low night temperature (16.3 °C). In the greenhouse, the growth of the vegetative organs (leaves, stem and shoots) in brinjal and tomato were negatively affected by the high level of temperature (34 °C) (Malfa, 1993).

2.4 Cost economics

In an economic analysis made in capsicum with three plant spacings (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, excellent quality fruits were obtained. Medium spacing of 45 x 30 cm gave the highest net returns of Rs. 21,018 per 100 m² per 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. 2,560/100/m²/year) with least cost benefit ratio of 1:1.65 (Rs. 16/kg) (Nagendra Prasad, 2001).

Singh *et al.* (2010) reported that the maximum crop duration (270 days) was recorded in sweet pepper under polyhouse conditions along with maximum fruit diameter (6.91 cm), highest individual fruit weight (62.17 g), average fruits yield (2.91 kg/plant), yield (17.48 kg/m²), gross returns (Rs. 349.68/m²), net returns (Rs. 281.45/m²) and cost : benefit ratio 1.0:5.5 in all five varieties, followed by poly-tunnel and plastic-mulching treatments.

Sreedhara *et al.* (2013) reported that the cost of establishment of capsicum production under protected condition was Rs. 2,51,109 per unit (0.25 acre). The total cost of cultivation of capsicum production under protected conditions was Rs. 55,080 per unit. The total variable cost was Rs. 20,374 per unit. Among the variable costs, the labour cost was highest (Rs. 10, 291), followed by expenditure on material cost (Rs. 8,487). Among the total cost of cultivation, the proportion of total fixed cost was highest (Rs. 34,707) compared to total variable cost (Rs. 20,373). The total yield of capsicum production under protected conditions was 5.50 tons per unit. The total returns and net returns from capsicum production under protected conditions were Rs. 1,54,734 per unit and Rs. 1,15,279 per unit, respectively. The B:C ratio of capsicum production under protected conditions was 3.92.

Rajender and Shukla (2013) studied six hybrids of bell pepper (Orabelle, Bomby, Mahabharath, Tanvi, Tanvi Plus and US-26) and among six varieties, Tanvi (Yellow-fruited) and Tanvi Plus (Red-fruited) recorded higher B:C ratio (2.37 and 2.06, respectively).

3. MATERIAL AND METHODS

The present investigation was carried out to study the performance of capsicum hybrids (*Capsicum annuum* L.var. *grossum*) viz., Orobelle (Yellow), Bomby (Red), Indra (Green), Bhachata (Yellow), Inspiration (Red), Sympatty (Orange), Mahabharath (Green), Krishna (Green), Yellow Wonder, Red Queen, Orange Wonder, Green Wonder, Capsicum Purple and Doctor Wonder (Green) under naturally ventilated polyhouse. The experiment was carried out at Hi-Tech Horticulture Unit, Saidapur farm, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. The material used and the methodology adopted are furnished hereunder.

Geographical Location

Dharwad is situated in transitional tract of Karnataka state at 15° 26' N latitude and 75° 07' E longitude at an altitude of 678 m above mean sea level. Dharwad is considered to be mild tropical rainy region (Appendix I).

3.1 Experimental Details

Present investigation was carried out at Hi- Tech Horticultural Unit, Saidapur farm, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, during the year 2015-2016 with following experimental details (Plate 1).

Field experiment details

- ✓ Crop : Capsicum
- ✓ Number of hybrids : 14
- ✓ Design of Experiment : RCBD
- ✓ Replication : 3
- ✓ Plot size : 4 m × 1.0 m
- ✓ Spacing : 45 cm × 30 cm between rows and plants.
- ✓ Bed to bed distance : 1.50 m

Treatment Details

Treatments	Hybrids	Treatments	Hybrids
T ₁	Orobelle	T ₈	Doctor Wonder
T ₂	Bomby	T ₉	Green Wonder
T ₃	Bachata	T ₁₀	Yellow Wonder
T ₄	Inspiration	T ₁₁	Orange Wonder
T ₅	Sympatty	T ₁₂	Capsicum Purple
T ₆	Mahabharath	T ₁₃	Red Queen
T ₇	Krishna	T ₁₄	Indra (control)



At seedling stage



95 days after transplanting

Plate 1. General view of experimental plot

3.2 Experimental Procedure

The crop was grown in naturally ventilated polyhouse by adopting the recommended package of practices (Capsicum Technical Bulletin, Hi-Tech Horticultural Unit, University of Agricultural Sciences, Dharwad). Anon., (2009)

3.3 Characters of capsicum hybrids

Orobelle (Yellow), Bomby (Red) and Indra (Green) F₁ hybrids were developed by Syngenta India Limited Company. These hybrids were said to have early fruit bearing character, with highest yield during initial 2 to 3 pickings.

List of capsicum hybrids evaluated under polyhouse condition

Sl. No.	Name of the hybrid	Colour of fruit	Company
1.	Bachata	Yellow	Rijk Zwaan India seeds Pvt. Ltd.
2.	Bomby	Red	Syngenta India Ltd.
3.	Doctor Wonder	Green	Doctor seeds Pvt. Ltd.
4.	Green Wonder	Green	Biocarve seeds
5.	Indra	Green	Syngenta India Ltd.
6.	Inspiration	Red	Rijk Zwaan India seeds Pvt. Ltd.
7.	Krishna	Green	Pahuja seeds Pvt. Ltd.
8.	Mahabharath	Green	Indo-American hybrid seeds (India) Pvt. Ltd.
9.	Orange Wonder	Orange	Biocarve seeds
10.	Orobelle	Yellow	Syngenta India Ltd.
11.	Purple	Purple	Biocarve seeds
12.	Red Queen	Red	Biocarve seeds
13.	Sympatty	Orange	Rijk Zwaan India seeds Pvt. Ltd.
14.	Yellow Wonder	Yellow	Biocarve seeds

3.3.1 Polyhouse:

Polyhouse gives better protection compared to nethouse due to total avoidance of rain water entry into polyhouse. The Polyhouse used for experimentation is with height of 6 m from the floor area, gutter height is 4 m from floor area and the ventilation is (20 %) of floor area. Width and length of polyhouse is about 18 m × 28 m, respectively.

GI pipes were used to construct polyhouse. Transparent UV stabilized polyethylene film 200 micron thickness was used for covering the polyhouse roof. It was provided with retractable or movable shade nets, at about 11 feet height just below the structures from ground level. The sides of the polyhouse were covered with 200 micron thick polyethylene film to a height of three feet from the ground level, to have better protection from rain splash. Remaining height of side wall was covered with 40 micron white coloured insect proof net from all the four sides. Construction of polyhouse costed about Rs. 500 per meter square.

3.3.2 Nursery raising

The seedlings were raised in pro-trays of 98 cells or cavities. The pro-trays were filled with sterilized cocopeat and seeds were sown one seed per cell to a depth of half a cm and covered with the same media. The filled trays are stacked one above the other and covered with plastic sheets till germination of seeds.

Seeds germinated in about a week after sowing. The trays were shifted to nethouse or polyhouse and lightly watered. After 15 days of sowing, mono ammonium phosphate 12:61:0 (3 g/l) and 22 days after sowing 19:19:19 (3 g/l) solution was drenched. The seedlings of 35 days old were transplanted into the beds.

3.3.3 Preparation of land in polyhouse and fumigation

The land was thoroughly ploughed and soil was brought to a fine tilth. Well decomposed organic manure at the rate of 20 kg per m² was mixed with soil. Raised beds were formed of 100 cm wider and 20 cm height. Between the beds walking space of 50 cm was provided.

Fumigation of beds was done by drenching four per cent formaldehyde (4 l/m² of bed) and covered with black polyethylene mulch sheet. Four days after formalin treatment, the polyethylene cover was removed the beds were raked and watered repeatedly every day to remove the trapped formalin fumes completely prior to transplanting.

3.3.4 Fertilizer application

Di-ammonium phosphate, urea and muriate of potash fertilizers were used at 12 kg, 6 kg and 6 kg, respectively for 500 m² area applied as a basal dose and remaining dose was applied 15 days after transplanting given through fertigation.

3.3.5 Laying of drip line

At center of the bed, one inline dripper lateral were placed. Inline dripper lateral had an emitting point for every 30 cm interval with a discharge rate of 2 l hr⁻¹.

3.3.6 Hardening

Before transplanting, the seedlings were hardened by reducing the amount of water and by gradual exposure to 25 per cent, 50 per cent and 75 per cent sunlight until full sunlight for one week.

3.3.7 Transplanting

The beds were watered to field capacity before transplanting. Seedlings of 35 days old were used for transplanting. Care was taken that there was no damage occurred to roots, while taking seedlings out from individual cells of protray. Seedlings were transplanted at a depth of 5 cm. After transplanting, seedlings were drenched with 3 g l⁻¹ copper oxychloride solution to the base of seedlings at the rate of 25 ml per plant. Watering the beds daily during afternoon by using hose pipe for a week was continuously done to avoid mortality of the plants.

3.3.8 Pruning

Capsicum plants were pruned to retain four stems. The tip of the plant splits into two at 5th or 6th node and were left to grow. These two branches again split in to two giving rise to four branches. At every node the tip splits into two giving rise to one strong branch and one weak branch, retain the strong branch and weak branch was pruned. Pruning was done at 30 days after transplanting with an interval of 10 days to retain only four stems per plant.

