PRODUCTIVITY OF CUCUMBER (*Cucumis sativus* L.) AS INFLUENCED BY SEASONS AND GROWING SYSTEMS

by

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THESIS

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DECLARATION

I, **Ambily Sadanandan (2008-12-103)**, hereby declare that this thesis entitled **"Productivity of cucumber (*Cucumis sativus* L.) as influenced by seasons and growing systems"** is a bonafide record of research work done by me during the course of research and that it has not been previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title of any other University or Society.

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Introduction

1. INTRODUCTION

Cucumber (*Cucumis sativus* L.) is a high value vegetable grown throughout India. It is mainly valued as salad and rarely as cooked vegetable and has got many medicinal, cosmetic and tonic properties. It is one of the most preferred vegetables grown under protected condition in the developed countries, but in developing countries like India it is mainly grown as an open field crop.

Cucumbers are grown during specific seasons (*zaid* and *kharif*) in northern India. Though the consumption of this vegetable is on rise in Kerala most of our demand is met from neighbouring states like Tamil Nadu and Karnataka. The commercial cultivation of this crop is limited to only certain pockets during winter season in Kerala. Being a high value crop its exploitation on commercial scale in poly-green house as off season crop will generate income among the unemployed youth of Kerala.

Protected cultivation of vegetables is a viable alternative against biotic and abiotic stresses and shows maximum genetic potentiality of the crops by controlling the microenvironment of the crops. Popular protected structures include plastic/polyhouses, net houses, tunnels, rain shelters, controlled environment greenhouses and plastic mulches coupled with fertigation. These are framed structures covered with transparent material and large enough to grow crops with partial or fully controlled environmental conditions to get maximum productivity and quality produce. UV stabilized polythene covered greenhouses are being widely used in recent years throughout the world.

The productivity of a particular crop in an area largely depends on the environment and protected cultivation is widely used to provide and maintain a controlled environment suitable for optimum crop production (Mahajan and Singh, 2006). It has the potential to usher quantum jump in production of high value speciality crops, economic viability and weather proofing in hilly areas. Limitation of

weather and small holdings faced by agriculturists can be mitigated to large extent by protected cultivation. The green houses protect the crop from extreme climatic conditions ensuring round the year harvest. The low cost bamboo based greenhouse structures covered with polythene are now within the reach of small and marginal farmers (Anuja *et al*., 2008).

Cucurbits are trailed either ground or as pandal/bower system. The pandal or bower system has got the advantage like higher yield, fruits of uniform size and colour which fetches high price in the market. According to Narayan *et al.* (2008) training is an important practice which enhances vegetative growth, yield and quality of fruits. The exposure to sunlight helps in physiological and photosynthetic activities leading to more growth, flowering, fruit development and ultimately higher yields of better quality. Farmers in Kerala grow cucurbits like bitter gourd, snake gourd, ridge gourd and ivy gourd on pandals which result in enhanced yield. Fruit quality is also superior (Peter *et al.,* 2008).

Despite its economic, medicinal and cosmetics values, not much work has been done on the protected cultivation or agro techniques of this crop in Kerala. Being a thermosensitive crop, its cultivation is limited to winter season in our state. Higher temperature during summer and heavy rains during rainy season are the factors which limit its cultivation during off season. Cucumbers are available in the market during the season only. Availability during their off season is possible only by greenhouse technology. This technology offers many benefits like improved productivity per unit area with superior quality, longer harvest duration and year round production of the crop. Naturally ventilated low cost green house named rain shelter will be a cost effective structure for off season production of cucumber in Kerala.

In this backdrop, the present study is undertaken with the following objectives

1) To investigate the feasibility of off season production of cucumber in rain shelter
2) To identify ideal variety for protected cultivation
3) To study the comparative performance of crops in rain shelter and open field.

Review of Literature

2. REVIEW OF LITERATURE

Cultivation of off season vegetables under polyhouse provides an opportunity to farmers to produce vegetables with high quality and yield. The polyhouse provides a protective structure with congenial environment and protects the crop from natural calamities. Tomato, capsicum, and cucumber are successfully cultivated in both low cost and high-tech polyhouses. Cucumber is one of the most preferred vegetables grown under protected condition in the developed world. The available literature on protected cultivation of cucumbers and cucurbits is reviewed under the following heads.

2.1 Performance of cucumber and other cucurbits under protected structures and open field

2.2 Influence of planting seasons on growth and yield of cucumber and other cucurbits

2.3 Influence of weather parameters on growth and yield of cucumber and other cucurbits

2.4 Influence of trailing methods on growth and yield of cucumber and other cucurbits

2.5 Economics of cultivation

2.1 Performance of cucumber and other cucurbits under protected structures and open field

Cucumbers are grown in the specific seasons under open field conditions particularly in northern India. But the productivity of open field grown cucumber during regular season is only 8-12t/ha (Seshadri, 1986). More *et al.* (1990) reported that variety Poinsette recorded maximum yield of 170.9t/ha in the low cost green

houses during winter season in north India and opined that Poinsette is the most promising cultivar for green house cultivation. Inside the greenhouse, Poinsette recorded maximum number of fruits (12.1/plant) of edible maturity and was 5-8 times greater than Sheetal, RKS 302 and Pusa Sanyog.

Mohamedien *et al*. (1993) observed that the cucumber cultivar Farid under polyhouse conditions gave maximum fruit weight (114.249g), fruit length (15.69 cm), diameter (3.3 cm) and yield (75.07 kg/plot) as compared to other cultivars. Similarly Chandra *et al*. (2000) conducted an experiment inside green house with cucumber varieties Priya and Poinsette and reported that the two varieties performed well in terms of yield inside the green house (Priya 70.1 t/ha, Poinsette 73.2t/ha) due to high utilization of carbon dioxide inside the polyhouse.

The performance of various cucumber cultivars under open field and greenhouse condition in Palampur, Himachal Pradesh during rainy season revealed that yield under open field was higher than greenhouse, Poinsette and K-75 had higher yields than the other cultivars, which could be attributed to greater fruit length, weight, and yield per plant (Sharma *et al.*, 2001).

Hamid *et al.* (2002) conducted a field experiment on six cucumber cultivars under agro-climatic conditions of Swat, Pakisthan and found that cultivar PARC-1 was the best among all the cultivars studied. PARC-1 recorded the earliest fruit initiation (53.00 days) and fruit maturity (69.66 days), and the highest number of fruits per plant (11.60) and fruit yield (10.66 t/ha). In an open field study, Ahamed *et al.* (2004) observed that the maximum vegetative growth in terms of vine length and leaf number per plant was recorded in the cultivar Punjab Local and the minimum in cultivar Yadenctva under the agro-climatic conditions of Rawalakot, Azad Jammu and Kashmir. The cultivar Punjab Local also produced fruit having the maximum diameter (4.59 cm). Maximum fruit yield per plant and per hectare were obtained

from the cultivar Market More followed by the cultivar Poinsette-76, which is due to more number of fruits per plant and greater fruit length.

Singh and Kumar (2004) opined that the low cost naturally ventilated greenhouses are more suitable and economical for year-round cucumber cultivation in the northern plains of India. The incidence of biotic stress (insect pests), plant mortality and use of chemical insecticides were found minimum under protected condition. The marketable fruit yield, gross income, net income, cost:benefit ratio and money saved were higher under protected condition. Vegetable cultivation under protected condition was, thus, an ideal technique to avoid biotic and abiotic stresses, and to enhance yield (Singh *et al*., 2005). Low cost polyhouse is becoming popular among the poor and marginal farmers in the hills. Tomato, cucumber and capsicum are the main off season vegetables grown under polyhouse in hills. The yield of these crops is one and a half to two times higher inside the polyhouse than in open field (Kumar *et al.,* 2005). Partial or fully controlled environmental conditions in the green house structures are providing maximum productivity and quality to the produce (Mahajan and Singh, 2006). According to Singh and Sirohi (2006) vegetable growers can substantially increase their income by protected cultivation of vegetables in off season as the vegetables produced during their normal season generally do not fetch good returns due to large availability of these vegetable in the markets. Off season cultivation of cucurbits under low plastic tunnels is one of the most profitable technologies under northern plains of India.

Pusa Sanyog is the most suitable cucumber variety for polyhouse cultivation as it produces an estimated yield of 1150q/ha followed by Poinsette (980q/ha). Pusa Sanyog is the earliest in maturity and has maximum duration of crop availability (Munshi and Kumar, 2007). Singh *et al.* (2007) reported that plastic low tunnels are highly suitable and profitable for off season cultivation of cucurbits like summer

squash, bottle gourd, bitter gourd, musk melon, water melon, round melon and long melon in peri-urban areas of northern plains of India.

Parthenocarpic slicing cucumber is one of the suitable and profitable crops for cultivation under naturally ventilated green houses in peri urban areas of India. Three crops of cucumber can be grown in this structure in a period of nine months (Singh and Hasan, 2008).

Eifediyi and Remison (2009) observed that Ashley is the best cultivar suited to Edo state of Nigeria among Marketmore 76, Palmetto, Marketer and Beith Alpha. Ashley variety produced the highest number of fruits per plant, highest fruit weight and high yield due to the genetic composition and its ability to quickly adapt to the environment.

Naturally ventilated greenhouse is the most suited low cost greenhouse in small farms field in mid hill region of north western Himalaya and can control the microenvironment inside the greenhouse for successful vegetable production (Kumar *et al.,* 2009). Singh *et al.* (2009) recommended polycarbonate greenhouse structures for exploiting maximum yield potential of crops under cold arid high altitude conditions of trans Himalayas when compared to polyench and trench structures. Growing vegetables by low tunnel technology (row cover technology) has many advantages with regards to increase in yield, early harvesting of vegetables, conserving soil warmth, protecting plant from wind and frost and ultimately increasing the net profit for the farmers (Lodhi *et al.,* 2009).

Bisht *et al.* (2011) studied the suitability of cucumber varieties under naturally ventilated polyhouse and found that Poinsette is the most suited variety and exhibited better vine length (2.77m), more number of primary branches (6.77) and

largest number of fruits per plants (32.8). Mean fruit yield per plant (5.27kg) and per hectare (1463.33q) were found maximum in Poinsette.

Several biotic and abiotic stresses are the major factors responsible for low productivity and poor quality in large number of vegetables crops under their open field cultivation especially during rainy and post rainy seasons. Protected cultivation has greater potential in augmenting production and quality of vegetables, in main and also during off season and maximizing water and nutrient use efficiency under varied agro climatic condition of the country (Singh *et al.*, 2012).

Singh (2012) found that parthenocarpic varieties of cucumber recorded 7-8 times higher yield than the standard check variety Poinsette (250q/ha) inside the polyhouse. Cucumber F1 hybrid Alisha recorded the highest yield per plant (5.13kg) as compared to other F1 hybrids *viz*., 243 Malav, Manorama, Champion, Sedona and Neelima under protected condition (Phookan and Boruah, 2012). Cucumber hybrid Kian was the most suitable for off season production of cucumber in polyhouse as compared to cucumber hybrid Isatis in low hill areas of Himachal Pradesh (Sharma *et al.*, 2012). Singh *et al.* (2012) reported that cucumber parthenocarpic variety Isatis and Kiyan performed well during winter planting in naturally ventilated multispan polyhouse as compared to variety Asma under insect proof net house.

Other cucurbits

Kumar *et al*. (2009) reported that in summer squash the total number of fruits and average fruit weight were higher under polyhouse as compared to open field in mid hills of north western Himalaya. The yield inside the polyhouse is 1.5 to 2.0 times more as compared to open field. Fast growth and development of crops under protected condition provide early harvest during off season due to which produce are getting higher price in the market.

Singh and Kumar (2009) evaluated five summer squash cultivars (Australian Green, Pusa Alankar, Goldy, C-135 and Adlika) during their off season cultivation under low plastic tunnels. Australian Green recorded the lowest number of days to first harvesting (58.0) and the highest average fruit yield (5.80 kg per plant or 696.0 q/ha). This cultivar produced long (25-30cm), dark green fruits with longitudinal strips.

2.2 Influence of planting seasons on growth and yield of cucumber and other cucurbits

Cucumber is mainly grown in summer and rainy seasons in India and to make them available in off season they are to be cultivated in green houses. According to Rajput *et al.* (1991) Sheetal, was an early maturing and high yielding variety suitable for cultivation on slopes receiving high rainfall during kharif, maturing in 92 days, and as a summer crop, maturing in 65 days. In three year tests it produced yields of 42.1 t/ha in kharif, greatly outperforming other varieties, and 20-30 t/ha in summer with fruits having an average weight of 350 g.

Borah (1999) observed the effect of different sowing seasons (summer, rainy and winter) and cucumber varieties AAUC-1, AAUC-2 and Diphu Local on the infestation levels of *Raphidopalpa foveicollis* in Assam and found that maximum yield (9830 kg/ha) was obtained from the summer sown crop of AAUC-1 with 2.8 beetles/plant and 33.3% plant damage followed by AAUC-2 and Diphu Local.

An experiment was laid out inside an LDPE film covered bamboo structured low cost polyhouse (gable even type) in which four cultivars of cucumber *viz*., Poinsette, Pusa Sanyog, AAUC-1 and AAUC-2 were grown during the winter season of 1996-97 and 1997-98 in Assam, as an off season crop. The variety AAUC-2 recorded the highest mean values for characters such as number of fruits per plant, fruit length, average fruit weight and yield per plant (Saikia *et al*., 2001).

Borah (2001) investigated the effect of different sowing dates of cucumber on the incidence of fruit fly (*Bactrocera cucurbitae*) and the yield of the crop and reported that sowing from 20th April to 20th May recorded significantly lower pest infestation than sowing crops from 20th June to 20th July. The maximum pooled yield (291.0 q/ha) was recorded from the 20th April sown crop which differed significantly from the rest of the sowing dates except the 20th May sowing. According to Jaksungnaro and Sema (2001) sowing time had significant influence on vegetative growth and on the number, size, yield and ascorbic acid content of fruits. The first sowing date (21 March) gave the best results in almost all the parameters, except for the size of fruit in Nagaland condition for cucumber AAUC-2.