3.3.9 Training

The main stem of plant was tied with four plastic twines to train along and tied to GI wire grid provided on the top of the plants. This is practiced after four weeks of transplanting. The new branches and plants were trained along the plastic twines.

3.3.10 Drip irrigation and Fertigation

Drip irrigation was given to provide two liters of water per meter square per day depending on the season.

Water soluble fertilizers were given through fertigation for entire crop growth period, starting from third week after transplanting. Fertigation was given twice a week as recommended in the table below.

Weekly scheduling of fertilizers for fertigation

Weeks	19:19:19	12:61:0	0:0:50
3 rd week	2 kg	0.5 kg	400 g
4 th week	2 kg	0.75 kg	400 g
5 th week	2 kg	0.75 kg	400 g
6 th week	2.5 kg	0.5 kg	0.5 kg
7 th week	2.5 kg	0.5 kg	0.5 kg
8 th week	2.5 kg	0.5 kg	0.5 kg
9 th week	3 kg	0.5 kg	0.5 kg
10 th week	3 kg	0.5 kg	0.75 kg
11 th week	3.5 kg	0.5 kg	0.75 kg
12 th week	4 kg	400 g	1 kg
13 th week	4 kg	400 g	1 kg
14 th week	4 kg	400 g	1 kg
15 th week	4 kg	400 g	1 kg
16 th week	4 kg	400 g	1 kg

3.3.11 Weeding and plant protection measures

Weeding was done at every 15 days interval and loosening of soil was done along with weeding.

3.3.11.1 Plant protection chemical application

Constant observations on pest and disease were made throughout the period of investigation and on the onset of every pest and diseases, control measures were taken as per the standard package of practices. The schedule of plant protection chemicals is given in the following table.

3.3.11.2 Plant protection measures

Sl. No.	Pest	Scientific Name	Chemicals	Occurance	Spray schedule of chemical	Dosage
1.	Thrips	<i>Scirtothrips dorsalis</i>	Imidacloprid + Acephate	February to April	15 days interval	2 g/ l
2.	Mites	<i>Polyphagotarsonemus latus</i>	Propagrite Spiromesifen	Feb to April	15 days interval	1 ml/ l
3.	Fruit borer	<i>Spodoptera litura</i>	Chlorantraniliprole	1 st fortnight of February	Only one spray at onset of the pest	0.25 ml / l
4.	White flies	<i>Bemisia tabaci</i>	Deltamethrin + Triazophos	April to July	8 days interval	1 ml/ l
5.	Leaf miner	<i>Leriomiza trifoli</i>	Propanophos	2 nd Fortnight January	Only one spray at onset of the pest	1 ml/ l
6.	Fusarium wilt	<i>Fusarium solani</i>	Carbendazim	1 st fortnight January	Only one spray at onset of the disease	2 g/ l
7.	Sclerotium wilt	<i>Sclerotium rolfsii</i>	Carboxin + Thiram	2 nd fortnight March	Only one spray at onset of the disease	2 g/ l
8.	Murda complex	Leaf curl virus+Thrips+ Mites	Imidacloprid + Acephate Spiromesifen	April to July	At 8 days interval	2 g/ l 1 ml / l

3.3.12 Harvesting

Fully matured fruits at 20 per cent colour break stage were harvested in colour capsicum and in green colour capsicum fully matured fruits were harvested periodically and used for further recordings of observations.

3.4 Observations

3.4.1 Vegetative parameters

3.4.1.1 Plant height

Five plants were tagged at random in each treatment for recording the plant height at an interval of 30 days starting from the date of transplanting. The plant height was measured from the ground level to the growing tip of the main stem at 30, 60, 90 and 120 days after transplanting (DAP). The average height was calculated and expressed in centimeters.

3.4.1.2 Number of leaves per plant

Well-developed leaves were counted at 30, 60, 90 and 120 days after planting from all the plants tagged for recording observations and the mean of number of leaves per plant was worked out at each stage.

3.4.1.3 Number of primary and secondary branches

From each labelled plants number of primary and secondary branches were counted and recorded. The observation was taken upto 30 days after planting only, after wards four main branches were maintained.

3.4.1.4 Days taken for flower initiation

Number of days taken from the date of transplanting to opening of first flower was recorded in each labelled plant.

3.4.1.5 Days required for first harvest from transplanting

Individual flowers were tagged and the same fruits were harvested at maturity by recording the date of harvest and number of days were counted and recorded.

3.4.2 Reproductive parameters

3.4.2.1 Number of flowers per plant

Fully opened flowers were counted from each tagged plant and recorded throughout the crop period.

3.4.2.2 Number of fruits per plant

The number of mature fruits that were harvested from the tagged plants in each picking was recorded till the final harvest.

3.4.2.3 Per cent fruit set

Ten unopened flower buds were tagged at random in each of the plant under observation. The number of fruits set from the tagged buds was recorded periodically and per cent fruit set was calculated.

$$\text{Per cent fruit set (\%)} = \frac{\text{Number of fruits set}}{\text{Number of flowers tagged}} \times 100$$

3.4.3 Quality parameters

3.4.3.1 Individual fruit weight

The fresh capsicum fruits harvested from the labelled plants from each treatment were weighed and recorded in grams (g). The mean fruit weight was taken at 2nd picking stage.

3.4.3.2 Fruit volume

Five fruits were randomly selected at 2nd picking from each plant under observation and the volume of fruit was recorded by dipping the fruits individually into a jar containing water and the excess over flowed water measured using a measuring cylinder and the mean was calculated and expressed in cubic centimeters (cc).

3.4.3.3 Pericarp thickness

Five fruits were selected randomly at 2nd picking were sliced at the equatorial plane to measure the pericarp thickness with the help of vernier calipers and the mean as computed was recorded in centimeter (cm).

3.4.3.4 Shelf life

Fully matured fruits were harvested from each treatment and they were kept under ambient conditions and the number of days were counted until the fruits remain fresh and at acceptable quality. The number of days was calculated to express the shelf life in days were counted and recorded.

3.4.3.5 Vitamin-C

Ascorbic acid content was determined by 2, 6-dichlorophenol indophenol visual titration method as described by Ranganna (1997). It was expressed in milligram per 100 grams (mg/100 g)

Five gram of fresh plant sample was taken in a beaker with four per cent oxalic acid and the sample was crushed with glass rod. Then suspension was filtered through filter paper in a volumetric flask to get supernatant liquid and made upto a known volume (100 ml) with four per cent oxalic acid. Five ml of this supernatant liquid was added with 10 ml of four per cent oxalic acid and titrated against 2, 6-dichlorophenol indophenol dye.

The ascorbic acid content was calculated by using following formula;

$$\text{Ascorbic acid (mg/100 g)} = \frac{0.5 \text{ (mg)}}{V_1 \text{ (ml)}} \times \frac{V_2 \text{ (ml)}}{5 \text{ (ml)}} \times \frac{100 \text{ (ml)}}{\text{Wt. of plant sample}} \times 100$$

Where; V_1 ml - Dye consumed for standardization.

V_2 ml - Dye consumed by plant sample extract.

3.4.3.6 Total soluble solids

The total soluble solids content of the fruits was estimated using a digital refractometer and expressed in °Brix.

3.4.3.7 Moisture content

Fully matured fruits were harvested, initial weight of the fruit was recorded, the fruit was cut into two halves and it was kept in hot air oven at 70 °C for 48 hours. After 48 hours final weight of the fruit was taken. The difference in initial and final weight was expressed in percentage (%).

3.4.3.8 Dietary fibre

The soluble, insoluble and total dietary fibre (TDF) fraction of dehydrated samples were analysed by following rapid enzymatic method of AOAC (1990). One g of moisture and fat free sample were digested with α -amylase, pepsin and pancreatin to remove the starch and protein. Then residue was filtered through filter paper by washing with 95 per cent ethanol and acetone. Then the content was oven dried at 105 °C till constant weight obtained and weighed after cooling. Then the collected filtrate was again washed with 95 per cent ethanol and allowed for 30 minutes to precipitate. Then the content was washed with 78 per cent ethanol, 95 per cent ethanol and acetone. Then oven dried at 105 °C till constant weight was obtained and weighed after cooling and ignited to ash. (g/ 100 g)

The soluble, insoluble and total dietary fibre content in capsicum was calculated by using following formula;

$$\text{Soluble/Insoluble/Total dietary fibre (g/100 g)} = \frac{\text{Weight of residue (g)} - \text{Weight of ash (g)}}{\text{Weight of sample (g)}} \times 100$$

3.4.4 Yield parameters

3.4.4.1 Fruit yield per plant

The weight of mature fruits harvested from each picking was recorded till final harvest and total of all harvests per plant was recorded in kilograms (kg).

3.4.4.2 Fruit yield per meter square

The weight of mature fruits harvested from each picking in tagged plants in each replication was recorded till final harvest and the total yield of fruits per meter square was computed and expressed in kg per meter square.

3.4.4.3 Fruit yield per hectare

The weight of mature fruits harvested from each picking in tagged plants in each replication was recorded till final harvest and the total yield of fruits per hectare was computed and expressed in tons per hectare.

3.5 Economics

Economics of capsicum production under protected structures was worked out by considering the present price of inputs and produce.

$$\text{Net returns (Rs. ha}^{-1}\text{)} = \text{Gross returns (Rs. ha}^{-1}\text{)} - \text{cost of cultivation (Rs. ha}^{-1}\text{)}$$

$$\text{Benefit: Cost ratio} = \frac{\text{Net returns (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

3.6 Statistical analysis

The data pertaining to vegetative, reproductive, quality and yield characters were tabulated treatment and replication wise. The data statistically analyzed by software MSTAT-C. Fisher and Yates tables (1957) were referred for knowing the tabulated values at five per cent level of significance at corresponding degree of freedom. Inferences were drawn as revealed by the analysis of tables.

4. EXPERIMENTAL RESULTS

The results of the present investigation entitled evaluation of capsicum hybrids under protected cultivation was carried out at Department of Horticulture (Lab work) and Hi-Tech Horticulture Unit, Saidapur farm, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during the year 2015-16. The results pertaining to the study are presented hereunder.

4.1 Vegetative parameters of capsicum hybrids

4.1.1 Plant height

The data on plant height at different crop growth stages with respect to different hybrids are presented in Table 1 and depicted in Fig. 1.

The mean plant height of fourteen capsicum hybrids differed significantly at all stages of crop growth *viz.*, 30, 60, 90 and 120 Days after planting (DAP).

The hybrid Krishna recorded the maximum plant height (36.87 cm) at 30 DAP which was significantly superior over the other hybrids and on par with Indra (35.93 cm) and Mahabharath (35.91 cm). The least plant height (29.51 cm) was recorded by Red Queen.

At 60 DAP, among the different hybrids, Indra recorded the maximum plant height (77.22 cm) and which was on par with Orobelle (75.39 cm) which was significantly superior over the other hybrids. The least plant height (64.85 cm) was recorded by Capsicum Purple.

At 90 DAP and 120 DAP, the hybrid Indra recorded maximum plant height (107.50 cm and 139.5 cm, respectively) which was significantly superior over the other hybrids and similarly hybrid Capsicum Purple recorded least plant height at 90 and 120 DAP (88.92 cm and 110.59 cm, respectively).

4.1.2 Number of leaves per plant

The data on number of leaves per plant at different crop growth stages with respect to different hybrids are presented in Table 2 and depicted in Fig. 2.

The number of leaves per plant of capsicum differed significantly due to genotypic variation among hybrids at all the stages of crop growth *viz.*, 30, 60, 90 and 120 Days after planting (DAP).

At 30 DAP, among the fourteen hybrids, Mahabharath recorded the maximum number of leaves per plant (31.47) which was on par with Orobelle (30.47), Bomby (31.27), Krishna (31.07) and Indra (30.40). The hybrid Mahabharath which was significantly superior over the T₃, T₄, T₅, T₈, T₉, T₁₀, T₁₁, T₁₂ and T₁₃ hybrids and the least number of leaves per plant (26.27) was recorded by Red Queen.

At 60 DAP, among the fourteen hybrids, Indra recorded the maximum number of leaves per plant (58.27) which was on par with Orobelle (57.73) and Orange Wonder (57.00). The hybrid Indra which was significantly superior for number of leaves over all the hybrids except Orobelle and Orange Wonder and the least number of leaves per plant (50.33) was recorded by Red Queen.

Table 1: Plant height of capsicum hybrids at different stages of crop growth under polyhouse condition

Treatments	Plant height (cm) at			
	30 DAP	60 DAP	90 DAP	120 DAP
T ₁ - Orobelle	33.53	75.39	104.79	134.89
T ₂ - Bomby	34.90	70.52	102.64	131.17
T ₃ - Bachata	30.05	70.24	100.82	125.78
T ₄ - Inspiration	31.78	73.22	101.80	129.07
T ₅ -Sympatty	31.20	72.01	101.93	127.20
T ₆ - Mahabharath	35.91	70.13	101.63	126.53
T ₇ - Krishna	36.87	73.95	100.34	124.34
T ₈ - Doctor Wonder	30.79	68.32	97.58	120.60
T ₉ - Green Wonder	31.90	68.20	95.66	117.39
T ₁₀ - Yellow Wonder	30.42	70.32	99.40	125.14
T ₁₁ - Orange Wonder	30.88	68.13	98.02	122.41
T ₁₂ - Capsicum Purple	30.39	64.85	88.92	110.59
T ₁₃ - Red Queen	29.51	66.08	95.03	118.29
T ₁₄ - Indra (control)	35.93	77.22	107.50	139.25
S.Em. ±	0.35	0.57	0.56	0.80
C.D. at 5 %	1.02	1.67	1.64	2.32

*DAP- Days After Planting

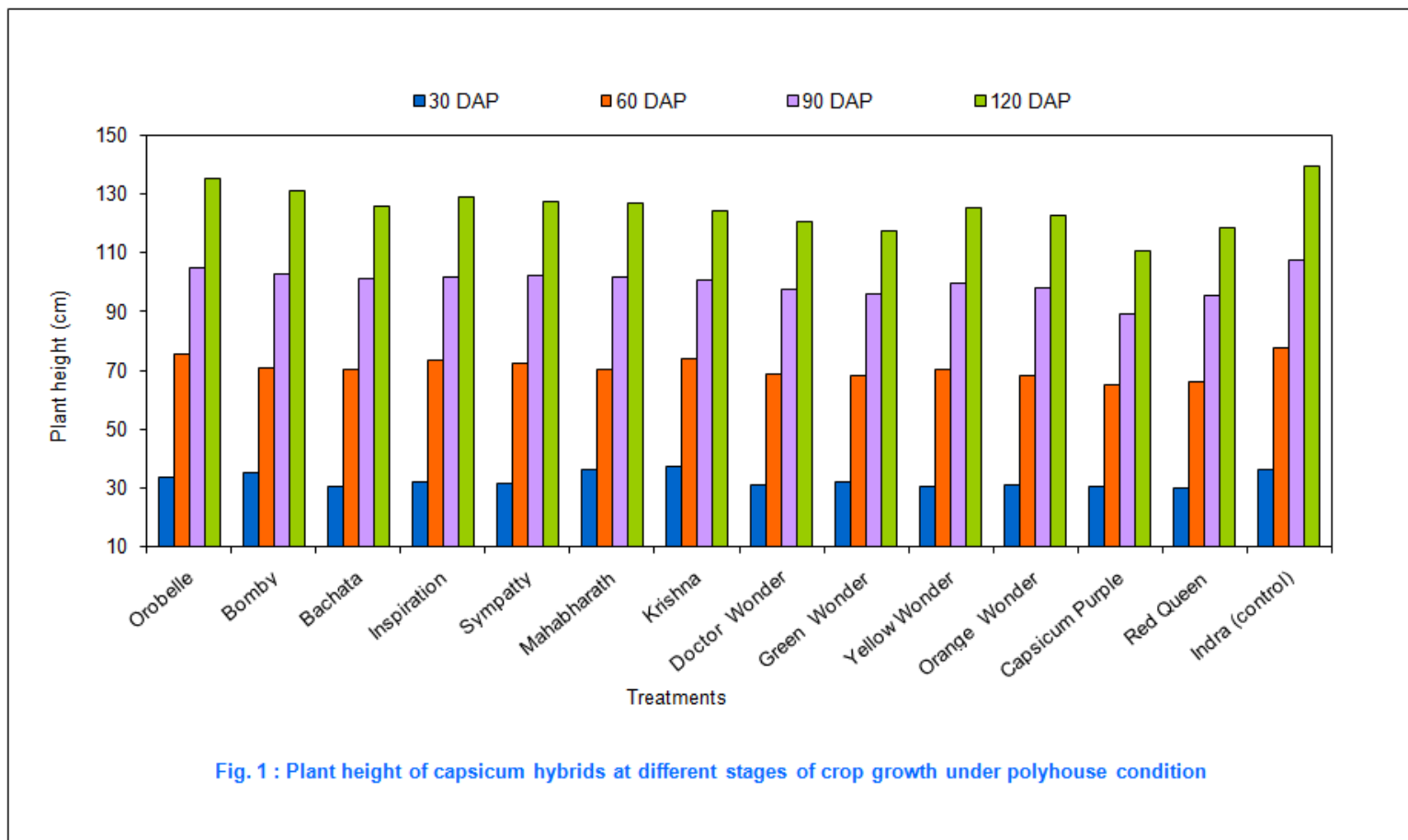


Fig. 1 : Plant height of capsicum hybrids at different stages of crop growth under polyhouse condition

Table 2. Number of leaves per plant of capsicum hybrids at different stages of crop growth under polyhouse condition

Treatments	30 DAP	60 DAP	90 DAP	120 DAP
T ₁ - Orobelle	30.47	57.73	74.00	103.13
T ₂ - Bomby	31.27	53.40	70.00	98.47
T ₃ - Bachata	28.27	52.93	70.44	100.33
T ₄ - Inspiration	29.33	54.00	68.33	97.33
T ₅ -Sympatty	29.20	55.07	69.44	97.93
T ₆ - Mahabharath	31.47	54.80	72.33	99.00
T ₇ - Krishna	31.07	54.27	72.89	96.13
T ₈ - Doctor Wonder	27.07	53.20	68.11	97.20
T ₉ - Green Wonder	27.13	51.67	65.22	95.27
T ₁₀ - Yellow Wonder	27.33	50.93	64.00	91.60
T ₁₁ - Orange Wonder	28.13	57.00	75.78	100.27
T ₁₂ - Capsicum Purple	26.53	55.20	63.33	90.93
T ₁₃ - Red Queen	26.27	50.33	67.44	95.80
T ₁₄ - Indra (control)	30.40	58.27	71.00	101.20
S.Em. ±	0.57	0.83	0.99	0.58
C.D. at 5 %	1.65	2.42	2.89	1.70