Das *et al.* (2003) conducted field experiments with 18 genotypes of cucumber in Bihar, during the summer season and rainy season. Among the genotypes, CHC-20 recorded the maximum fruit yield of 2.74 kg/vine with a fruit weight of 403.11 g and fruit length of 5.19 cm, followed by Pusa Sanyog and PCUC-15 and opined that these three genotypes were suited for cultivation during summer and rainy seasons in Bhagalpur region. Ravikumar *et al.* (2003) studied the influence of spacing, nipping and fruit retention on yield parameters and seed yield in cucumber Poinsette during summer and kharif seasons. In the kharif season, narrow spacing recorded the highest percentage of filled seeds per fruit (67.5%) and seed yield (76.6 kg/ha). In the summer season, narrow spacing also recorded the highest percentage of filled seeds per fruit (51.6%) and seed yield (60.8 kg/ha). No nipping treatment recorded high number of filled seeds per fruit (119.7) and seed yield (71.4 kg/ha) during the kharif season. The retention of 4 and all fruits per vine produced high seed yield. Similar trends were observed during the summer season also.

Tropical gynoecious cucumber hybrids like H-211 and H-27 in the greenhouse and H-36 and H-211 in the open field were considered as early hybrids during December and April seasons. H-210 and H-211 in the greenhouse and H-211 and H-22 in the open field were considered high yielding during both seasons (Badgujar and More, 2004). Early sowing of cucumber immediately after the onset of monsoon produced significantly highest fruit yield (10.36 t ha^{-1}) over the late sowings carried out after one, two and three weeks of monsoon onset (Yadav and Patil, 2008).

Yadav and Patil (2008) studied the effect of sowing time on the incidence of downy mildew of cucumber Sheetal during kharif season. Downy mildew incidence was observed on crop sown during 24th, 25th, 26th and 27th meteorological week (MW) at 40, 39, 33 and 25 days after sowing, respectively. The disease incidence progressively increased with an increase in crop age from the date of incidence. The incidence of downy mildew was first observed in 29th MW (0.25%) on the crop sown in 24th MW.

According to Santos *et al.* (2008) cucumber performed best when planted around 23rd February allowing the crop to grow and set fruit during the cool part of the season (March and April), summer squash produced highest yields when planted on 23rd February or later and the best planting dates of musk melon were between 25th January and 9th Februay in Florida. A study conducted at Teaching and Research Farm of the Ambrose Alli University, Nigeria by Eifediyi and Remison (2009) to evaluate five varieties of cucumber and to determine the appropriate time during the wet season for planting revealed that April planting was best than May and June planting due to highest fruit yield per hectare.

Kishor *et al.* (2010) studied the effect of season on cucumber variety Pusa Uday in the northern plains of India and found that kharif season crop flowered 10 days in advance (40.79 days) as compared to spring summer crop (50.67days). The delay in flowering during spring summer was because of environmental conditions (chilling weather) coupled with transplant shock during the months January and February. Number of fruits per plant was higher in kharif (1.7) to spring summer (1.57). This is due to the development of more secondary branches bearing female flowers during the kharif season. Seed yield per fruit, seed yield per ha and 1000 seed weight were recorded higher for spring summer crop. Therefore, spring summer was better to kharif for seed production.

Other cucurbits

Summer squash cultivars Senator and Elite produced the fewest pistillate flowers when planted in midsummer in southeastern United states and found that these varieties were better choice for production during cooler portions of the season (NeSmith *et al.*, 1994).

Singh *et al.* (2002) conducted field experiment during 1998-99 to determine the suitable sowing date (30th November, 10th December and 20th December) for early production of cucurbitaceous vegetables (cucumber, watermelon, longmelon and ridge gourd) for availability in the beginning of the summer season in Bihar, India. The highest yield (159.78 q/ha) was obtained from watermelon sown on 30 November compared to sowing on 10th and 20th December. The lowest yield (89.81 q/ha) was obtained from ridge gourd sown on 20th December.

2.3. Influence of weather parameters on growth and yield of cucumber and other cucurbits

Cucurbits are warm season crops requiring a minimum of about 15-18^{0}C and 30-35^{0}C maximum temperature for successful cultivation. Environmental factors greatly affect the vegetative and reproductive characters in cucumber (Frankel and Galun, 1977). Temperature, light intensity, and relative humidity are the main factors which influences the growth and development of plants considerably (Reddy, 1999). Modification of above the factors is possible inside green house structures. Temperature is the one of the most easily and frequently modified environmental factors influencing plant growth.

2.3.1 Temperature

Matlob and Kelly (1972) studied the effect of high temperature on pollen growth of snake cucumber and cucumber and found that high temperatures of 80-100^{0}F before or during pollination resulted in failure of pollen tube growth in cucumber, while fertilization and seed set occurred in snake cucumber. The optimum air and root temperature of cucumber plants was 25^{0}C (Folster, 1974). Vooren (1980) reported that increasing night temperature from12^{0}C to 20^{0}C under greenhouse condition decreased the number of days taken for first flower production (earliness). According to Drews (1980) low night temperatures (<17^{0}C) increased cucumber fruit set and total yield and very high temperatures (>35^{0}C), reduced fruit set to 30%. Karlsen (1981) observed maximum growth of aerial parts in cucumber at 30^{0}C air and 20^{0}C root temperature. In the preplanting stage, the 24^{0}C day and 17^{0}C night temperature combination produced plants which were taller, heavier and leafier than those grown at 21^{0}C day and 19^{0}C night and during the first 12 weeks of harvesting the larger plants produced significantly more fruit (Slack and Hand, 1983).

According to Nagoaka *et al.* (1984) optimum temperature range for photosynthesis in cucumber was 28-33^{0}C and transpiration rate in cucumber was not increased with temperature. With the lowest night temperature (9^{0}C) after planting there was a delay in growth, poor elongation of laterals and reduction in total cucumber yield (Yamashita *et al*., 1984). More and Munger (1987) reported that gynoecious line of cucumber was more stable under low temperature and low photoperiod. At higher temperature, the gynoecious genotypes were less stable and photoperiod had no influence on stability at high temperature. They also observed that high temperature of 87.8^{0}F caused reduction in vine length. Vine length and internodal length were more at 75^0/65^{0}F DT/NT temperature and 16hrs day length. Under the above temperature and day length maximum dry weight was also recorded. They also found that node to first female flower was progressively increased with increase in the mean temperature.

Shi *et al.* (1991) noticed that highest net photosynthetic rate at 30^{0}C when plants were at an early growth stage and at 35^{0}C during mid late growth stage and at 35^{0}C large quantities of assimilates were transported to vegetative parts in cucumber plant. According to Marcellis (1993) total leaf area and leaf weight per plant of cucumber plants were greater at 25^{0}C than at 18^{0}C, though the reverse was true for individual leaf area and weight. Staub and Navasio (1993) reported that high temperature (22^{0}C to 45^{0}C) and high relative humidity (75%) led to the development of pillowy fruit disorder. Plant height is a function of the number of nodes and the length of each internode, and both were strongly influenced by greenhouse temperatures. Node number or formation rate increased as the average temperature increased (Berghage, 1998).

Under high temperature, the neck of cucumber fruits became longer, abnormal fruits increased, skin of fruits became harder and ascorbic acid concentration decreased and yield also decreased (Ling Bo *et al*., 2004). In a study

conducted on cucumber in Nadia, West Bengal, India the ratio of number of female flower to male flower was higher in favourable condition and less under stress micro environmental condition. The value of female to male flower ratio was usually found less than one. The higher the temperature, less the moisture content in the soil, within field capacity to plant wilting point, and the less the inter plant spacing, the higher was the maleness, when the intensity of sunshine and day length remained the same. The expression of female flowering gene was more stress sensitive (Das, 2008).

Other Cucurbits

Low temperature promotes parthenocarpic fruit set of summer squash and increases rate of growth and final weight of fruits (Rylski, 1974). The summer squash cultivars Senator and Elite produced the fewest pistillate flowers when planted in midsummer in southeastern United states, when temperature averaged 26^0C (NeSmith *et al.,* 1994). Kumar *et al.* (2009) reported that temperature moderation inside the green house facilitated early transplanting of summer squash seedling and fast growth and development provided early harvest of the crop. Wein *et al.* (2004) studied that high temperature delayed the formation and anthesis of female flowers of pumpkin in southeastern United States and prevented fruit production in time.

2.3.2 Light

According to Nagoaka *et al.* (1984) both photosynthetic and transpiration rates increased linearly with increasing light intensity (over a wide range between 28.9 and 57.6 klx in different trials). KyungEnn *et al.* (1995) studied that the effects of light and water stress on the germination of cucumber seeds. Under water stress (-0.48 MPa), germination rate was very low (8%) in the light (1300 Lux), but was higher (51%) in dim light (5-10 Lux).

According to QingJun *et al.* (2003) low light intensity reduced sensitivity of cucumber to low temperatures and improved chlorophyll content, leaf area and chlorophyll fluorescence quantum yield. The photosynthesis rate was reduced under low light intensity. The intensity of light played the leading role in growth of cucumber under the low temperature condition, while the low temperature played the leading role under the critical low temperature condition. The tolerance to low temperature and low light intensity were not always synergetic for the same cucumber genotype.

Crop duration increased with reduced PAR (photosynthetically active radiation) levels due to delayed flowering and longer fruit development period. The relative dry matter yield of cucumber at 50% PAR was 0.90. Leaf weight ratio remained more or less similar up to 50% PAR. The highest number of fruits per plant (21.83) and the heaviest individual fruits (267.3 g) were recorded at 75% PAR. The highest fruit yield was obtained at 75% PAR (16.09 t/ha), followed by 50, 100 and 25% PAR (11.73, 11.28 and 4.57 t/ha, respectively). The relative fruit yield of cucumber at 75 and 50% PAR were 1.43 and 1.04, respectively. Considering total dry matter and relative fruit yield, cucumber was found suitable for growing under reduced light condition up to 50% PAR (Haque *et al.*, 2005)

Under different light quality (red, blue) the plant height, flower bud differentiation and photosynthesis rate improved greatly, while for UV-A and UV-B the growth rate was lower compared with the control. The transpiration rate of cucumber leaf under red and blue light was higher compared with the UV-A and UV-B light. When under UV-B light the stoma conduction, transpiration rate, and the CO_2 concentration between cells as well as the photosynthesis rate were decreased, at the same time the germination rate, fresh and dry weight, plant height and flower differentiation number were decreased; while the stoma density and thickness of cucumber leaf were increased greatly (Shaohui *et al.*, 2007).

According to Petterson *et al.* (2010) photosynthetic characteristics, chlorophyll index and leaf area were examined in selected leaves of cucumber (*Cucumis sativus* L. cv. Euphorbia). In the first experiment, plants of cucumber were grown horizontally at a lighting period of 20 h day^{-1}. Photosynthetic measurements in horizontally growing cucumbers showed that there was no decline in photosynthetic capacity when cucumber leaves were developing under good light conditions. In a second experiment, plants were grown in a traditional high wire cultivation system under 20 h day^{-1} lighting period until they reached final height and then exposed to different lighting periods (20 and 24 h day^{-1}) for 3 weeks. In stands of cucumber plants photosynthetic measurements showed that the lower leaves have a significant reduction in photosynthetic capacity due to reduced light conditions. Three weeks exposure to 24 h day^{-1} lighting period reduced leaf area by 20%. Plant grown under continuous light had also lower chlorophyll index compared to plants grown under 20 h day^{-1} lighting period. Higher PPF (photosynthetic photon flux) condition during healing and acclimatization of grafted cucumber seedlings improved the growth and quality of the above (Jang *et al.,* 2011).

2.3.3 Humidity

The development of mildew (*Sphaerotheca fuliginea*) in glass house cucumbers indicated that high humidity was most conducive to conidial germination but at later stages of infection (mycelial growth, conidial production and conidial dispersal) low humidity was more favourable to the fungus than high humidity (Abiko and Kishi, 1979). According to Nagoaka *et al.* (1984) photosynthetic rates increased, whereas transpiration rates decreased, with increasing relative humidity (from 40 to 80%) in cucumber plants. Bakker (1988) reported that the vegetative growth of cucumber was enhanced by either high day or night humidity and fruit quality was reduced by high 24 h average humidities.

Bakker and Sonneveld (1988) studied the effects of interactions between environmental humidity, Ca supply and electrical conductivity (EC) of the growing medium on Ca deficiency in the leaves and found that the effect of humidity on Ca deficiency increased with increasing EC and decreasing Ca supply. When Ca accounted for more than 47% of all cations in the root environment, the effect of humidity on Ca deficiency was negligible. In a greenhouse experiment, the effects of air temperature and relative humidity on the growth of semi forced cucumber Natsunokaori were investigated. Air temperature of 30^0C and relative humidity of 60% promoted the development of fruit and suppressed the development of lateral branches. In pinching cultivation, air temperature of 25^0C and relative humidity of 40% promoted the development of lateral branches by suppressing fruit growth. However, the percentage of marketable fruits and total number of fruits increased at 25^0C air temperature and 40% relative humidity (Hirama *et al.*, 2002).

2.4 Influence of trailing systems on growth and yield of cucumber and other cucurbits

In order to get maximum photosynthetic area per unit of ground area, indeterminate vegetables such as tomato and cucumber are trained on to strings suspended from an overhead wire. Cucumber can be trained on number of training systems.

Vertical training or staking cucumber plants increased yield, enhanced fruit quality and improved the control of foliar and fruit diseases as compared to the traditional method of growing cucumber on the ground (Konsler and Strider, 1973). Yurina and Ganichkina (1975) reported that both short pinching and the Dutch method changed the plant branching habit and the short pinching method improved leaf photosynthetic productivity. According to Stan *et al.* (1980) for hybrid

cucumber Amazone, the highest total (281.3 t/ha) and early (115.1 t/ha) yields were obtained from pergola trained plants (pruned to retain 8-10 fruits and 3-4 laterals). The lowest total and early yields (177.3 and 68.4 t/ha, respectively) were obtained from control plants (V training and no pruning).

Hanna and Adams (1984) reported that trellising increased harvesting efficiency in cucumber while improving yield by reducing damage to vines and improving net photosynthetic rate. Moerman (1985) observed that yields and average fruit weight were highest with the hedge system of training in cucumber. Pruning enhanced the total yields of Lucinde, but depressed the early yields of Corona. Highest productivity was obtained with V system at high density but mean fruit weight decreased (Bakker and Vooren, 1985). Gobeil and Gosselin (1989) opined that the duration of flowering and fruit maturation were shorter in cucumber when pruned in summer season. Trellising improved total and marketable yield of cucumber and also suggested that trellised cucumbers were easier to harvest than ground culture cucumbers. Klieber *et al.* (1993) observed that umbrella training system in english cucumber permitted high canopy light penetration resulting in darker fruit and a longer shelf life. Hanna (1993) recommended that producing trellised cucumbers in the presence of tomato skeletons i.e. double cropping tomatoes and cucumbers is economically feasible. Al-Harbi *et al.* (1996) observed that training the cucumber plants to a single stem resulted in taller plants with larger leaf areas, higher shoot fresh and dry weights and higher yields.

Jaiswal *et al.* (1997) studied the effect of staking system *viz*., bamboo sticks or tree branches (farmer's practice), staking using jute strings or no staking on the yield of cucumbers Bhaktapur Local and observed that staking system did not influence the days required to first harvest and staking using bamboo sticks or tree branches produced more fruits than jute string and no staking. But staking with jute string gave 5.6 and 29% more marketable fruits than the farmers' practice of staking

and no staking, respectively. Shetty and Wehner (1998) reported that cucumber cultivars grown on trellis support possessed higher vine length, incidence of powdery mildew, fruit shape, fruit quality, fruit firmness, marketable yield and percentage of culled fruit. Welles (1999) opined that, through the High Wire System of training high yield of excellent fruit quality (keeping quality) could be obtained almost year round in the case of cucumber plants.

Tokatly and Ozgur (1999) observed that growing pickling cucumbers on wires gave good yield and quality as compared with growing them on the ground. On 150 cm wire height, which gave the highest yield in all the cultivars, the yields obtained in pickling cucumbers were 3.13 kg/m^2 in Fancipak F_1, 3.46 kg/m^2 in Ophix F_1 and 3.05 kg/m^2 in Quest F1. The guernsey arch, vertical and inclined cordons and the umbrella system were some of the main training systems (Thakur and Spehia, 2001).

Masahiro *et al.* (2001) examined the effects of vertical training to improve yield and quality on cucumbers cultured in green houses. Vertical training was superior in quality, and it reduced the harvest time but inferior to pinching in total yield. Kosson and Dobrzan´ska (2002) studied that the effect of four plant training systems on yield and storability of Polish short-fruited cucumber Aramis and highest early yield was recorded for the plant training system consisting of a main stem topped on the wire. No differences in greenness of fresh fruits after harvest from different training systems were observed.

Training in cucumber improved the productivity and quality in the overwintering long-term cultivation (Kato and Takahashi, 2006). Coiling of stem around the growing bag at a spacing of 45X60 cm produced better leaf growth, total yield and marketable yield in green house grown cucumber (Premalatha *et al.,* 2006). Ming *et al*. (2010) observed that the twin head "V" high wire system was more cost

effective for year round greenhouse cucumber production as it allowed for uniform foliar and light distribution and higher yield and quality. The twin head system also improved the fruit grades in 'Bodega' by increasing the percentage of fruit in medium size while reducing the percentage of fruit in small size. Cucumber plant growth, yield and yield components were better under staking than no staking and best with 5 meter raised platform staking method since the number of leaves, flowering, pollination and fruiting were well enhanced due to better display to sunlight (Okonmah, 2011). Wire training and leaving three second lateral branches unpinched yielded a greater number of harvested fruits and higher marketable yields than the other training methods and training methods appeared suitable for forcing cucumber culture (Hirama *et al*., 2011)

Other cucurbits

The pointed gourd plants were left to trail over the ground (control) or were trained over dried bamboo bushes, or over 1 or 1.5m high bamboo supports. The best plant growth and the highest yield (146.15 q/ha) were obtained on 1m supports. The control yield was 57.46 q/ha (Prasad and Singh, 1987). Sharma *et al.* (1988) observed that in field trials with bottle gourd cultivar Pusa Summer Prolific Long lowest numbers of female flowers, branches and fruits and ultimately the lowest yield per plant were recorded in treatment where branching on the main shoot was allowed from the ninth to fifteenth node.

Yadav *et al.* (1989) reported that in pointed gourd highest yield of 136.3 q/ha was obtained at the closer spacing with the bower system. Joshi *et al.* (1994) reported that bower training system was economically feasible in bitter gourd (*Momordica charantia* L.) as compared to ground, bush system on dry cotton plant, kniffen system of training. Joshi *et al.* (1995) observed that the incidence of *Dacus*

cucurbitae on *Momordica charantia* was lowest in bower system of training as compared to bush, kniffin and ground training systems during kharif season.

The percentage of increase in yield over the ground training system was 71.83, 200.65 and 243.80% in the bush, kniffin and bower systems, respectively, which was attributed to low incidence of pests and diseases in bitter gourd (Bhokare and Ranpise, 2004) Solangi *et al.* (2009) observed that staking in ridge gourd and sponge gourd gave 30-35% increase in yield and also insect pest protection. Hilli *et al.* (2009) reported that in ridge gourd telephone method of trailing with higher dose of fertilizers recorded significantly more vine length, number of leaves dry matter, higher fruit and seed yield compared to other levels of fertilizer without trailing.

Bower system of training recorded profuse growth, in respect of length of vine, leaves, and branches per plant, leaf area as well as number of nodes and internodal length with longer and dark green fruits, maximum number of fruits per vine (30.46) and highest yield of marketable fruits (78.25 q ha^{-1}) as compared with ground system (22.76 q ha^{-1}) in bitter gourd (Bhokare and Ranpise, 2010). Ranpise *et al.* (2010) reported that in bitter gourd, bower system of training were recorded significantly less infestation of fruit fly and significantly minimum incidence of anthracnose, powdery mildew, and downy mildew and recorded more number of fruits per plant, longer and dark green fruits with maximum yield. It was found superior over ground, bush and kniffin system of training.

2.5 Economics of cultivation

Greenhouse technology is quite feasible and cost effective after 4-5 years of cultivation. The construction of greenhouse costs more during the first year (More and Chandra, 1998). According to Chandra *et al.* (2000) the cost of construction of a

polyhouse in a 1000m^2 area comes to Rs 7 lakh. The net income comes to 10/m^2/season. In a polyhouse tomato, capsicum and cucumber can be grown profitability. The cost benefit ratio of cucumber cultivation under the Israeli greenhouse system was worked out as 1:1.13, whereas the cost benefit ratio for the Indian greenhouses was 1:2.06 under New Delhi conditions of India (Singh and Kumar, 2004). Singh *et al.* (2004) reported that cultivation of summer squash under low tunnels early in season is highly profitable with a cost benefit ratio of 1:3.96. The initial and total cost of production under low tunnels is very less as compared to its cultivation under greenhouse or walk in tunnels. The cost benefit ratio of musk melon and summer squash comes as 1: 3.98 and 1:3.96 in their off season cultivation under plastic low tunnels (Singh *et al.*, 2005). According to Singh *et al.* (2005) the cost benefit ratio of year round cucumber production under the greenhouse was 1:2.29 and the cost of green house was 500/m^2 under New Delhi condition.

Munshi and Kumar (2007) reported that under optimum conditions in low cost polyhouse, cucumber Pusa Sanyog and summer squash Pusa Alankar can give a net return of Rs 63 and Rs 23/m^2/season. The cost benefit ratio of cucumber cultivation under greenhouse was worked out as 1:2.29 under New Delhi conditions of India. It was concluded that the low cost naturally ventilated greenhouses are more suitable and economical for year round cucumber cultivation for northern plains of India (Singh *et al.*, 2007). Singh and Hasan (2008) opined that naturally ventilated greenhouses are simple and medium cost greenhouses which can be erected with a cost of Rs 600-700/m^2 and these greenhouses can be used successfully and efficiently for growing year round parthenocarpic cucumber, off season musk melon, tomato and sweet pepper crops. In India the cost of commercial greenhouse ranged from 150/m^2 for simple plastic tunnel type greenhouse to aluminium framed, polycarbonate cladded, fully automated climate controlled system costing Rs 5000/m^2 or even more (Sirohi, 2008).

Materials and Methods

3. MATERIALS AND METHODS

The present investigation was carried out in the Department of Olericulture, College of Horticulture, Vellanikkara during 2009 with the objective of studying the feasibility of off season production of cucumber in rain shelter, to identify an ideal variety for protected cultivation and also to study the comparative performance of crops in rain shelter and open field.

3.1. EXPERIMENTAL SITE

3.1.1 Location

The site is located at $10^0$31 'N latitude and $76^0$13' E longitude and at an altitude of 22.25m above mean sea level.

3.1.2 Climate and soil

The area experiences a typical warm humid tropical climate and receives an average rainfall of 3400mm per year. The soil of the experimental site comes under the textural class of sandy clay loam and is acidic in reaction. The materials used and methods followed are presented below.

3.1.3 Season

The experiment was carried out in two seasons *viz*., February to May 2009 and June to August 2009 (off seasons) under two growing conditions (rain shelter and open field).

3.2. MATERIALS

3.2.1 Protected structure

A low cost rain shelter (gable shape) constructed in the Department of Olericulture was used for study (Plate 1). The frame of the rain shelter was made up

Plate 1. Rain shelter

of G. I pipes. Cladding was provided with UV stabilized low density polyethylene film (UVLDPE) of 200 micron thickness. The floor area was 100m^2 (20m X 5m) with a side height of 2m and central height of 3.5m. The four sides of the rain shelter are open and naturally ventilated.

3.2.2 Varieties

Three varieties of cucumber were used for the study (Plate 2). The details of varieties are given in Table 1.

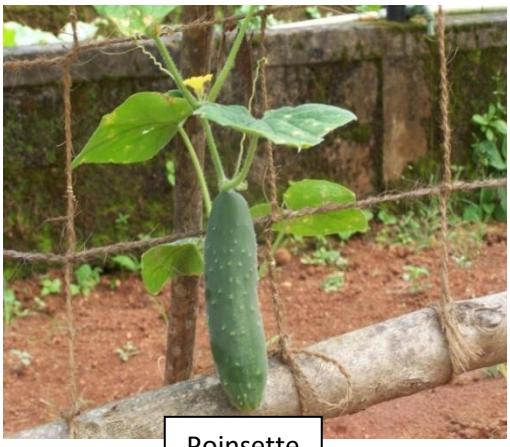
Table 1. Name of varieties and their sources

Sl No	Variety	Sources
1	Poinsette	National Seeds Corporation, New Delhi
2	AAUC-2	Assam Agricultural University, Jorhat
3	Kuruppamthara Local	Kerala Agricultural University, Vellanikkara

3.3. METHODS

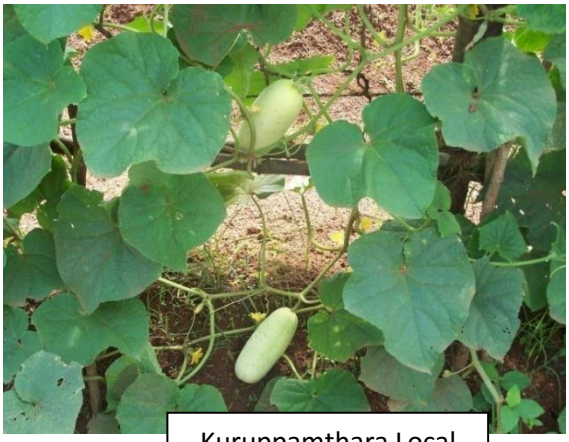
3.3.1 Layout and experimental design

The experiment was laid out in randomized block design with three replications. There were six plants per replication. The size of plot was 3m^2. Each plot comprised of two furrows at a spacing of 2m and in each furrow there were three plants at a spacing of 50cm.



Poinsette

AAUC-2



Kuruppamthara Local

Plate 2. Varieties

Open field

Rain shelter

Plate 3. General view of the growing conditions

3.4.CULTURAL OPERATIONS

3.4.1 Preparation of main field and sowing

The experimental field (open field and rain shelter) was cleared thoroughly before sowing. Furrows were taken 2m apart in each plot. Farm yard manure @ 25t/ha was incorporated at the time of land preparation. Seeds were sown in furrows at a spacing of 50cm. Gap filling was done within ten days after sowing (Plate 3).

3.4.2 Fertilizer application and after cultivation

Urea, superphosphate and potash were the source materials for supplying nutrients N, P_2O_5, and K_2O respectively. These nutrients were mixed based on the package of practices recommendation 70:25:25kg/ha. Half dose of N and full dose of P_2O_5 and full dose of K_2O were applied as basal dose and remaining half dose of N was applied in two equal split doses at the time of vining and full blooming. Intercultural operations were done inside the rain shelter and in open field, as per package of practices recommendation (KAU, 2007).

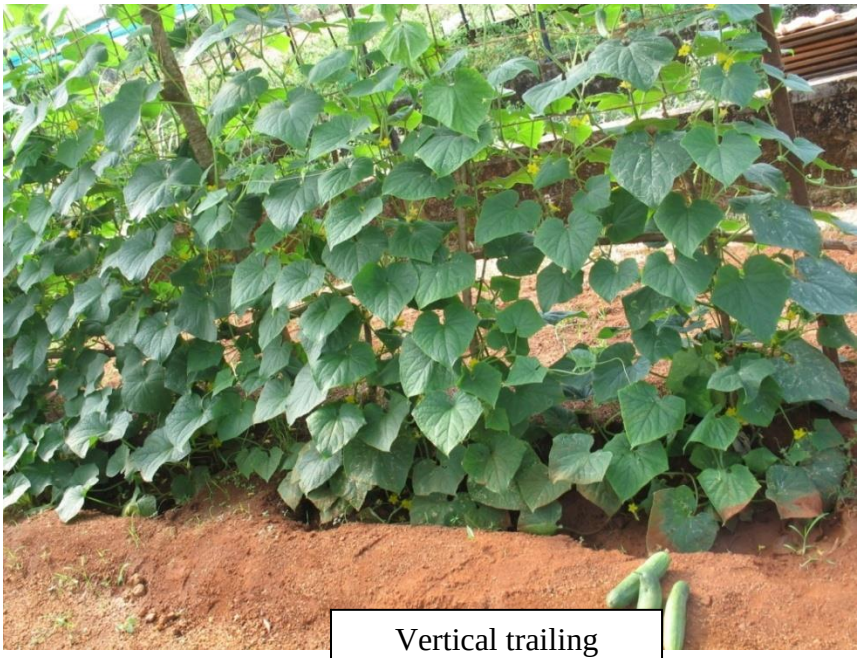
3.4.3 Trailing

Vertical trailing with coir and bamboo poles and horizontal trailing on branches and plant twigs were practiced both in rain shelter and open field during the two seasons (Plate 4). Pruning or pinching of the branches was not done.