*DAP- Days After Planting

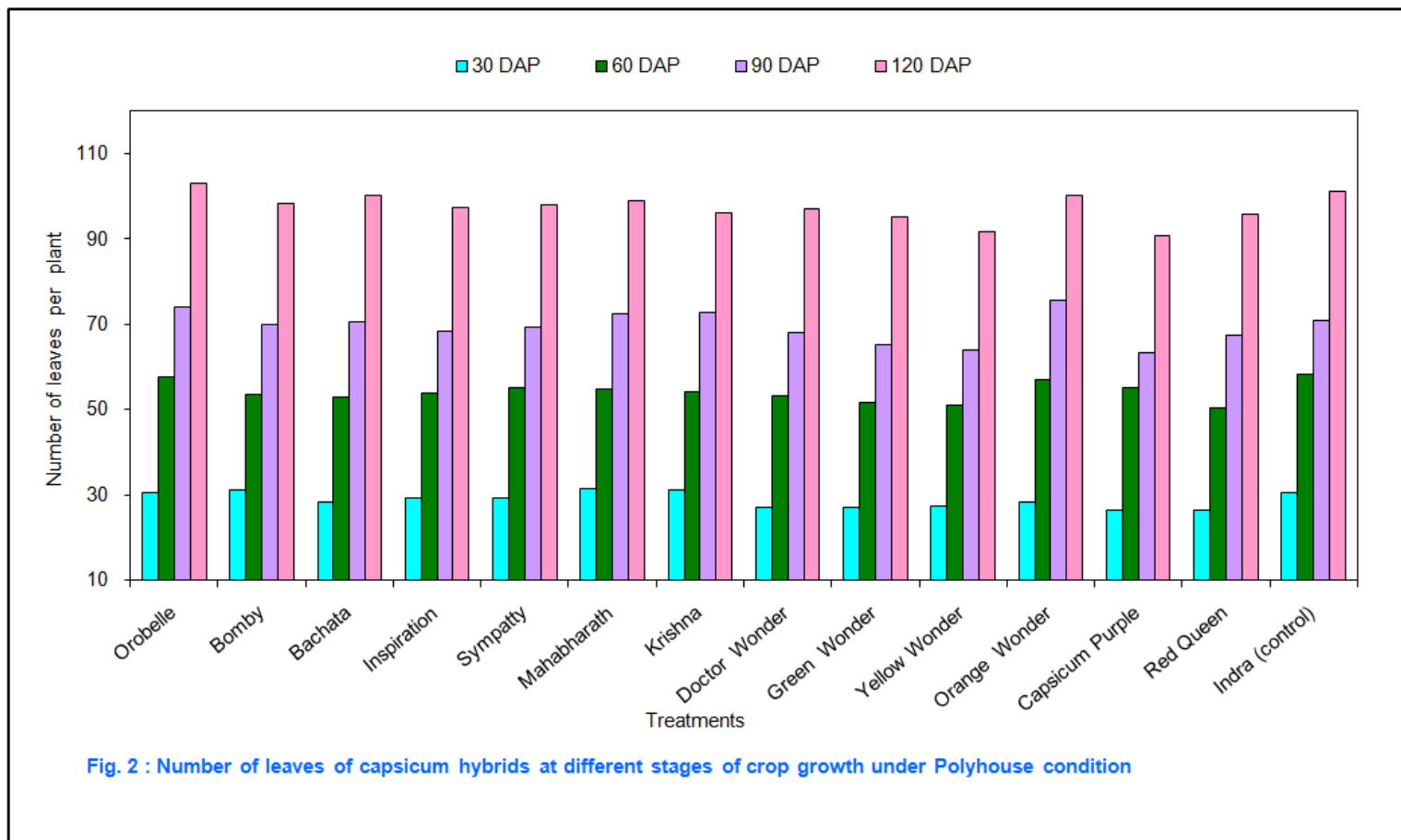


Fig. 2 : Number of leaves of capsicum hybrids at different stages of crop growth under Polyhouse condition

Orange Wonder recorded the maximum number of leaves per plant (75.78) at 90 DAP, which was on par with Orobelle (74.00) and Krishna (72.89). The Orange Wonder which was significantly superior over the other hybrids and the least number of leaves per plant (63.33) was recorded by Capsicum Purple.

At 120 DAP, among the fourteen hybrids, Orobelle recorded the maximum number of leaves per plant (103.13) which was significantly superior over the other hybrids and the least number of leaves per plant (90.93) was recorded by Capsicum Purple.

4.1.3 Number of primary and secondary branches per plant

The data on number of primary and secondary branches per plant at different crop growth stages with respect to different hybrids are presented in Table 3 and depicted in Fig. 3.

The number of primary and secondary branches per plant differed significantly due to genotypic difference of hybrids, at all stages of crop growth viz., 30, 60, 90 and 120 Days after planting (DAP).

Green Wonder and Capsicum Purple recorded more number of primary branches (2.40 and 2.40, respectively) which was on par with Mahabharath (2.33) and the least number of primary branches (2.00) was recorded in Bachata, Inspiration, Sympatty, Doctor Wonder and Orange Wonder.

Among the fourteen hybrids, Capsicum Purple recorded more number of secondary branches (4.73) which was on par with Bomby (4.47), Orobelle (4.33), Mahabharath (4.67), Green Wonder (4.53) and Red Queen (4.47) and the least number of secondary branches (3.47) was recorded by Doctor Wonder.

4.1.4 Days to flower initiation

The data on time taken for flower initiation with respect to different hybrids are presented in Table 4 and depicted in Fig. 4.

Bachata and Sympatty took maximum number of days (38 days) to flower opening which was on par with Orobelle (36.67 days) and Inspiration (37.67 days) and which was significantly superior over the other hybrids. Least time taken for flower initiation was recorded by Capsicum Purple (29.00 days).

4.1.5 Days to first harvest

The data on time required for first harvest with respect to different hybrids are presented in Table 4 and depicted in Fig. 4.

Hybrids Inspiration and Sympatty took maximum number of days (92.82 days) for first harvest which was on par with Bachata (91.33 days) and Inspiration (90.67 days) which was significantly superior over all the hybrids. Lowest time taken for first harvesting was recorded by Capsicum Purple (75.21 days).

4.2 Reproductive parameters of capsicum hybrids

4.2.1 Number flowers per plant

The data on number flowers per plant with respect to different hybrids are presented in Table 5 and depicted in Fig. 5.

Table 3. Number of primary and secondary branches per plant of capsicum hybrids recorded under polyhouse condition

Treatments	Primary branches per plant	Secondary branches per plant
T ₁ - Orobelle	2.07	4.33
T ₂ - Bomby	2.13	4.47
T ₃ - Bachata	2.00	4.07
T ₄ - Inspiration	2.00	4.07
T ₅ –Sympatty	2.00	4.13
T ₆ - Mahabharath	2.33	4.67
T ₇ - Krishna	2.07	4.07
T ₈ - Doctor Wonder	2.00	3.47
T ₉ - Green Wonder	2.40	4.53
T ₁₀ - Yellow Wonder	2.07	4.07
T ₁₁ - Orange Wonder	2.00	4.07
T ₁₂ - Capsicum Purple	2.40	4.73
T ₁₃ - Red Queen	2.07	4.47
T ₁₄ - Indra (control)	2.07	4.13
S.Em. ±	0.06	0.12
C.D. at 5 %	0.18	0.36