3.4.4 Plant protection

Plant protection measures were taken as per the package of practices recommendation (KAU, 2007). Plants severely attacked by mosaic disease were uprooted and destroyed. Cracked fruits were also discarded.

Plate 3. General view of the growing conditions



Vertical trailing

Horizontal trailing

Plate 4. Horizontal trailing and vertical trailing

3.4.5 Harvesting

Harvesting was started when fruit reached optimum size but still tender. Observations were recorded only from marketable fruits.

3.5 BIOMETRICAL OBSERVATIONS

Five plants per replication of each treatment were selected for recording observations. Five fruits were randomly selected from each replication for recording observations on fruit characters.

3.5.1 Vegetative characters

a. Length of main vine (m)

Plants were pulled out after final harvest and length of main vine was measured from collar region of the plant to the tip of main vine. Length of vine was measured in metre.

b. Branches per plant

Number of branches originating from the main vine was counted at final harvest after pulling out plants.

3.5.2 Reproductive characters

a. Days to first male flower opening

Number of days was counted from the date of sowing to the date when the first male flower opened.

b. Days to first female flower opening

Number of days was counted from the date of sowing to the date when the first female flower opened.

c. Node at which first female flower emerged

Nodes were counted from the lowest one, at which first female flower emerged.

d. Days to first harvest

The number of days taken from sowing to first harvest at tender fruit was recorded.

e. Duration of crop

Days were counted from date of sowing to the date of last harvest was recorded.

f. Number of harvest

Total number of harvests made from each replication till the end of crop was recorded and mean was calculated.

g. Fruits per plot

The number of fruits per plot per replication was recorded and mean was worked out.

h. Yield per plot (kg)

Weights of fruits harvested from each plot at different dates were recorded separately. These were added to get total yield per plot.

i. Average fruit weight (g)

Weight of five fruits obtained from five plants in each replication was observed and average was calculated.

j. Fruit length (cm)

Length of five fruits obtained from five plants in each replication was recorded separately and average was calculated.

k. Fruit girth (cm)

Girth of five fruits from obtained five plants in each replication was recorded separately and average was calculated.

l. Flesh thickness (cm)

The flesh thickness of five fruits obtained from five plants in each replication was recorded separately and average was calculated.

m. Number of seeds per fruit

Fruits were harvested after full maturity and number of seeds per fruit was counted.

n. Biotic factors (incidence of pest and diseases)

Observations on the incidence of major pests and diseases *viz.*, damping off, mosaic, downy mildew, fruit fly and pumpkin beetle were recorded. The percentage of pest and disease incidence was calculated using the following formula.

$$\text{Percentage of pest/disease incidence} = \frac{\text{Number of plants affected by the pest/disease}}{\text{Total number of plants}} \times 100$$

3.6. METEOROLOGICAL OBSERVATIONS

The minimum and maximum temperature were observed daily using thermometer and relative humidity using dry and wet bulb thermometer in both growing conditions. Rainfall data was collected from the Agromet observatory of the college of Horticulture, Vellanikkara.

3.7 ECONOMICS OF CULTIVATION

Economics of production was worked out for the rain shelter crop and open field for both seasons. Total return was estimated with realized yield. Benefit: cost ratio of each crop under both growing conditions was worked out for comparison.

3.8 STATISTICAL ANALYSIS

The data recorded on vegetative characters and reproductive characters were statistically analysed by using statistical package (MSTAT-C) (Freed, 1986).

Results

4. RESULTS

The observations recorded on various growth and yield characters during the experimental period were statistically analyzed and the results are presented below.

4.1. SUMMER SEASON

4.1.1. VEGETATIVE CHARACTERS

4.1.1.1 Vine length (m)

Maximum vine length was recorded in AAUC-2 (4.52m) followed by Poinsette (3.11m) and Kuruppamthara Local (2.68m) when grown in rain shelter. In the open field also vine length was maximum in AAUC-2 (3.39m) followed by Poinsette (2.48m) and Kuruppamthara Local (2.30m). The differential response of trailing method over growing condition was recorded. In the open field horizontally trailed Poinsette had a vine length of 2.93m and was significantly different from vertically trailed Poinsette (2.02m) (Table 2).

4.1.1.2 Branches per plant

AAUC-2 recorded maximum number of branches (27.75) inside the rain shelter followed by Kuruppamthara Local (17.06) and Poinsette (10.51). In the open field also AAUC-2 recorded maximum number of branches (17.65) followed by Kuruppamthara Local (12.66) and Poinsette (9.69). The differential response of trailing method over growing condition was recorded. In the open field, horizontally trailed Poinsette recorded maximum number of branches (14.17) and was significantly different from vertically trailed Poinsette (5.22) (Table 3).

Table 2. Length of main vine (m) during summer season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	2.70	4.41	2.73	3.28	2.93	3.66	2.09	2.89
Vertical trailing	3.53	4.62	2.63	3.59	2.02	3.12	2.52	2.55
Mean	3.11	4.52	2.68	3.44	2.48	3.39	2.30	2.72
CD (1)	0.60							
CD (2)	0.49							
CD (3)	0.85							

Table 3. Branches per plant during summer season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	8.10	27.66	17.13	17.63	14.17	16.40	11.66	14.08
Vertical trailing	12.92	27.84	17.00	19.25	5.22	18.91	13.66	12.59
Mean	10.51	27.75	17.06	18.44	9.69	17.65	12.66	13.33
CD (1)	4.83							
CD (2)	3.95							
CD (3)	6.84							

(1) -CD performance of varietal means within polyhouse/openfield

(2) - CD performance of horizontal/vertical trailing within polyhouse/openfield

(3) - CD performance of varietal means within polyhouse/openfield and trailing methods

4.1.2. REPRODUCTIVE CHARACTERS

4.1.2.1 Days to first male flower opening

Poinsette took minimum days (31.11) to first male flower opening inside the rain shelter followed by AAUC-2 (35.80) and Kuruppamthara Local (47.73). In the open field Kuruppamthara Local took minimum days (32.58) to first male flower opening. Varieties Poinsette and AAUC-2 was on par with Kuruppamthara Local (32.58) with mean values 32.93 and 33.30 respectively. The differential response of trailing method over growing condition was recorded. In the open field, horizontally trailed Poinsette took 30.26 days and was significantly different from vertically trailed Poinsette (35.06) (Table 4).

4.1.2.2 Days to first female flower opening

Poinsette was early (35.41) to open female flowers inside the rainshelter followed by AAUC-2 (40.88) and Kuruppamthara Local (53.23). In the open field varieties Kuruppamthara Local (37.25) and AAUC-2 (38.28) were on par with Poinsette (37.16). The differential response of trailing method over growing condition was recorded. In the open field, vertically trailed Kuruppamthara Local was late to flower (40.08) and was significantly different from horizontally trailed variety (34.41)(Table 5).

4.1.2.3 Node at which first female flower emerged

Lowest number of node at which first female flower emerged was noticed in the variety Poinsette (5.26) followed by AAUC-2 (10.16) and Kuruppamthara Local (11.16) inside the rain shelter but in the open field both Poinsette (6.59) and AAUC-2 (6.45) was on par followed by Kuruppamthara Local (9.37). There was no significant difference between trailing methods under both growing conditions. In

Table 4. Days to first male flower opening during summer season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	31.05	35.98	48.66	38.56	30.26	34.11	31.16	31.84
Vertical trailing	31.18	35.63	46.80	37.87	35.06	32.50	34.00	34.03
Mean	31.11	35.80	47.73	38.22	32.93	33.30	32.58	32.94
CD (1)	3.37							
CD (2)	2.75							
CD (3)	4.77							

Table 5. Days to first female flower opening during summer season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	35.96	40.65	53.60	43.40	37.00	39.27	34.41	36.81
Vertical trailing	34.86	41.11	52.86	42.94	37.33	37.30	40.08	38.24
Mean	35.41	40.88	53.23	43.17	37.16	38.28	37.25	37.56
CD (1)	3.58							
CD (2)	2.93							
CD (3)	5.07							

(1) - CD performance of varietal means within polyhouse/openfield

(2) - CD performance of horizontal/vertical trailing within polyhouse/openfield

(3) - CD performance of varietal means within polyhouse/openfield and trailing method

the open field horizontally trailed Kuruppamthara Local (5.91) and was significantly different from vertically trailed one (12.83) (Table 6).

4.1.2.4 Days to first harvest

During summer season, the days to first harvest was prolonged inside the rain shelter. Variety Poinsette took minimum number of days to first harvest (43.83) followed by AAUC-2 (50.83) and Kuruppamthara Local (62.00). In the open field Kuruppamthara Local took minimum number of days (47) for first harvest. AAUC-2 (49) was on par with Poinsette (48.33). The differential response of trailing method over growing condition was recorded. Vertically trailed AAUC-2 was early to first harvest (44.33) than horizontally trailed one (53.66) and values were significantly different (Table 7).

4.1.2.5 Duration of crop

AAUC-2 had maximum duration inside the rain shelter (89.33) followed by Kuruppamthara Local (87.55) and Poinsette (79.50). In the open field Poinsette showed minimum crop duration (81.83). Kuruppamthara Local (84.50) was on par with AAUC-2 (85.50). The differential response of trailing method over growing condition was recorded. Rain shelter grown vertically trailed AAUC-2 had maximum crop duration (92.00). Horizontally trailed Poinsette grown inside rain shelter showed maximum crop duration of 86.66 and was significantly superior over vertically trailed Poinsette (72.33) (Table 8).

4.1.2.6 Number of harvest

AAUC-2 had maximum number of harvest (11.16) inside the rain shelter, followed by Kuruppamthara Local (9.33) and Poinsette (9.0). In the open field, three varieties were on par. There was no significant difference between different trailing methods under two growing conditions (Table 9).

Table 6. Node at first female flower emerged during summer season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	5.5	10.63	11.0	9.04	7.43	6.35	5.91	6.56
Vertical trailing	5.03	9.69	11.33	8.68	5.75	6.55	12.83	8.38
Mean	5.26	10.16	11.16	8.86	6.59	6.45	9.37	7.47
CD (1)	2.62							
CD (2)	2.14							
CD (3)	3.70							

Table 7. Days to first harvest during summer season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	43.33	51.66	63.00	52.67	46.66	53.66	46.00	48.77
Vertical trailing	44.33	50.00	61.00	51.77	50.00	44.33	48.00	47.44
Mean	43.83	50.83	62.00	52.22	48.33	49.00	47.00	48.11
CD (1)	2.70							
CD (2)	2.20							
CD (3)	3.82							

(1) –CD performance of varietal means within polyhouse/openfield

(2) - CD performance of horizontal/vertical trailing within polyhouse/openfield

(3) – CD performance of varietal means within polyhouse/openfield and trailing methods

Table 8. Duration of crop during summer season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	86.66	86.66	87.00	86.77	81.66	87.00	85.00	84.55
Vertical trailing	72.33	92.00	88.00	84.11	82.00	84.00	84.00	83.33
Mean	79.50	89.33	87.50	85.44	81.83	85.50	84.50	83.94
CD (1)	3.66							
CD (2)	2.99							
CD (3)	5.18							

Table 9. Number of harvest during summer season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	9.00	11.00	9.00	9.66	11.00	11.33	11.66	11.33
Vertical trailing	9.00	11.33	9.66	10.00	10.33	12.00	9.66	10.66
Mean	9.0	11.16	9.33	9.83	10.66	11.66	10.66	11.00
CD (1)	1.57							
CD (2)	1.28							
CD (3)	2.23							

(1) –CD performance of varietal means within polyhouse/openfield

(2) - CD performance of horizontal/vertical trailing within polyhouse/openfield

(3) – CD performance of varietal means within polyhouse/openfield and trailing methods

4.1.2.7 Fruits per plot

Number of fruits per plot was maximum in the variety AAUC-2 (84.33) followed by Poinsette (67.16) and Kuruppamthara Local (42.50) inside the rain shelter. In the open field AAUC-2 produced maximum fruits per plot (68.33) followed by Poinsette (55.66) and Kuruppamthara Local (46.33). There was no significant difference between different trailing methods under two growing conditions (Table 10).

4.1.2.8 Yield per plot (kg)

Maximum yield per plot was obtained from the variety AAUC-2 (34.23kg) followed by Kuruppamthara Local (19.90kg) and Poinsette (15.58kg) inside the rain shelter. AAUC-2recorded maximum yield (25.77kg) followed by Kuruppanthara Local (15.62kg) and Poinsette (13.54kg) in the open field also. Horizontally trailed rain shelter grown AAUC-2 yielded 38.08kg tender fruits and was on par with vertically trailed rain shelter grown AAUC-2 (30.39kg) (Table 11).

4.1.2.9 Average fruit weight (g)

Variety Kuruppamthara Local recorded fruit weight of 481.66g followed by AAUC-2 (438.33g) and Poinsette (244.79g) inside the rain shelter. In the open field maximum average fruit weight was observed in the variety Kuruppamthara Local (431.25g) followed by AAUC-2 (425.0g) and Poinsette (255.5g). Inside the rain shelter horizontally trailed Poinsette recorded minimum fruit weight (222.92g) as compared to AAUC-2 (448.33) and Kuruppamthara Local (481.66). In the open field AAUC-2 recorded same fruit weight (425g) under two trailing methods (Table 12) and (Plate 5).

Table 10. Fruits per plot during summer season

Treatments	Rain shelter				Open field			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	63.00	89.66	43.00	65.22	62.66	69.00	49.33	60.33
Vertical trailing	71.33	79.00	42.00	64.11	48.66	67.66	43.33	53.22
Mean	67.16	84.33	42.50	64.66	55.66	68.33	46.33	56.77
CD (1)	23.72							
CD (2)	19.63							
CD (3)	33.54							

Table 11. Yield per plot (kg) during summer season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	13.73	38.08	19.75	23.85	15.87	27.41	14.42	19.23
Vertical trailing	17.42	30.39	20.05	22.62	11.22	24.13	16.82	17.39
Mean	15.58	34.23	19.90	23.23	13.54	25.77	15.62	18.31
CD (1)	6.95							
CD (2)	5.68							
CD (3)	9.84							

(1) –CD performance of varietal means within polyhouse/openfield

(2) - CD performance of horizontal/vertical trailing within polyhouse/openfield

(3)– CD performance of varietal means within polyhouse/openfield and trailing

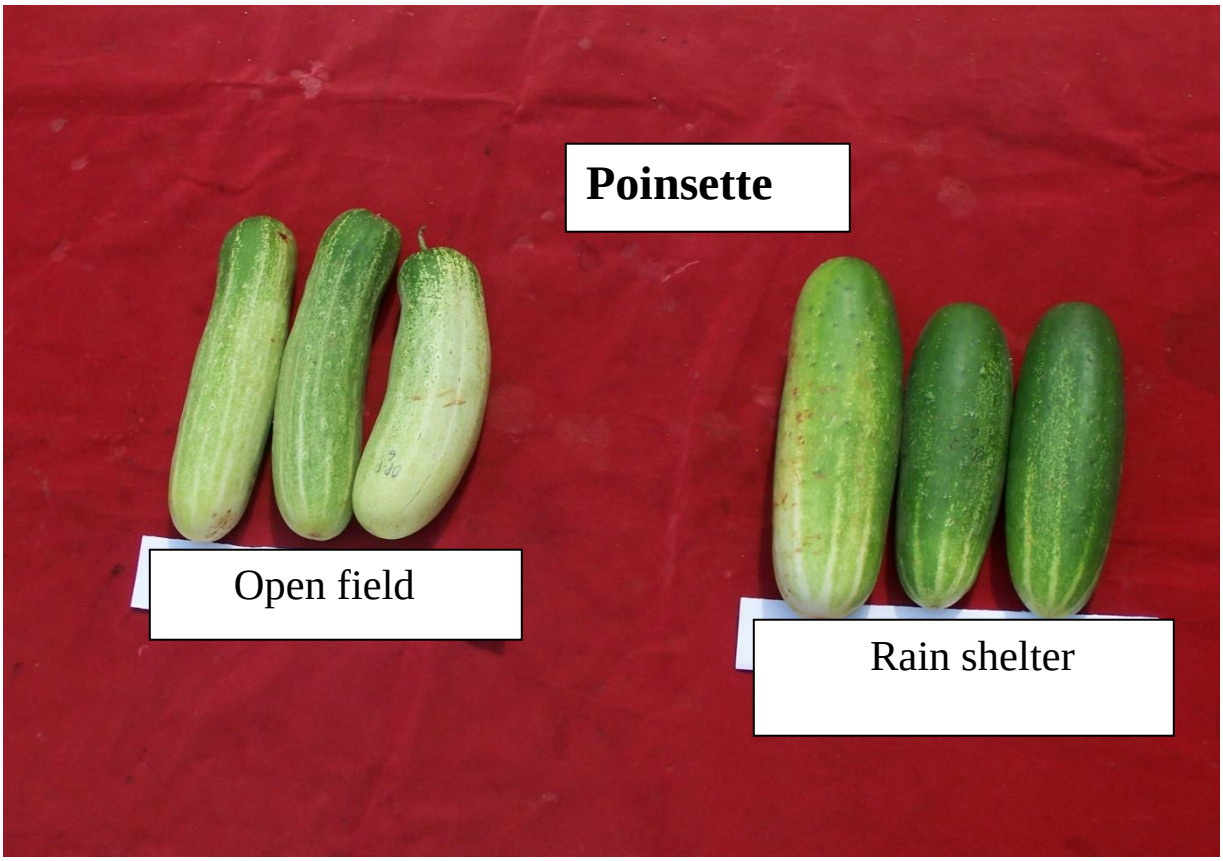


Plate 5. Poinsette inside the rain shelter and open field during summer season

4.1.2.10. Fruit length (cm)

Maximum fruit length was recorded by AAUC-2 (22.68cm) followed by Poinsette (18.86cm) and Kuruppamthara Local (18.67cm) inside the rain shelter. In the open field AAUC-2 produced fruits with maximum length (22.22cm) followed by Poinsette (19.25cm) and Kuruppamthara Local (17.75cm). Inside the rain shelter vertically trailed AAUC-2 produced longer fruits (23.50cm) as compared to horizontally trailed variety (21.86cm) (Table 13) and (Plate 6).

4.1.2.11 Fruit girth (cm)

Kuruppamthara Local produced fruits with maximum girth (22.51cm) followed by Poinsette (19.05cm) and AAUC-2 (18.71cm) inside the rain shelter. In the open field Poinsette (18.61cm) and AAUC-2 (18.80cm) was on par with Kuruppamthara Local (18.82cm). In the open field, vertically trailed Poinsette produced girth of 19.53cm and was significantly different from horizontally grown Poinsette (17.70cm) (Table 14) (Plate 7).

4.1.2.12 Flesh thickness (cm)

Maximum flesh thickness was noticed in Kuruppamthara Local (2.15cm) followed by AAUC-2(1.56cm) and Poinsette (1.21cm) inside the rain shelter. In the open field Kuruppamthara Local recorded maximum flesh thickness (2.03) followed by AAUC-2 (1.57cm) and Poinsette (1.20cm). Inside the rain shelter, vertically trailed Kuruppamthara Local had maximum fiesh thickness (2.15cm) followed by horizontally trailed variety (2.13cm). Kuruppamthara Local was superior over other varieties under two conditions and seasons (Table 15).

4.1.2.13 Number of seeds per fruit

AAUC-2 produced maximum number of seeds (371.66) inside the rain shelter followed by Kuruppamthara Local (355) and Poinsette (325). In the open

Table 12. Average fruit weight (g) during summer season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	222.92	448.33	481.66	384.30	256.67	425	420.83	367.5
Vertical trailing	266.67	428.33	481.66	392.22	254.33	425	441.67	373.67
Mean	244.79	438.33	481.66	388.26	255.5	425.0	431.25	370.58
CD (1)	43.27							
CD (2)	35.31							
CD (3)	61.18							

Table13. Fruit length (cm) during summer season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	18.83	21.86	18.68	19.79	19.26	22.60	17.61	19.82
Vertical trailing	18.90	23.50	18.66	20.35	19.23	21.85	17.90	19.66
Mean	18.86	22.68	18.67	20.07	19.25	22.22	17.75	19.74
CD (1)	1.14							
CD (2)	0.93							
CD (3)	1.61							

(1) - CD performance of varietal means within polyhouse/openfield

(2) - CD performance of horizontal/vertical trailing within polyhouse/openfield

(3) - CD performance of varietal means within polyhouse/openfield and trailing methods

Table 14. Fruit girth (cm) during summer season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	15.83	19.09	22.35	19.09	16.93	17.16	20.18	18.09
Vertical trailing	16.40	17.88	22.56	18.94	16.80	18.50	22.03	19.11
Mean	16.11	18.48	22.46	19.02	16.86	17.83	21.10	18.60
CD (1)	1.10							
CD (2)	0.90							
CD (3)	1.56							

Table 15. Flesh thickness (cm) during summer season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	1.16	1.59	2.13	1.63	1.2	1.58	1.96	1.58
Vertical trailing	1.26	1.54	2.16	1.65	1.2	1.56	2.10	1.62
Mean	1.21	1.56	2.15	1.64	1.2	1.57	2.03	1.60
CD (1)	0.071							
CD (2)	0.58							
CD (3)	0.10							

(1) –CD performance of varietal means within polyhouse/openfield

(2) - CD performance of horizontal/vertical trailing within polyhouse/openfield

(3) – CD performance of varietal means within polyhouse/openfield and trailing methods

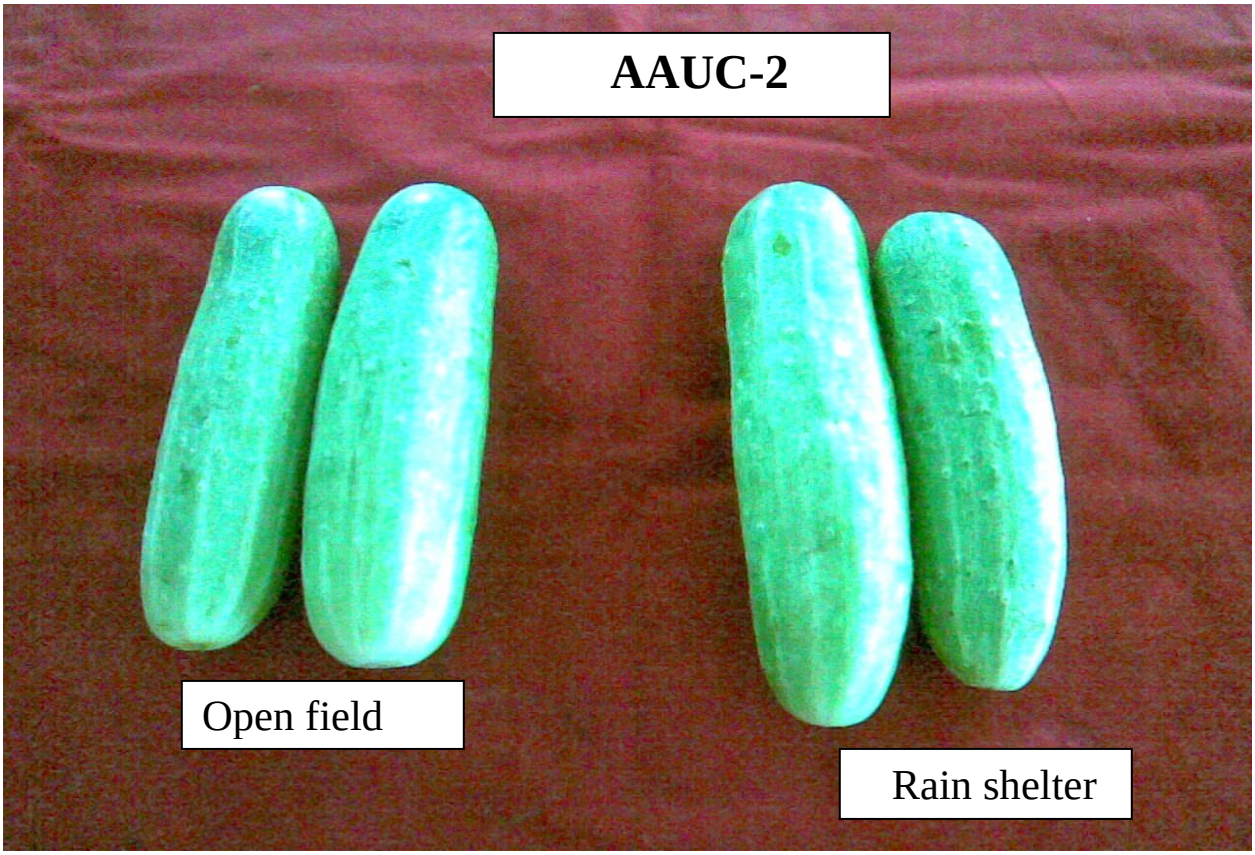


Plate 6. AAUC-2 inside the rain shelter and open field during summer season

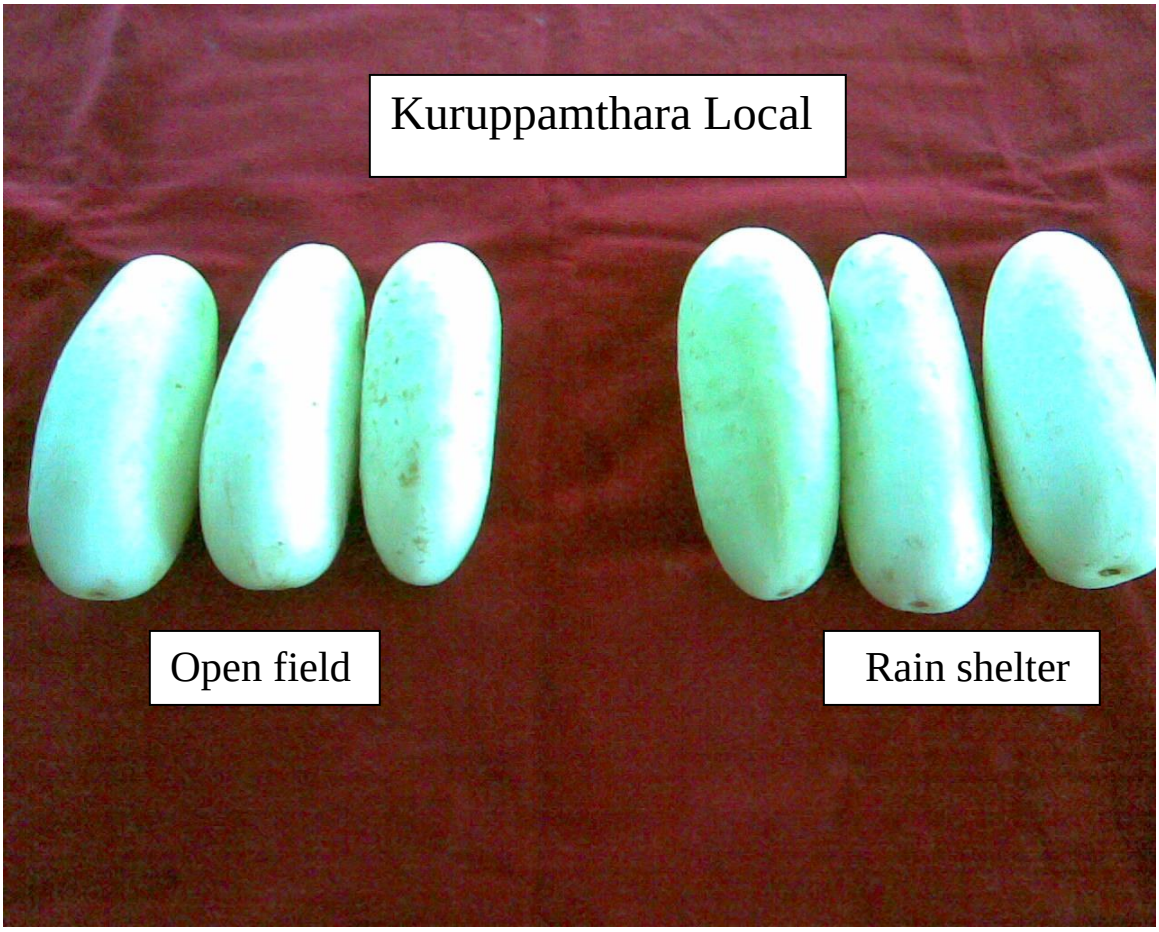


Plate7. Kuruppamthara Local inside the rain shelter and open field during summer season

field Poinsette produced maximum number of seeds (335.16) followed by AAUC-2 (315.83) and Kuruppamthara Local (271.66). Inside the rain shelter vertically trailed varieties produced maximum number of seeds (381.66) than horizontally trailed variety (319.44). Inside the rain shelter vertically grown AAUC-2 produced maximum seeds (436.66) and was significantly superior over horizontally trailed variety (306.66). In the open field vertically grown Kuruppamthara Local produced maximum seeds (303.33) and was significantly superior over horizontally trailed variety (240.00) (Table 16).