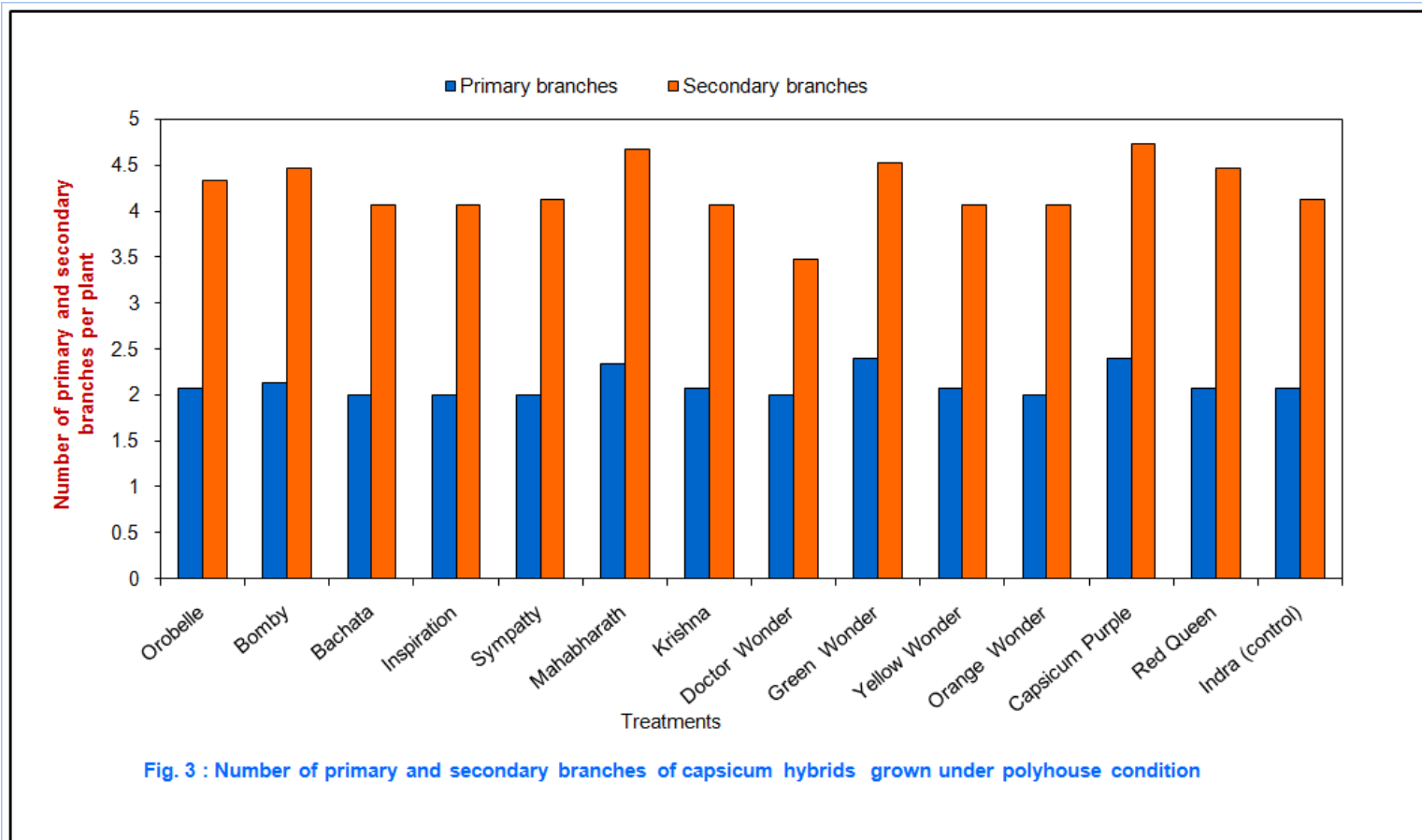


Fig. 3 : Number of primary and secondary branches of capsicum hybrids grown under polyhouse condition

Table 4. Days taken for first flower initiation and fruit harvest of different capsicum hybrids in polyhouse

Treatments	Days to flower initiation (days)	Days to first harvest (days)
T ₁ - Orobelle	36.67	87.33
T ₂ - Bomby	35.67	86.00
T ₃ - Bachata	38.00	91.33
T ₄ - Inspiration	37.67	90.67
T ₅ –Sympatty	38.00	92.82
T ₆ - Mahabharath	33.00	77.67
T ₇ - Krishna	32.00	76.33
T ₈ - Doctor Wonder	31.00	77.40
T ₉ - Green Wonder	31.00	76.54
T ₁₀ - Yellow Wonder	30.00	82.29
T ₁₁ - Orange Wonder	29.83	85.91
T ₁₂ - Capsicum Purple	29.00	75.21
T ₁₃ - Red Queen	30.33	83.33
T ₁₄ - Indra (control)	34.67	81.67
S.Em. ±	0.62	0.82
C.D. at 5 %	1.80	2.40

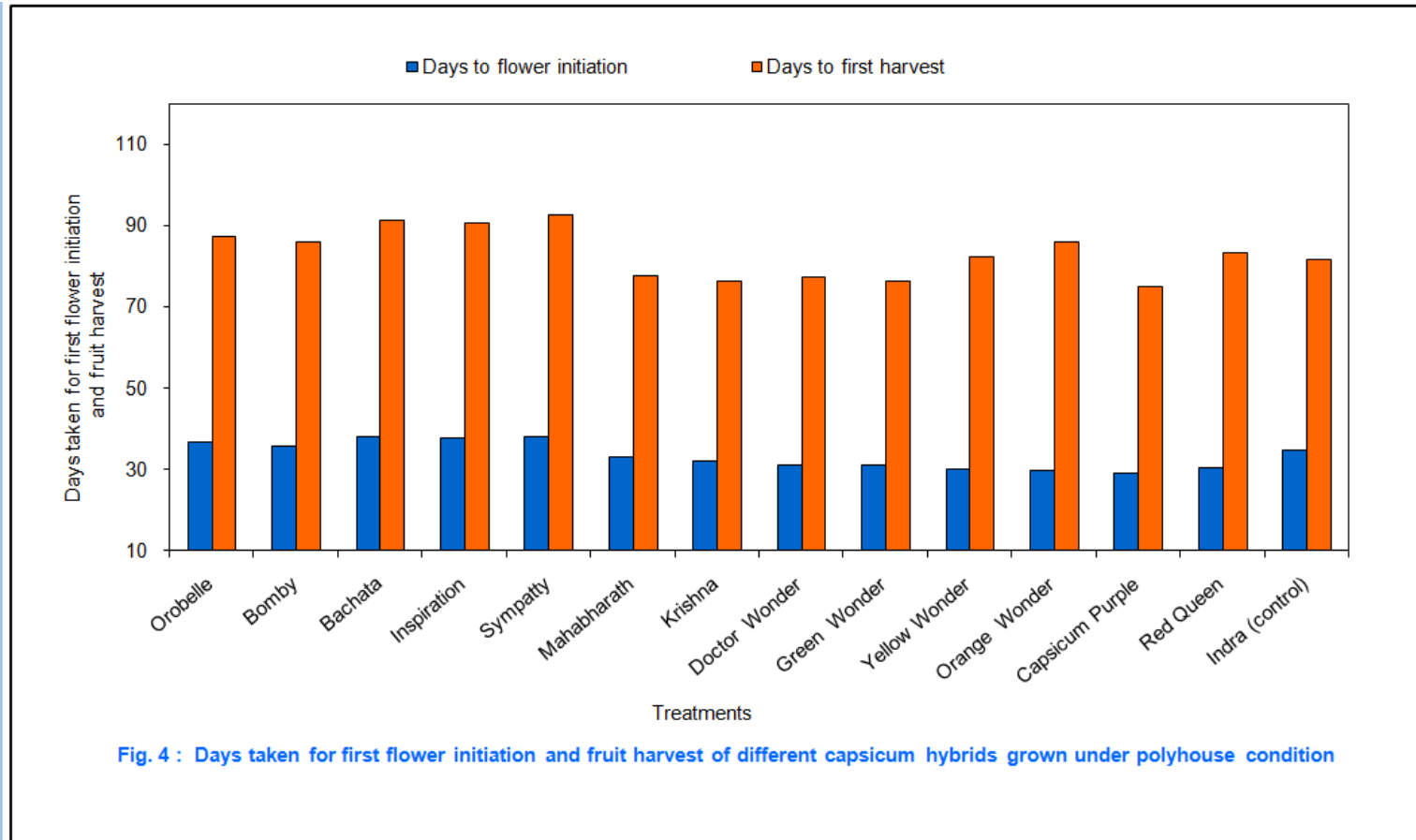


Fig. 4 : Days taken for first flower initiation and fruit harvest of different capsicum hybrids grown under polyhouse condition

The maximum number of flowers per plant (41.69) was recorded by Yellow Wonder which is on par with all the hybrids except Mahabharath, Krishna and Doctor Wonder. The least number of flowers per plant (34.50) recorded in Krishna hybrid.

4.2.2 Per cent fruit set

The data on per cent fruit set with respect to different hybrids are presented in Table 5 and depicted in Fig. 5.

Bachata recorded maximum fruit set (47.61 %) which was significantly superior over all the hybrids. The minimum fruit set (36.48 %) was recorded by Orange Wonder.

4.2.3 Number of fruits per plant

The data on number of fruits per plant with respect to different hybrids are presented in Table 5 and depicted in Fig.5 (Plate 2a, 2b and 2c).

Among the fourteen hybrids evaluated, Bachata recorded maximum number of fruits per plant (18.13) which was significantly superior over the other hybrids and was on par with Orobelle, Inspiration and Indra. The least number of fruits per plant (13.06) was recorded by Krishna.

Individual fruits of different capsicum hybrids under study depicted in Plate 3a and 3b.

4.3 Quality parameters

4.3.1 Fruit weight

The data on fruit weight (g) and fruit volume (cc) with respect to different hybrids are presented in Table 6 and depicted in Fig. 6.

Among the different hybrids, Inspiration recorded higher fruit weight (136.09 g/fruit) which was on par with Oroballe (T₁), Bomby (T₂), Bachata (T₃), Inspiration (T₄) and Sympatty (T₅) which was significantly higher than other hybrids like T₆, T₇, T₈, T₉, T₁₀, T₁₁, T₁₂, T₁₃ and T₁₄, the least fruit weight (98.86 g/fruit) was recorded by Capsicum Purple (T₁₂).