4.1.2.14 Incidence of pest and diseases

Pest incidence was minimum under two growing conditions. Some plants were infested by leaf miner and fruit flies towards the end of cropping season. The major diseases were damping off at early stage (seedling) and mosaic disease. During summer season, all the three varieties were infested by damping off and Kuruppamthara Local was infested more (11.76%) than Poinsette (7.69%) and AAUC-2 (4.5%) in the open field. Inside the rain shelter only Poinsette was affected by this disease (6.66%). Mosaic incidence was observed only in the rainshelter and Kuruppanthara Local was affected more (66.66%) than Poinsette (56.66%) and AAUC-2 (28.57) (Table 17).

Cracked fruits were also observed in both growing conditions. Poinseete produced cracked fruits more inside the rainshelter (7.19%) than open field crop (5.30%). AAUC-2 produced less cracked fruits inside the rainshelter (0.44) than open field (1.7) (Plate 10).

Table 16. No of seeds per fruit during summer season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	306.66	306.66	345.0	319.44	332.0	338.33	240.00	303.44
Vertical trailing	343.33	436.66	365.0	381.66	338.33	293.33	303.33	311.66
Mean	325.00	371.66	355.0	350.55	335.16	315.83	271.66	307.55
CD (1)	32.08							
CD (2)	26.19							
CD (3)	45.36							

(1) –CD performance of varietal means within polyhouse/openfield

(2) - CD performance of horizontal/vertical trailing within polyhouse/openfield

(3) – CD performance of varietal means within polyhouse/openfield and trailing methods

Table 17 Incidence of diseases and cracking

Variety	Damping off (%)	Bud necrosis like symptoms (%)	Cracking (%)
Poinsette (OP)	7.69	0	5.3
AAUC-2 (OP)	4.5	0	1.7
Kuruppamthara Local(OP)	11.76	0	2.15
Poinsette (RS)	6.66	56.66	7.19
AAUC-2 (RS)	0	28.57	0.44
Kuruppamthara Local(RS)	0	66.66	0.39

4.2 Weather data

Maximum temperature during summer season ranged from 33.2^{0}C to 36.4^{0}C inside the rainshelter and it was 30.8^{0}C to 37.0^{0}C in the open field. The minimum temperature range was 20.4^{0}C to 26.5^{0}C inside the rainshelter and 21.8^{0}C to 25.3^{0}C in the open field. Relative humidity (morning) ranged from 62.8% to 97% inside the rainshelter and in the open field it varied from 69% to 94%. The total rainfall during the summer season was 223.60mm (Table 18 and 19).

Table 18.Weather data during 2009 (February-April) inside the rain shelter

Standard week	Max. temp. ^{0}C	Min. temp. ^{0}C	RH(Morning) %
6	36.2	21.2	67
7	35.6	20.4	72.2
8	36.4	21.4	65.8
9	35.8	23.1	74
10	35	23.5	83
11	35.4	24.25	69.6
12	35.5	23.75	70.8
13	35.5	24	76.71
14	36	25.5	79.83
15	36	25	97
16	33.2	26.5	92
17	36	24	81
18	36	27	76
19	35.8	24.2	70.2
20	36	24.8	62.8
21	34.2	23.8	75.4
22	34.8	24	78

Table 19. Weather data during 2009 (February to April) in the open field

Standard week	Max. temp. ^{0}C	Min. temp. ^{0}C	RH(Morning) %	Rainfall (mm)
6	34.5	21.8	69	0
7	34.5	21.8	82	0
8	35.7	23.2	75	0
9	35.4	24.6	93	0
10	35	24.3	83	0
11	35.3	23.9	86	23.4
12	35.1	24.3	88	5.6
13	35.1	25.2	89	0
14	37	25.3	90	8.7
15	33.4	24.5	91	4.6
16	33	24.3	89	2.6
17	34.6	25.3	85	0
18	34.4	26	85	0.6
19	34.8	25.3	88	23
20	33	24.4	87	11
21	30.8	24.1	94	140.4
22	31.8	24.4	81	3.7

4.2. RAINY SEASON

4.2.1. VEGETATIVE CHARACTERS

4.2.1.1 Vine length (m)

Vine length of plant measured from the collar region to the tip was maximum in Kuruppamthara Local (2.40m) followed by AAUC-2 (1.48m) and Poinsette (0.82m) inside the rain shelter. The vine length of Kuruppamthara Local was 2.97m followed by AAUC-2 (1.99m) and Poinsette (0.88m) in the open field. The differential response of trailing method over growing condition was recorded. In the open field, vertically trailed AAUC-2 had a vine length of 2.75m and was significantly different from horizontally trailed AAUC-2 (1.23m). Vertically trailed Kuruppamthara Local had a vine length of 4.35m and was significantly different from horizontally trailed Kuruppamthara Local (1.58m). In the open field trailing methods were significantly different from each other, and vertically trailed plant produced maximum vine length (2.73m) as compared to horizontally trailed plant (1.16m). Inside the rain shelter no significant difference was noticed between trailing methods (Table 20).

4.2.1.2 Branches per plant

Kuruppamthara Local recorded maximum number of branches (19.04) inside the rain shelter followed by AAUC-2 (8.80) and Poinsette (1.70). In the open field also Kuruppamthara Local recorded maximum number of branches (10.60) followed by AAUC-2 (6.24) and Poinsette (0.80). Inside the rain shelter, horizontal trailing (10.85) was superior over vertical trailing (8.84), but in the open field horizontal trailing (5.27) was on par with vertical trailing (6.49). The differential response of trailing method over growing condition was recorded. In the open field, vertically trained Kuruppamthara Local produced 12.41 numbers of branches and was significantly different from horizontally trailed variety (8.79). Horizontally trailed

Table 20. Length of main vine (m) during rainy season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	0.96	1.69	2.40	1.68	0.67	1.23	1.58	1.16
Vertical trailing	0.68	1.28	2.40	1.45	1.10	2.75	4.35	2.73
Mean	0.82	1.48	2.40	1.57	0.88	1.99	2.97	1.95
CD (1)	0.369							
CD (2)	0.30							
CD (3)	0.52							

Table 21. Branches per plant during rainy season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	2.41	11.10	19.04	10.85	0.80	6.22	8.79	5.27
Vertical trailing	1.0	6.50	19.04	8.84	0.80	6.26	12.41	6.49
Mean	1.70	8.80	19.04	9.84	0.80	6.24	10.60	5.88
CD (1)	2.17							
CD (2)	1.77							
CD (3)	3.07							

(1) - CD performance of varietal means within polyhouse/openfield

(2) - CD performance of horizontal/vertical trailing within polyhouse/openfield

(3) - CD performance of varietal means within polyhouse/openfield and trailing methods

AAUC-2 recorded maximum number of branches (11.10) inside the rain shelter and was significantly superior over vertically trained AAUC-2 (6.50) (Table 21).

4.2. REPRODUCTIVE CHARACTERS

4.2.2.1 Days to first male flower opening

Poinsette took minimum days (38.43) to first male flower opening inside the rain shelter followed by AAUC-2 (41.06) and Kuruppamthara Local (48.73). In the open field also Poinsette took minimum days (38.62) to first male flower opening followed by AAUC-2 (41.41) and Kuruppamthara Local (47.14). The differential response of trailing method over growing condition was recorded. Inside the rain shelter, horizontally trailed Poinsette took 34.66 days and was significantly different from vertically trailed Poinsette (42.20). In the open field vertically trained AAUC-2 took minimum days to first male flower opening (39.33) and was statistically significant from horizontally trailed variety (43.50) but variety Poinsette took maximum days to produce male flower under vertical trailing (40.00) as compared to horizontal trailing (37.25) (Table 22).

4.2.2.2 Days to first female flower opening

Poinsette took minimum days (45.51) to first female flower opening inside the rain shelter followed by AAUC-2 (46.52) and Kuruppamthara Local (53.27). In the open field also Poinsette took minimum days (45.75) to first female flower opening followed by AAUC-2 (47.90) and Kuruppamthara Local (53.55). The differential response of trailing method over growing condition was recorded. In the open field, vertically trailed AAUC-2 took 44.37 days and was significantly different from horizontally trailed variety (51.43). Inside the rain shelter, horizontally trailed Poinsette took 42.02 days and was significantly different from vertically trailed Poinsette (49.00). No significant difference was noticed between the trailing methods under both the conditions (Table 23).

Table 22. Days to first male flower opening during rainy season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	34.66	42.80	48.50	41.98	37.25	43.50	47.05	42.60
Vertical trailing	42.20	39.33	48.96	43.50	40.00	39.33	47.23	42.18
Mean	38.43	41.06	48.73	42.74	38.62	41.41	47.14	42.39
CD (1)	2.77							
CD (2)	2.26							
CD (3)	3.92							

Table 23. Days to first female flower opening during rainy season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	42.02	48.66	53.35	48.01	44.0	51.43	53.80	49.74
Vertical trailing	49	44.37	53.20	48.85	47.50	44.37	53.55	48.39
Mean	45.51	46.52	53.27	48.43	45.75	47.90	53.55	49.06
CD (1)	4.80							
CD (2)	3.92							
CD (3)	6.80							

(1) - CD performance of varietal means within polyhouse/openfield

(2) - CD performance of horizontal/vertical trailing within polyhouse/openfield

(3) - CD performance of varietal means within polyhouse/openfield and trailing method

4.2.2.3 Node at which first female flower emerged

Lowest number of node at which first female flower emerged was noticed in the variety Poinsette (5.50) followed by AAUC-2 (6.89) and Kuruppamthara Local (13.52) inside the rain shelter. In the open field also Poinsette recorded minimum number of node (7.0) and was followed by Kuruppamthara Local (8.75) and AAUC-2 (9.66). No significance difference was noticed between trailing methods under both growing conditions. Inside the rain shelter maximum value was noticed in horizontally trailed Kuruppamthara Local (14.54) but in the open field horizontally trailed AAUC-2 recorded maximum value (10.08) for female flower opening (Table 24).

4.2.2.4 Days to first harvest

During rainy season, variety AAUC-2 took minimum number of days to first harvest (52.82) followed by Poinsette (56.01) and Kuruppamthara Local (60.86) inside the rain shelter. In the open field also same pattern was observed, AAUC-2 took minimum number of days to first harvest (56.82) followed by Poinsette (56.52) and Kuruppamthara Local (65.0). The differential response of trailing method over growing condition was recorded. Vertically trailed AAUC-2 took lowest number of days for first harvest (54.25) and horizontally trailed AAUC-2 took 59.40 days to first harvesting and values were significantly different. No significant difference was noticed between the trailing methods under both the conditions. Inside the rain shelter, horizontally trailed Poinsette (52.50) took minimum days to first harvest and significantly superior over Kuruppamthara Local (61.76) and AAUC-2 was on par with Kuruppamthara Local with a value of 53.90. In the open field, horizontally trailed varieties were significantly different from each other (Table 25).

Table 24. Node at first female flower emerged during rainy season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	5.52	7.79	14.54	9.28	7.50	10.08	9.0	8.86
Vertical trailing	5.47	6.0	12.50	7.99	6.50	9.25	8.50	8.08
Mean	5.50	6.89	13.52	8.63	7.0	9.66	8.75	8.47
CD (1)	5.16							
CD (2)	4.21							
CD (3)	7.31							

Table 25. Days to first harvest during rainy season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	52.50	53.90	61.76	56.05	52.55	59.40	65.00	58.98
Vertical trailing	59.53	51.75	59.95	57.07	60.50	54.25	65.00	59.91
Mean	56.01	52.82	60.86	56.56	56.52	56.82	65.00	59.44
CD (1)	5.94							
CD (2)	4.85							
CD (3)	8.40							

(1) - CD performance of varietal means within polyhouse/openfield

(2) - CD performance of horizontal/vertical trailing within polyhouse/openfield

(3) - CD performance of varietal means within polyhouse/openfield and trailing methods

4.2.2.5 Duration of crop

Kuruppamthara Local variety showed maximum crop duration inside rain shelter (79.04) and under open field also (88.0), than other two varieties. Inside the rain shelter AAUC-2 (72.57) was on par with Kuruppamthara Local followed by Poinsette (69.26). In the open field both Poinsette and AAUC-2 were significantly different from Kuruppamthara Local (88). The differential response of trailing method over growing condition was recorded. Rain shelter grown horizontally trailed Kuruppanthara Local showed maximum crop duration (84.75) than vertically trailed Kuruppamthara Local (73.33). In the open field, Kuruppamthara Local recorded same value under two trailing systems (88) followed by AAUC-2 under horizontally trailed condition (81.40) and was significantly different from vertically trailed condition (68.50) (Table 26).

4.2.2.6 Number of harvest

Inside the rain shelter, AAUC-2 recorded highest number of harvest (7.50) followed by Kuruppamthara Local (5.00) and Poinsette (4.0) but in the open field Kuruppamthara Local recorded maximum number of harvests (10.0) followed by AAUC-2 (8.5) and Poinsette (2.50). Inside the rain shelter horizontally trailed cucumber variety showed highest number of harvests (6.66) and was significantly different from vertically trailed varieties (4.33). But in the open field horizontally trailed cucumber varieties (6.66) were on par with vertically trailed varieties (7.33). Rain shelter grown horizontally trailed Kuruppamthara Local showed maximum number of harvests (7.00) and significantly different from vertically trailed Kuruppamthara Local (3.00) but in the open field vertically trailed Kuruppamthara Local (12.50) was superior over horizontally trailed Kuruppamthara Local (7.50) (Table 27).