4.3.2 Fruit volume

Among the different hybrids, Doctor Wonder (T₈) recorded highest fruit volume (318.97 cc) which was on par with Orobelle (T₁), Bomby (T₂), Bachata (T₃), Inspiration (T₄), Mahabharath (T₆) and Green Wonder (T₉) which was significantly higher than other hybrids like T₅, T₇, T₁₀, T₁₁, T₁₂, T₁₃ and T₁₄ and least (269.67 cc) fruit volume was recorded by Red Queen (T₁₃).

4.3.3 Pericarp thickness

The data on pericarp thickness (cm) and shelf life (days) with respect to different hybrids are presented in Table 7 and depicted in Fig. 7.

Among the fourteen hybrids, Bachata recorded maximum pericarp thickness (0.82 cm), which was on par with Indra (0.81 cm), Bachata which was superior over the other hybrids. Least pericarp thickness (0.67 cm) was recorded by Capsicum Purple.

4.3.4 Shelf life

The maximum shelf life (7.83 days) was recorded in hybrid Bhachata (T₃) which was superior over the treatments T₇, T₈, T₉, T₁₁, T₁₂ and T₁₃. The hybrid Bachata was on par with T₁, T₂, T₄, T₅, T₆, T₁₀ and T₁₄. Lesser shelf life was recorded by Krishna (5.33 days) and Capsicum Purple (5.33 days).

Table 5. Number of flowers per plant, number of fruits per plant and per cent fruit set of capsicum hybrids grown under polyhouse condition

Treatments	Number of flowers per plant	Number of fruits per plant	Per cent fruit set
T ₁ - Orobelle	40.13	16.87	42.03
T ₂ - Bomby	37.51	15.01	40.01
T ₃ - Bachata	40.18	18.13	47.61
T ₄ - Inspiration	37.06	17.12	46.19
T ₅ -Sympatty	39.32	15.97	40.61
T ₆ - Mahabharath	34.83	14.03	40.27
T ₇ - Krishna	34.50	13.06	37.86
T ₈ - Doctor Wonder	36.01	14.40	39.99
T ₉ - Green Wonder	39.14	15.00	38.32
T ₁₀ - Yellow Wonder	41.69	16.08	38.56
T ₁₁ - Orange Wonder	40.78	14.88	36.48
T ₁₂ - Capsicum Purple	37.40	14.97	40.01
T ₁₃ - Red Queen	38.22	13.99	36.61
T ₁₄ - Indra (control)	37.93	16.27	42.89
S.Em. ±	1.61	1.03	0.414
C.D. at 5 %	4.69	3.01	1.20

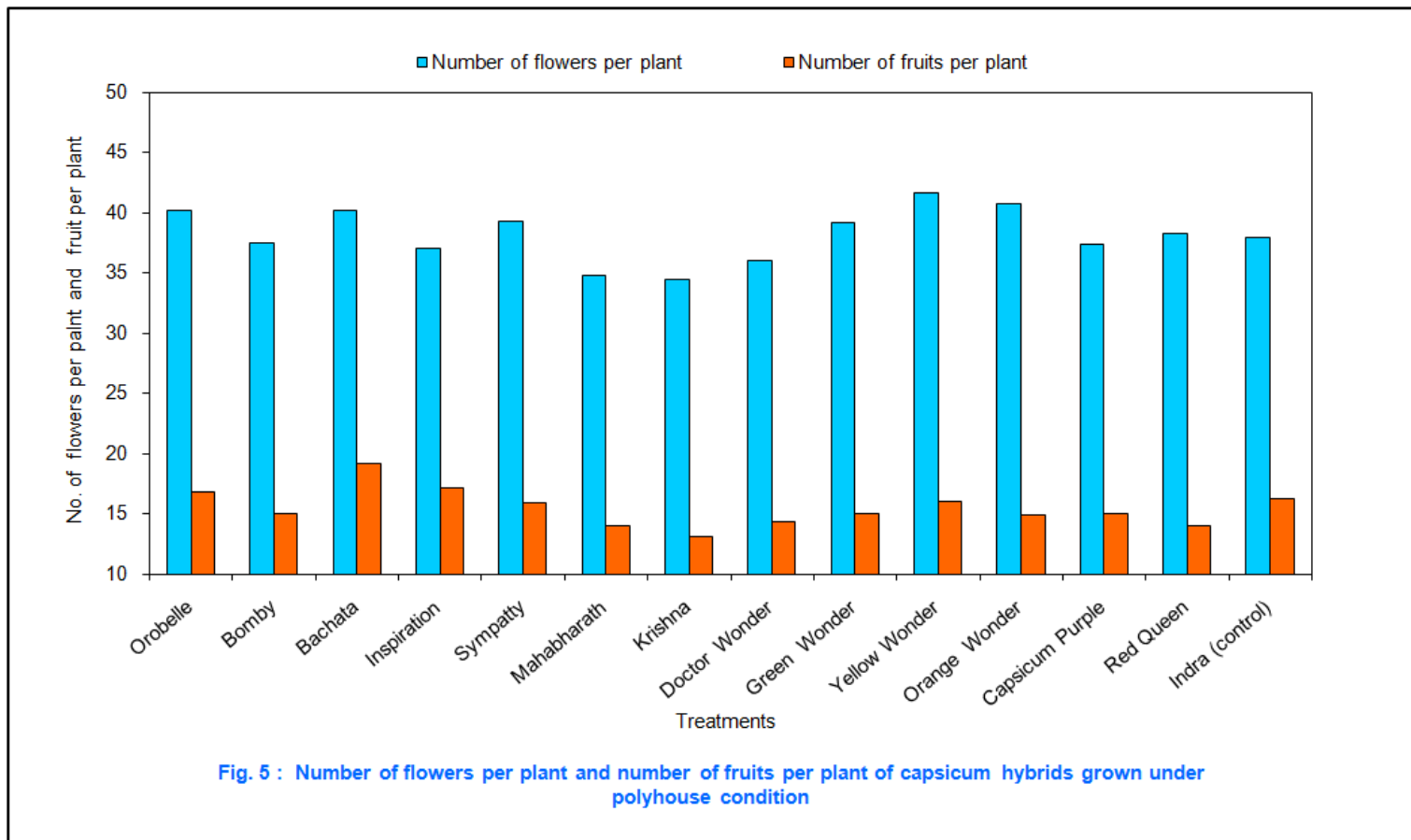


Fig. 5 : Number of flowers per plant and number of fruits per plant of capsicum hybrids grown under polyhouse condition



Docter Wonder



Green Wonder



Indra



Mahabharath



Red Queen

Plate 2a. Different capsicum hybrids : In bearing stage



Bachata



Inspiration



Orange Wonder

Plate 2b. Different capsicum hybrids : In bearing stage

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5. DISCUSSION

Growth, development, productivity and quality of any crop largely depend upon the interaction between the genetic constitution of the plants and the environmental conditions under which they are grown. Every plant species has its own specific inherent characters such as colour, size, growth, storability, cooking and processing qualities. The atmospheric condition under which it is grown has a large bearing on the realization of its genetic potential. Capsicum is one such crop, which responds very well to the favorable environmental conditions. Under modern vegetable production technology, a great emphasis is given to have appropriate plant density, proper pruning and training level in order to boost up the production per unit area.

The present investigation was carried out in naturally ventilated polyhouse, with fourteen hybrids like Orobelle (Yellow), Bomby (Red), Indra (Green), Bachata (Yellow), Inspiration (Red), Sympatty (Orange), Mahabharath (Green), Krishna (Green), Yellow Wonder, Red Queen, Orange Wonder, Green Wonder, Capsicum Purple and Doctor Wonder (Green) to know the performance of capsicum hybrids under protected structures. The results obtained are discussed hereunder.

5.1 Vegetative growth parameters of capsicum hybrids

Among the fourteen hybrids the highest plant height (139.25 cm) was recorded in Indra at 120 DAP. The least plant height (110.59 cm) was recorded by Capsicum Purple.

Among the hybrids, the maximum number of leaves (103.13) per plant was noticed in Orobelle at 120 DAP. The least number of leaves (90.93) was recorded by Capsicum Purple. Maximum number of primary (2.40) and secondary (4.73) branches was found in Capsicum Purple. This might be due to the genetic constitution of the hybrid. The differential response of vegetative growth of the different hybrids may be due to differences in genetic constituents of the varieties and microclimate condition (Bergefurd *et al.*, 2011).

5.2 Reproductive parameters of capsicum hybrids

5.2.1 Days to flower initiation and days to first harvest

Among the hybrids, early flowering (29.00 days) was recorded in Capsicum Purple and more time (38 days) taken for initiation of flower was recorded in Bachata and Sympatty, respectively. Among the hybrids, early to first harvest (75.21 days) was recorded in Capsicum Purple and late to first fruit harvest (92.82 days) was recorded by Sympatty. This might be due to genetic constitution of the different hybrids that leads to differ in flower initiation and days taken for first harvest. Similar findings were noticed by Rajender and Shukla (2013) and Ahmed *et al.* (2015) in capsicum.

The maximum number of flowers per plant (41.69) was recorded by Yellow Wonder which is on par with all the hybrids except T₆, T₇, and T₈. The least number of flowers (34.50) were recorded by Krishna. This could be attributed to the increased number of secondary branches per plant. These results are in conformity with Bhatt and Rao (1993) and Kurubetta (2008) in capsicum.