Table 26. Duration of crop during rainy season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	65.0	73.40	84.75	74.38	62.50	81.40	88.0	77.30
Vertical trailing	73.53	71.75	73.33	72.87	68.50	68.50	88.0	75.0
Mean	69.26	72.57	79.04	73.62	65.50	74.95	88.0	76.15
CD (1)	7.03							
CD (2)	5.74							
CD (3)	9.94							

Table 27. Number of harvest during rainy season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	4.50	8.50	7.0	6.66	3.0	9.50	7.50	6.66
Vertical trailing	3.50	6.50	3.0	4.33	2.0	7.50	12.50	7.33
Mean	4.0	7.50	5.0	5.5	2.5	8.5	10.0	7.0
CD (1)	1.96							
CD (2)	1.60							
CD (3)	2.77							

(1) - CD performance of varietal means within polyhouse/openfield

(2) - CD performance of horizontal/vertical trailing within polyhouse/openfield

(3) - CD performance of varietal means within polyhouse/openfield and trailing methods

4.2.2.7 Fruits per plot

AAUC-2 produced maximum number of fruits per plot (25.75) inside the rain shelter followed by Kuruppamthara Local (19.25) and Poinsette (8.50). But in open field maximum number of fruits per plot was produced by Kuruppamthara Local (59.75) followed by AAUC-2 (28.25) and Poinsette (9.50). Horizontally trailed cucumber varieties produced more number of fruits (24.16) per plot as compared to vertically trailed varieties (11.50) inside the rain shelter but in the open field vertically trailed varieties produced more number of fruits (37.16) as compared to horizontally trailed varieties (27.83). Inside the rain shelter horizontally trailed AAUC-2 produced more number of fruits per plot (34.50) as compared to vertically trailed AAUC-2 (17.0). But in the open field AAUC -2 produced almost equal number of fruits under horizontally trailing (28.50) and vertically trailing (28.00). Vertically trailed Kuruppamthara Local produced more number of fruits per plot (73.50) as compared to horizontally trailed (46.0) in the open field (Table 28).

4.2.2.8 Yield per plot (kg)

Maximum yield per plot was obtained from the variety AAUC-2 (9.76kg) followed by Kuruppamthara Local (8.0kg) and Poinsette (0.98kg) inside the rain shelter whereas in the open field Kuruppanthara Local recorded maximum yield (22.85kg) followed byAAUC-2 (9.40kg) and Poinsette (0.50kg). Vertically trailed Kuruppamthara Local yielded 26.27kg fruits in the open field and horizontally trailed rain shelter grown AAUC-2 yielded 13.11kg tender fruits. Inside the rainshelter horizontally trailed varieties had highest yield (8.55) than vertically trailed varieties (3.94kg). Inside the rain shelter horizontally trailed AAUC-2 (13.11kg) was on par with Kuruppamthara Local (11.41kg) and significantly different from Poinsette (1.15kg) (Table 29).

Table 28. Fruits per plot during rainy season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	9.50	34.50	28.50	24.16	9.00	28.50	46.0	27.83
Vertical trailing	7.50	17.0	10.0	11.50	10.0	28.0	73.50	37.16
Mean	8.50	25.75	19.25	17.83	9.50	28.25	59.75	32.50
CD (1)	8.94							
CD (2)	7.30							
CD (3)	12.64							

Table 29. Yield per plot (kg) during rainy season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	1.15	13.11	11.41	8.55	0.46	9.71	19.43	9.87
Vertical trailing	0.81	6.42	4.58	3.94	0.53	9.10	26.27	11.97
Mean	0.98	9.76	8.0	6.25	0.50	9.40	22.85	10.92
CD (1)	4.24							
CD (2)	3.48							
CD (3)	6.01							

(1) - CD performance of varietal means within polyhouse/openfield

(2) - CD performance of horizontal/vertical trailing within polyhouse/openfield

(3) - CD performance of varietal means within polyhouse/openfield and trailing methods

4.2.2.9 Average fruit weight (g)

Variety AAUC-2 recorded maximum fruit weight (471.25g) followed by Kuruppamthara Local (467.5g) and Poinsette (221.25g) inside the rain shelter. In the open field maximum fruit weight was noticed in horizontally trailed Kuruppamthara Local (490.0g) and significantly different from AAUC-2(379.16g) and Poinsette (182.5g), inside the rain shelter horizontally trailed AAUC 2 (465.0g) was on par with Kuruppamthara Local (477.50g) and significantly superior over Poinsette (237.50g) (Table 30).

4.2.2.10. Fruit length (cm)

Maximum fruit length was produced by AAUC-2 (23.74cm) followed by Kuruppamthara Local (18.09cm) and Poinsette (16.33cm) inside the rain shelter. In the open field AAUC-2 produced fruits with maximum length (21.82cm) followed by Kuruppamthara Local (17.82cm) and Poinsette (14.78cm). Inside the rain shelter horizontally trailed AAUC-2 produced longer fruits (24.14cm) as compared to vertically trailed variety (23.35cm). (465.0g) was on par with Kuruppamthara Local (477.50g) and significantly superior over Poinsette (237.50g) (Table 31) and (Plate 8).

4.2.2.11 Fruit girth (cm)

Kuruppamthara Local produced fruits with maximum girth (21.32cm) followed by AAUC-2 (19.52cm) and Poinsette (16.91) inside the rain shelter. In the open field, Kuruppamthara Local (21.79cm) followed by AAUC-2 (18.28cm) and Poinsette (15.23cm). In the open field, vertically trailed Kuruppamthara Local produced fruits with maximum girth (21.93cm) followed by horizontally trailed one(21.65cm) (Table 32) and (Plate 9).

Plate 8. AAUC-2 inside the rain shelter and open field during rainy season

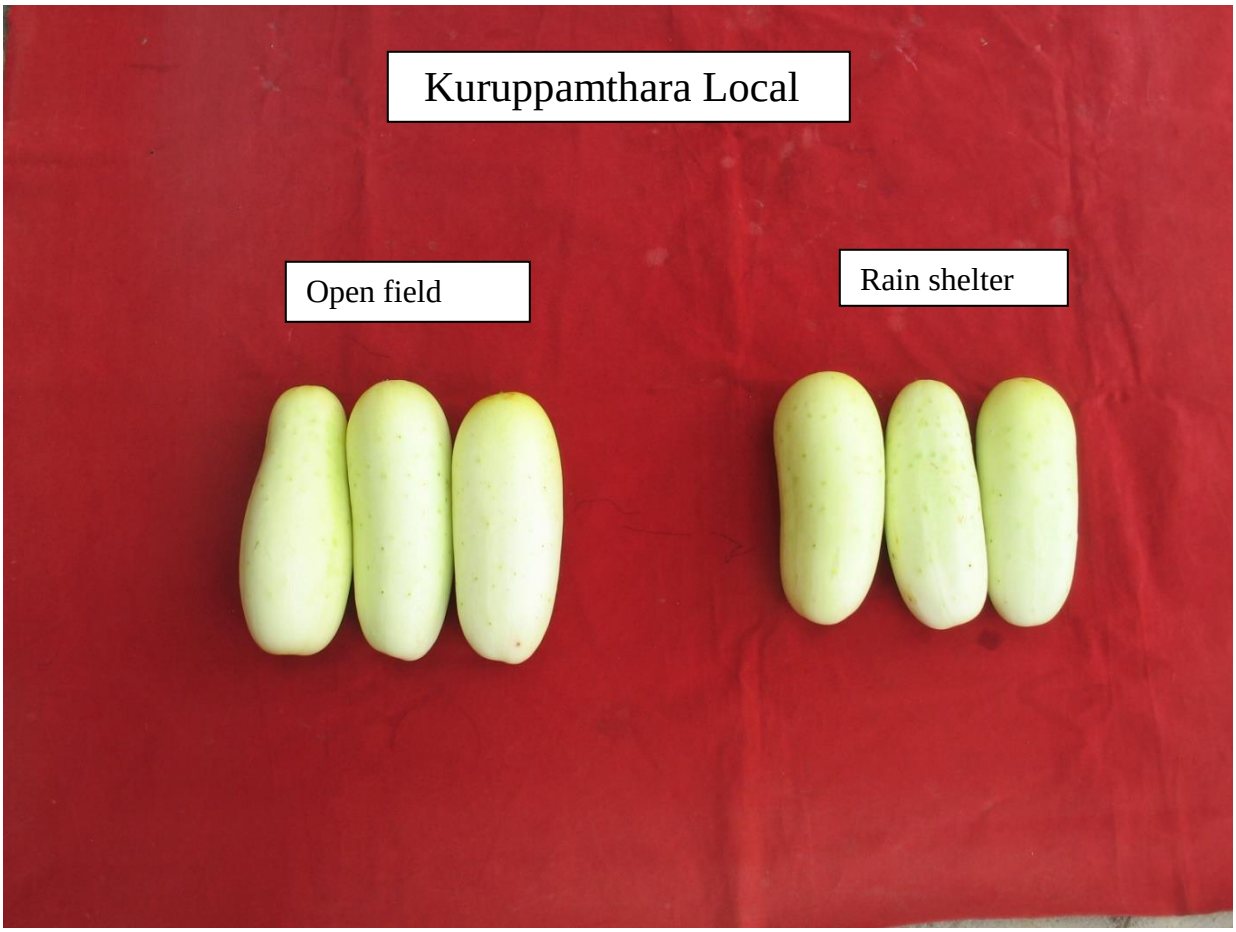


Plate 9. Kuruppamthara Local inside the rain shelter and open field during rainy season

Table 30. Average fruit weight during rainy season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	237.50	465.0	477.50	393.33	182.50	379.16	490.0	350.55
Vertical trailing	205.5	477.50	457.50	380.0	197.50	425.0	485.0	369.16
Mean	221.25	471.25	467.50	386.66	190.0	402.08	487.50	359.86
CD (1)	32.77							
CD (2)	26.75							
CD (3)	46.37							

Table 31. Fruit length (cm) during rainy season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	16.42	24.14	18.30	19.62	14.72	22.58	17.97	18.42
Vertical trailing	16.25	23.35	17.88	19.16	14.85	21.07	17.88	17.93
Mean	16.33	23.74	18.09	19.39	14.78	21.82	17.82	18.18
CD (1)	0.87							
CD (2)	0.71							
CD (3)	1.23							

(1) - CD performance of varietal means within polyhouse/openfield

(2) - CD performance of horizontal/vertical trailing within polyhouse/openfield

(3) - CD performance of varietal means within polyhouse/openfield and trailing method

4.2.2.12 Flesh thickness (cm)

Maximum flesh thickness was noticed in Kuruppamthara Local (2.10cm) followed by AAUC-2(1.55cm) and Poinsette (1.0cm) inside the rain shelter. In the open field Kuruppamthara Local recorded maximum flesh thickness (2.18cm) followed by AAUC-2 (1.53cm) and Poinsette (0.90cm). In the open field, horizontally trailed Kuruppamthara Local produced maximum girth fruits (2.20cm) and followed by vertically trailed variety (2.17cm) (Table 33).

4.2.2.13 Number of seeds per fruit

Kuruppamthara Local produced more number of seeds (453.75) inside the rain shelter followed by AAUC-2(447.75) and Poinsette (272.50). In the open field AAUC-2 produced maximum number of seeds (501.25) followed by Kuruppamthara Local (451.25) and Poinsette (228.75). There is no significant difference between trailing methods under both growing conditions. Inside the rain shelter horizontally trained AAUC-2 produced maximum number of seeds (573.0) than vertically trained AAUC-2 (322.50). In the open field vertically grown AAUC-2 produced seeds (500.0) and was on par with horizontally trailed variety (502.50) (Table 34).

4.2.2.14 Incidence of pest and diseases

Pest incidence was minimum during rainy season. Downy mildew and mosaic were two main diseases during rainy season. Mosaic severity was more during rainy season than summer season. Poinsette was more susceptible to mosaic inside the rain shelter (37.03%) and in the open field (27.27%). Inside the rain shelter AAUC-2 was least affected by mosaic (6.06%) and than open field (13.79%). During rainy season Kuruppamthara Local was not affected by mosaic under both conditions. Cracked fruits were also minimum in the rainy season (Table 35) and (Plate 11 to 13).

Table 32. Fruit girth (cm) during rainy season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	17.07	19.35	21.79	19.40	15.12	17.50	21.65	18.09
Vertical trailing	16.75	19.70	20.86	19.10	15.35	19.06	21.93	18.79
Mean	16.91	19.52	21.32	19.25	15.23	18.28	21.79	18.43
CD (1)	0.79							
CD (2)	0.64							
CD (3)	1.15							

Table 33. Flesh thickness (cm) during rainy season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	0.95	1.53	2.05	1.51	0.90	1.51	2.20	1.53
Vertical trailing	1.0	1.55	2.15	1.59	0.90	1.55	2.17	1.54
Mean	1.0	1.55	2.10	1.55	0.90	1.53	2.18	1.54
CD (1)	0.08							
CD (2)	0.07							
CD (3)	0.11							

(1) - CD performance of varietal means within polyhouse/openfield

(2) - CD performance of horizontal/vertical trailing within polyhouse/openfield

(3) - CD performance of varietal means within polyhouse/openfield and trailing methods

Table 34. No of seeds per fruit during rainy season

Treatments	**Rain shelter**				**Open field**			
	Poinsette	AAUC-2	Kuruppamthara Local	Mean	Poinsette	AAUC-2	Kuruppamthara Local	Mean
Horizontal trailing	240.0	573.0	415.0	409.33	235	502.50	435.0	390.83
Vertical trailing	305.0	322.50	492.0	373.33	222.50	500.0	467.50	396.66
Mean	272.50	447.75	453.75	391.33	228.75	501.25	451.25	393.75
CD (1)	56.22							
CD (2)	45.90							
CD (3)	79.52							

(1) - CD performance of varietal means within polyhouse/openfield

(2) - CD performance of horizontal/vertical trailing within polyhouse/openfield

(3) - CD performance of varietal means within polyhouse/openfield and trailing methods

Table 35. Incidence of mosaic diseases during rainy season

Variety	Mosiac (%)
Poinsette (OP)	27.27
AAUC-2 (OP)	13.79
Kuruppamthara Local(OP)	0
Poinsette (RS)	37.03
AAUC-2 (RS)	6.06
Kuruppamthara Local(RS)	0

Plate 10. Mosaic disease affected Poinsette during rainy season

Plate 11. Downy mildew affected crop

Plate 12. Mosaic disease in the open field

Plate 13. Cracked Poinsette fruits

4.2.2.15 Weather data

During rainy season maximum temperature inside the rain shelter ranged from 29.5^{0}C to 33.62^{0}C and minimum temperature ranged from 21 to 28.9^{0}C. In the open field maximum temperature ranged from 27.1^{0}C to 31.1^{0}C and minimum temperature range was 22.5^{0}C to 23.7^{0}C. Morning humidity ranged from 85% to 93.4% inside rain shelter and 92-96% in the open field. Total rainfall during the rainy season was 2083.0mm (Table 36 and 37).