Bachata recorded maximum fruit set (47.61 %) which was significantly superior over all the hybrids. The minimum fruit set (36.48 %) was recorded by Orange Wonder. This might be due to good vegetative growth besides effective pollination and fertilization and lower abscission rate of flowers. Similar results were recorded by Backer (1989) in sweet pepper.

Bachata recorded maximum number of fruits per plant (18.13) which was significantly superior over the other hybrids, which was on par with Orobelle, Inspiration and Indra. The least number of fruits per plant (13.06) were recorded by Krishna. might be due to more number of flowers and high value of per cent fruit set because of vigorous and healthy plants. These results are line with Backer (1989) in sweet pepper.

5.2.2 Quality parameters

The hybrid Inspiration recorded higher mean fruit weight (136.09 g/fruit). This may be due to high heterotic effect and genetic constituent of the hybrid. Zende (2008) recorded significantly higher fruit weight (147.74 g/fruit) under protected conditions. Kurubetta (2008) also reported similar results regarding fruit weight and yield in bell pepper. Variation in fruit weight in bell pepper from 27.3 g to 200 g has been reported also by Luitel *et al.* (2011).

The hybrid Doctor Wonder recorded higher mean fruit volume (318.00 cc). This could be due to increase in size of fruits (length and breadth), resulting in the increased fruit weight and volume in that hybrid.

The hybrid Inspiration recorded higher fruit weight (136.09 g/fruit) and the hybrid Doctor Wonder has recorded maximum volume (318.97 cc). This could be due to high up take of nutrient and buildup of sufficient photosynthesis enabling the increased size and volume of fruit. Similar findings were recorded by Buitelaar and Janse (1987) in tomato and Mohomedien (1991) in cucumber. Kanwar and Sharma (2010) also reported significant differences among hybrids for fruit weight, fruit volume and ultimately yield per unit area. Fruit size was less important for processing purpose, but it was important for table purpose according to Resh (2013) as fruit size determines the consumer preference.

The shelf life of capsicum hybrids is an important quality parameter because it directly influences the time that can be taken before marketing the produce. Increased shelf life is directly related to the pericarp thickness. The hybrid Bachata recorded higher shelf life (7.83 days) which was on par with the treatment T₆ and T₇. This is because of thicker pericarp (0.82 cm) which prevented the moisture loss and shrinkage. Similar results were recorded by Rai (1992) in capsicum.

Maximum pericarp thickness (0.82 cm) was recorded by Bachata which was followed by Indra (0.81 cm). The lesser pericarp thickness (0.67 cm) was found in Capsicum Purple. This might be due to the characteristic feature of the hybrid. These findings were in conformity with Kurubetta (2008) in capsicum.

Capsicum fruits are hollow from inside therefore, a thick fruit wall is preferred to help the fruits with stand long distant transportation and retain firmness for a longer period of time. These findings were similar to Arya and Saini (1977), Sweta Rani (2003), Valsikova and Belko (2004) and Choudhary *et al.* (2011) in bell pepper.

Bachata recorded maximum fruit set (47.61 %) which was significantly superior over all the hybrids. It may be due to consequences of production of more flowers per plant which is genetic inheritance of particular hybrid with lower abscission rate of flowers. The minimum fruit set (36.48 %) was recorded by Orange Wonder. Similar findings were recorded by Backer (1989) and Bhatt and Rao (1993) in bell pepper.

Higher Vitamin-C content was recorded in Orobelle (167.50 mg/100 g) hybrid which was superior over all hybrids evaluated. Generally, the higher ascorbic acid content would increase the nutritive value of capsicum, which would help better retention of colour and flavour. Capsicum varieties and hybrids possessing high ascorbic acid content are of great demand in export markets as opined by Sweta Rani (2003), Banaras *et al.* (2005) and Choudhary *et al.* (2011) in capsicum.

Pevicharova *et al.* (2007) also recorded lower amount of vitamin-C content under higher temperature and stated that in bell pepper fruits high day temperature decreased the total vitamin-C of fruits (Appendix I).

Higher TSS content was recorded in Inspiration (6.57 °Brix) which was found to be superior over all other treatments. Since capsicum is used for salad making, fruits with high TSS are highly preferred. TSS is an important quality attribute of capsicum fruit which increases the palatability and also it determines the varieties for processing industries. Similar findings were recorded by Hajarica and Phookan (2005) in tomato and Sood *et al.* (2007) in capsicum.

The minimum moisture content was recorded in Bachata which was superior over all the treatments evaluated. Bachata recorded maximum dietary fibre content (1.98 g/100 g) which was significantly superior over other hybrids and least dietary fibre content (1.27 g/100 g) was recorded by Orange Wonder. Minimum moisture content and maximum dietary fibre is due to the firmness or brittleness of the hybrid. Similar findings were recorded by Wahundeniya *et al.* (2002) in tomato.

5.2.3 Yield parameters

Bachata recorded maximum yield per plant (2.41 kg/plant) and yield per meter square (14.44 kg) which were significantly superior over the other hybrids and also recorded higher yield per hectare (100.50 t/ha) which was on par with Inspiration (97.16 t/ha), least yield per plant (1.43 kg/plant), least yield per meter square (8.04 kg) and least yield (55.96 t/ha) was recorded by Red Queen. Bachata and Inspiration hybrids are significantly superior over other hybrids. It might be due to higher number of flowers, fruits and maximum per cent fruit set. Similar findings were obtained by Granges and Leger (1989), Fontes *et al.* (1997), Pitam Chandra *et al.* (2000), Nagendra Prasad (2001), Kavita *et al.* (2008) and Kurubetta (2008) in capsicum.

The overall observations on vegetative, reproductive and quality parameters at different crop growth stages are depicted in Table 11. The results indicate that the hybrid Indra exhibited maximum potential or on par with potential hybrids (Bachata, Orobelle, Bomby, Inspiration and Sympatty) for plant height, number of leaves at all different stages of vegetative growth. Least values were recorded for all the vegetative parameters in hybrid Capsicum purple. The hybrid Bachata exhibited maximum potential or on par with the potential hybrids (Orobelle, Bomby, Indra, Inspiration and Sympatty) for yield and quality traits.

5.2.4 Cost and economics

The higher fruit yield (100.50 t/ha), gross returns (Rs. 40,25,664.00/ha) and net returns (Rs. 30,64,066.00/ha) was recorded by hybrid Bachata and lower fruit yield (59.72 t/ha), lower gross returns (Rs. 23,88,672.00/ha) and net returns (Rs. 15,64,114.00/ha) were recorded by hybrid Red Queen. Higher fruit yield in Bachata attributed to higher gross returns and net returns.

Maximum Benefit Cost ratio (B:C ratio) was recorded in Orobelle (Rs. 3.47) and it was found to be superior over other hybrids because of its higher yield and lower seed cost than Bachata and Inspiration even they recorded higher yield but higher seed cost attributed to lower B:C ratio compared to Orobelle. Kurubetta (2008) also reported same results in capsicum.

The economics of capsicum hybrids vary since cost of production vary with the hybrids. Even yield of Bachata is more but its B:C ratio is not maximum like Orobelle because seed cost Bachata is more than Orobelle in farmers points of view. As per B:C ratio, Orobelle is very good hybrid but production point of view Bachata is very good hybrid.

Future line of work

1. There is a need to evaluate capsicum genotypes in different media to know the effect of substrates on growth, yield and quality.
2. Morphological and molecular characterization of available public and private sector genotypes or accessions for growth, yield and quality using specific primers.
3. Crop improvement through hybridization by involving promising genotypes to improve yield and fruit quality.
4. Development of genotypes resistance to pests and diseases under protected cultivations.
5. Foliar application of micronutrients and organic products (bio-agents and extracts) to enhance quality and residue free capsicum production.

6. SUMMARY AND CONCLUSION

An experiment was conducted at Hi-Tech Horticulture Unit, Main Agricultural Research Station, Saidapur Farm, University of Agricultural Sciences, Dharwad, during 2015-2016 to study the performance of capsicum hybrids under different protected structures. The treatments comprised fourteen capsicum hybrids viz., Orobelle (Yellow), Bomby (Red), Indra (Green), Bachata (Yellow), Inspiration (Red), Sympatty (Orange), Mahabharath (Green), Krishna (Green), Yellow Wonder, Red Queen, Orange Wonder, Green Wonder, Capsicum Purple and Doctor Wonder (Green). The experiment was laid out in Randomized completely block design with three replications. The salient findings of the study are summarized below.

1. In case of vegetative characters, the maximum plant height was recorded at 120 DAP. Among the different hybrids, Indra recorded the maximum plant height which was significantly superior over the others hybrids and the least plant height was recorded by Capsicum Purple.
2. Orobelle recorded the maximum number of leaves per plant which was significantly superior over the other hybrids and the least number of leaves per plant was recorded by Capsicum Purple at 120 DAP.
3. Bachata and Sympatty took maximum number of days to flower opening which was on par with Orobelle and Inspiration and which was significantly superior over the other hybrids. Least number of days were taken for flower initiation was recorded by Capsicum Purple.
4. Inspiration and Sympatty took maximum number of days to first harvest which was on par with Bachata, which was significantly superior over all the hybrids. Least number of days were taken for first harvesting was recorded by Capsicum Purple.
5. The maximum number of flowers per plant was recorded by Yellow Wonder which is on par with all the hybrids except Mahabharath, Krishna and Doctor Wonder. The least number of flowers per plant recorded in Krishna hybrid.
6. Bachata recorded maximum fruit set which was significantly superior over all the hybrids. The minimum fruit set was recorded by Orange Wonder.
7. Bachata recorded maximum number of fruits per plant which was significantly superior over the other hybrids, which was on par with Orobelle, Inspiration and Indra. The least number of fruits per plant were recorded by Krishna.
8. Inspiration recorded highest fruit weight which was on par with Orobelle, Bomby, Bachata, Inspiration and Sympatty and least fruit weight was recorded by Capsicum Purple.
9. Doctor Wonder recorded highest fruit volume which was on par with Orobelle, Bomby, Bachata, Inspiration, Mahabharath and Doctor Wonder and least fruit volume was recorded by Red Queen.
10. Bachata recorded maximum pericarp thickness which was on par with Indra and Bachata which was superior over the other hybrids. Least pericarp thickness was recorded by Capsicum Purple.
11. The maximum shelf life was recorded in hybrid Bachata which was superior over the other treatments. Lesser shelf life was recorded by Krishna and Capsicum Purple.

12. Orobelle recorded maximum TSS content which was significantly superior over the other hybrids and least TSS content was recorded by Capsicum Purple.
13. Orobelle recorded maximum vitamin-C content which was significantly superior over the other hybrids and least vitamin-C content was recorded by Capsicum Purple.
14. Bachata recorded least moisture content which was on par with Orobelle, Sympatty and Inspiration. Maximum moisture content was recorded by Capsicum Purple.
15. The hybrid Bachata recorded maximum yield per plant which was significantly superior over other hybrids and least yield per plant was recorded by Red Queen.
16. Bachata recorded maximum yield per meter square which was significantly superior over the other hybrids and least yield per meter square was recorded by Red Queen.
17. Bachata recorded maximum yield per hectare which was on par with Inspiration. Bachata and Inspiration hybrids are significantly superior over other hybrids and least yield was recorded by Red Queen.
18. The higher fruit yield was recorded by hybrid Bachata and lower fruit yield was recorded by hybrid Red Queen.
19. The higher gross income and net income was recorded by hybrid Bachata. While, lower gross income and net income was recorded by Red Queen.
20. With respect to benefit cost ratio, Orobelle was found to be superior over the other hybrids. Red Queen recorded the lower benefit cost ratio.

Conclusion

The hybrid Bachata was found to be superior for reproductive and quality parameters, which indicates hybrids showing superiority during reproductive stage is very important for high yield. As per B:C ratio, Orobelle is good hybrid from the farmers point of view as it is suitable for local market. But from total yield point of view and quality is concerned, Bachata is a good and promising hybrid for export purpose. Export quality of Bachata is due to maximum pericarp thickness, vitamin-C, good shelf life and suitable for long distance transportation. B: C ratio would be maximum from Bachata hybrid compared to all other hybrids with regard to export price of capsicum.

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Appendix I : Mean monthly meteorological data during (2015-2016) crop growth period at Hi-tech Horticulture Unit, Saidapur farm, MARS, Dharwad

Month	Relative humidity (%)		Temperature °C maximum		Temperature °C minimum	
	Outside	Inside	Outside	Inside	Outside	Inside
December, 2015	50.78	64.79	30.63	36.92	15.74	17.38
January, 2016	44.53	59.74	30.08	36.85	14.21	15.45
February, 2016	46.61	61.96	33.59	39.61	17.87	19.18
March, 2016	41.34	54.02	36.13	42.01	20.63	21.48
April, 2016	50.27	65.78	38.00	42.96	21.65	22.48
May, 2016	58.69	72.86	36.11	40.68	22.10	23.69
June, 2016	78.18	91.84	29.20	33.21	21.36	22.02
Average	52.91	67.28	33.39	39.06	19.08	20.24

Appendix II: Calculation of detailed cost of cultivation of capsicum hybrids under protected structure (one hectare) for one crop

1. Cost of infrastructure facilities

Sl. No.	Particular	Total cost (Rs.)	Depreciated cost (Rs.) for one year	Depreciated cost (Rs.) for one crop
A	Naturally ventilated polyhouse			
1	Structure/drip irrigation facilities			
a)	Structure (excluding cladding material) Rs. 600/m ² for life span of 15 years	60,00,000	4,00,000	2,00,000
b)	Drip irrigation system @ Rs. 55/m ² for life span of 10 years	5,50,000	55,000	27,500
2	Interest on fixed cost (a and b) @ 14 % per annum	-	7,700	3,850
3	Repair and maintenance cost	-	40,000	20,000
	Total operational cost	-	5,02,700	2,51,350

2. Cost of planting material (Rs.)

Hybrids	Cost of seedling per hectare
T ₁ - Orobelle	Rs. 62,640
T ₂ - Bomby	Rs. 62,640
T ₃ - Bachata	Rs. 1,91,328
T ₄ - Inspiration	Rs. 1,91,328
T ₅ -Sympatty	Rs.1,91,328
T ₆ - Mahabharath	Rs. 58,464
T ₇ - Krishna	Rs. 48,024
T ₈ - Doctor Wonder	Rs. 37,584
T ₉ - Green Wonder	Rs. 54,288
T ₁₀ - Yellow Wonder	Rs. 54,288
T ₁₁ - Orange Wonder	Rs. 54,288
T ₁₂ - Capsicum Purple	Rs. 54,288
T ₁₃ - Red Queen	Rs. 54,288
T ₁₄ - Indra (control)	Rs. 62,640

Contd...

3. Cost of growing media and its preparation

Sl. NO.	Particular	Polyhouse (Rs.)
1	Media (FYM + vermicompost)	25,000
2	Fumigation (with 4% formaldehyde) 40 ml /m ² = 400 l @ Rs. 47/l	18,800
3	Labour cost (200 man days @ Rs. 235/day)	47,000
	Total	90,800

4. Cost of fertigation

19:19:19		12:61:0		0:0:50		DAP		Total (Rs.)
Quantity (kg)	Cost (Rs.)	Quantity (kg)	Cost (Rs.)	Quantity (kg)	Cost (Rs.)	Quantity (kg)	Cost (Rs.)	
420.2	42,020	322	41,860	280	30,800	500	13,000	1,27,680
19:19:19- Rs. 100/kg		12:61:0- Rs. 130/kg		0:0:50- Rs. 110/kg		DAP – Rs. 26/kg		

5. Cost of micronutrient

Micronutrient cost	Polyhouse (Rs.)
Cost	24,000
Total	24,000

6. Cost of plant protection chemicals

Sl. No.	Plant protection chemical	Polyhouse (Rs.)
1	Insecticides spray	36,540
2	Fungicides spray	19,000
	Total	55,540

7. Cost of labour

Sl. No.	Labour	Polyhouse (Rs.)
1	Men-300 man days @ Rs. 235/day	70,500
2	Women-640 man days @ Rs. 235/day	1,50,400
	Total	2,20,900

EVALUATION OF CAPSICUM HYBRIDS UNDER PROTECTED CONDITION

MANOJ, B. V

2016

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ABSTRACT

An experiment was conducted to evaluate capsicum hybrids under protected condition at the Hi-tech Horticulture Unit, Saidapur Farm, MARS, University of Agricultural Sciences, Dharwad, Karnataka during summer 2015-16. Fourteen capsicum hybrids viz., Orobelle, Bomby, Bachata, Inspiration, Sympatty, Mahabharath, Doctor Wonder, Green Wonder, Yellow Wonder, Orange Wonder, Capsicum Purple, Krishna, Red Queen and Indra (check) were evaluated in completely randomized block design with three replications. Results revealed that, among fourteen hybrids, Indra recorded higher plant height (77.22, 99.72 and 139.25 cm) at 60, 90, and 120 DAT, respectively. Bachata recorded maximum fruits per plant and per cent fruit set (18.13 and 47.61 %, respectively). Bachata and Inspiration recorded higher fruit yield per plant (2.41 and 2.33 kg, respectively), yield per hectare (100.50 t and 97.16 t, respectively) and also maximum shelf life (7.83 and 7.50 days, respectively). The maximum vitamin-C content (167.50 mg/100 g) was recorded in Orobelle. The minimum moisture content in fruit was recorded by Bachata (90.23 %) followed by Orobelle (90.41 %), Sympatty (90.69 %) and Inspiration (91.50 %). The maximum dietary fibre content (1.98 g/100 g of fruit) was recorded by Bachata. Among the fourteen hybrids evaluated with considering the quality and reproductive parameters with respect to colour of the fruit, among the five colour yellow colour (Bachata), red colour (Inspiration), orange colour (Sympatty) and green colour (Indra) were promising hybrids. The gross returns (Rs. 40,25,664.00 ha⁻¹) and net returns (Rs. 30,64,066.00 ha⁻¹) were recorded significantly higher in the hybrid Bachata. All these above mentioned parameters were lowest in hybrid Capsicum Purple. The results of present investigation indicated that the hybrid Bachata was found suitable and highly economic followed by Inspiration and Orobelle.