4.3 Cost benefit ratio

During rainy season, inside the rain shelter, the total cost of cultivation was recorded as Rs 32 per m^2 and the total benefit was Rs 45 per m^2. Cost benefit ratio of rain shelter crop was 1:1.40. In the open field, the total cost for cultivation was recorded as RS 12 per m^{2}and the total benefit was Rs 72 per m^2 and cost benefit ratio of open field crop during rainy season was 1:6.0. During summer season, total benefit was Rs 165 per m^2 and cost benefit ratio inside the rain shelter was 1:5.15. In the open field, the total cost for cultivation was recorded as RS 15 per m^2 and the benefit was Rs 72 per m^2 and cost benefit ratio was calculated as 1:4.8 (Table 38).

Table 36.Weather data during 2009 (June to August) inside the rain shelter

Standard week	Max. temp. 0C	Min. temp. 0C	RH(Morning) %	Rainfall (mm)
23	29.8	23.7	95	33.6
24	31.1	24	92	45.7
25	29.7	23.5	95	120.9
26	29	23.1	95	160.2
27	27.1	22.5	96	221.3
28	28.8	23.2	95	184.9
29	27.6	22.7	96	371.5
30	30.7	23	94	40.5
31	29.7	23.2	96	133.2
32	30.9	23.5	95	30.9
33	30.3	23.5	95	107.6
34	30.3	22.7	95	189.6
35	29.1	22.9	96	106.8
36	28.5	23.2	96	110.8
37	31.1	23.6	93	0.2
38	30.2	23.2	94	70.8
39	30.5	23.1	94	54.5

Table 37. Weather data during 2009 (June to August) in the open field

Standard week	Max. temp. ^{0}C	Min. temp. ^{0}C	RH(Morning) %	RH(Noon) %
23	32.6	23	85	65
24	33.2	23.5	92	75
25	32	21.5	89	69
26	32.2	23	92	67
27	33.12	25	91.25	76.5
28	30	23.5	90.33	86.5
29	30	26	90	88
30	29.5	28.9	93.4	84
31	33.62	24.25	91.2	67.87
32	30.58	24.25	91	75
33	32.5	24	88.6	71.25
34	33.2	24	85	62
35	32	21	90	86
36	32.2	22.2	91.2	78.5
37	31	21.5	91.8	76.5
38	32.8	21	90.6	77.3
39	32.6	22.2	92.8	68.9

Table 38. Comparison of cost benefit ratio of the crops cultivated under rain shelter and open field during off seasons

	Rain shelter	Open field
Summer season	1:5.15	1:4.8
Rainy season	1:1.4	1:6.0

Discussion

5. DISCUSSION

Cucumber (*Cucumis sativus* L.) is an important salad vegetable grown throughout the world. It is considered as the fourth most important vegetable crop after tomato, cabbage and onion (Tatlioglu, 1993). Cucumber is one of the most preferred vegetables grown under protected condition in the developed world. It can be successfully cultivated in both low cost and high tech polyhouses.

Protected cultivation provides suitable microclimate for growth and development of plants, ensures year round production of vegetables, provides quality produce and is most suited to peri urban and urban cultivation. Popular protected cultivation structures include plastic or polyhouses, net houses, tunnels, rain shelter, controlled environment green houses and plastic mulches coupled with fertigation. Protected cultivation issues in India are breeding suitable varieties or hybrids of crops for protected cultivation, integrated pest management, good agricultural practices, low pressure fertigation, use of vegetable grafts, human resource development, intensification of research on protected cultivation, tools and machinery for protected cultivation, low cost structures for small and marginal farmers, post harvest handling of produce and waste management (Singh, 2012).

The present study entitled “Productivity of cucumber (*Cucumis sativus* L.) as influenced by seasons and growing systems” was attempted to identify the feasibility of off season production of cucumber in rain shelter, to identify ideal variety for protected cultivation and to study the comparative performance of crops in rain shelter and open field.

Results of the study are discussed under the following heads.

5.1 Influence of seasons and growing conditions on vegetative characters

5.2 Influence of seasons and growing conditions on reproductive characters

5.3 Influence of weather parameters on vegetative, reproductive characters and pest and disease incidence

5.4 Influence of trailing methods on vegetative, reproductive characters and pest and disease incidence

5.5 Economics of cultivation

5.1 Influence of seasons and growing conditions on vegetative characters

5.1.1 Length of main vine (m)

During summer season, AAUC-2 recorded maximum vine length (4.52m) inside the rain shelter and showed significant difference from Poinsette (3.11m) and Kuruppamthara Local (2.68m). In the open field also AAUC-2 performed well (3.39m) and was significantly differed from Poinsette (2.48m) and Kuruppamthara Local (2.30m). All the varieties recorded maximum vine length inside the rain shelter. This may be due to favourable microclimate inside the rain shelter. Mishra *et al.* (2003) reported the same result in greenhouse grown okra, Srichandan *et al.* (2006) in shadenet grown cauliflower and Thangam and Thamburaj (2008) in shadenet grown tomato.

During rainy season, Kuruppamthara Local recorded maximum vine length in the open field (2.97m) and rain shelter (2.40m) and was significantly differed from other two varieties under two growing conditions. Ahamed *et al.* (2004) that the maximum vegetative growth in terms of vine length and leaf number per plant in the cultivar Punjab Local under the agro climatic conditions of Rawalakot, Azad Jammu and Kashmir.

Vine length was more during summer season than rainy season. Cucumber prefers warm season and bright sunny days for growth and development. Plant height is a function of the number of nodes and length of each internode and both are

strongly influenced by temperatures. As the average temperature increases node number or also increases (Berghage, 1998) (Fig 1).

5.1.2 Branches per plant

AAUC-2 recorded maximum number of branches (27.75) inside the rain shelter and in the open field also (17.65). Both the values were significantly superior over other two varieties during summer season. Kuruppamthara Local produced more number of branches inside the rain shelter (19.04) and in the open field (10.60) during rainy season. Number of branches produced by the plants and vine length were highest inside rain shelter during summer seasons. Tallness of plants especially indeterminate type of growth habit led to more number of branches (Mehta *et al.*, 2010). Schoch (1972) explained that shading the plants increased cell division and cell expansion. Auxin concentration may increase under shade condition and result in increased plant height because of apical dominance. Apical dominance along with increased rate of cell division and cell enlargement greatly influence the plant height (Fig 2).

5.2 Influence of seasons and growing conditions on reproductive characters

5.2.1 Days to first male flower opening

During summer season Poinsette took minimum days (31.11) to first male flower opening and was significantly superior to AAUC-2 (35.80) and Kuruppamthara Local (47.73) inside rain shelter. But in the open field, three varieties *viz*., Poinsette (32.93), Kuruppamthara Local (32.58) and AAUC-2 (33.30) were on par. Open field grown AAUC-2 and Kuruppamthara Local produced first male flower within minimum days than rain shelter grown varieties. During rainy season also Poinsette produced male flower at minimum days (38.43) and was significantly superior over AAUC-2 (41.06) and Kuruppamthara Local (48.73) inside the rain shelter and in the open field also same pattern was observed. Abraham (2006)

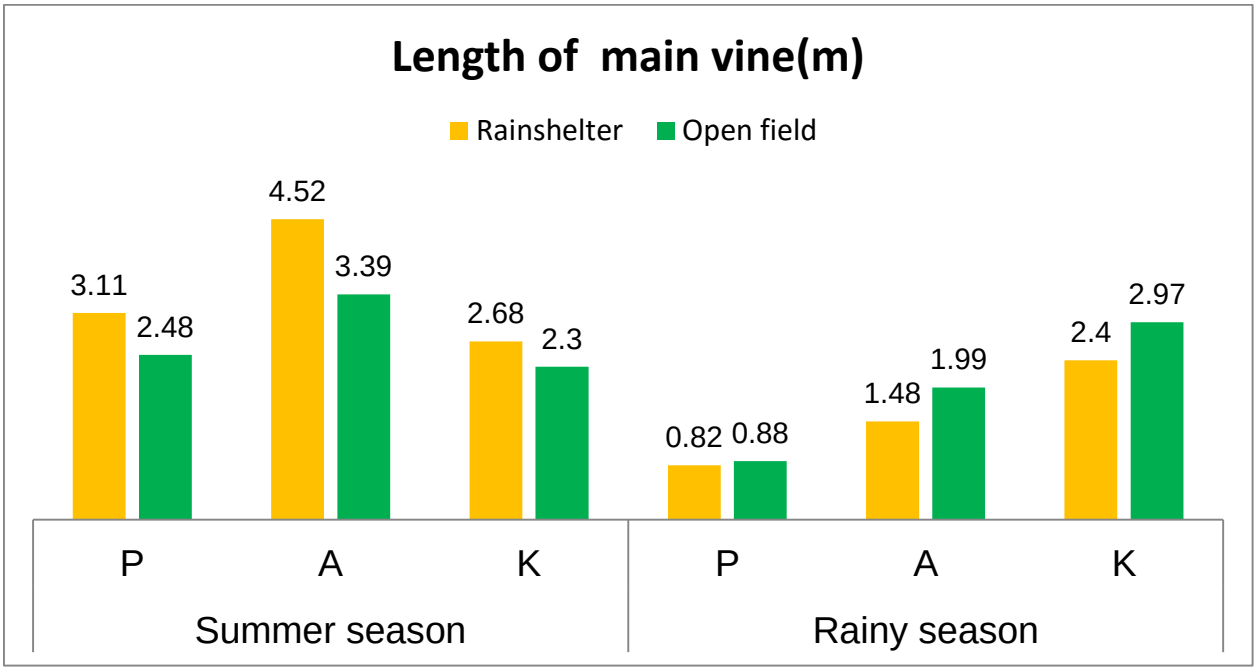


Fig 1. Comparison of main vine length (m) during summer and rainy season

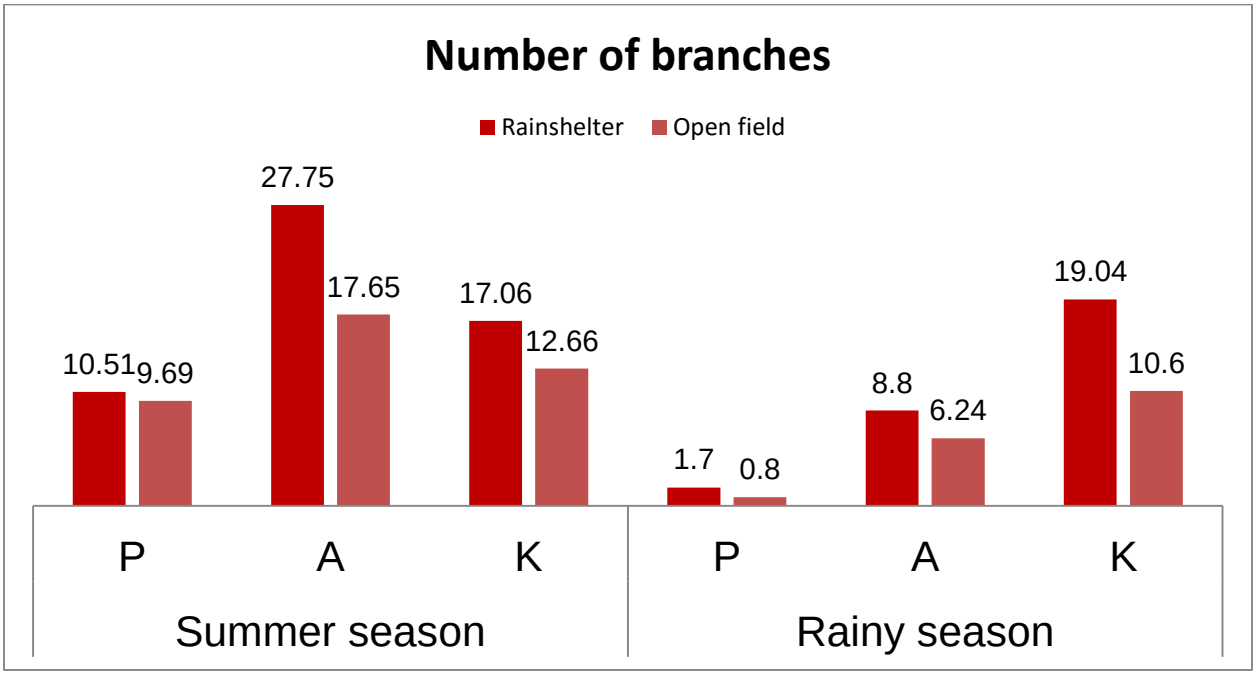


Fig 2. Comparison of number of branches per plant during summer and rainy season

reported that in AAUC-2 male flower emergence was late in summer season (41 days). During summer season, the varieties produced male flower earlier than rainy season. This may be due to the prevailing high temperature. But Kishore *et al.* (2010) reported in northern India kharif season crop flowered 10 days in advance than spring summer (Fig 3).

5.2.2 Days to first female flower opening

During summer season, Poinsette was early to form female flower both in the rain shelter (35.41) and open field (37.16). But AAUC-2 and Kuruppamthara Local were early in the open field (38.28 and 37.25 respectively) but late inside the rain shelter (40.88 and 53.23 respectively). In the open field, there was no significant difference between varieties. During rainy season also, Poinsette was early to form female flower both in rain shelter (45.51) and in the open field (45.75). AAUC-2 and Kuruppamthara Local recorded minimum days inside the rain shelter (46.52 and 53.27 respectively) than in the open field (47.90 and 53.55 respectively). Summer season grown crops took minimum days to form female flower than rainy season. During rainy season rain shelter grown crop took minimum days than open field. Chandra *et al.* (2000) observed that variety Poinsette took 48 days to flowering inside the polyhouse during winter season in northern India (Fig 4).

5.2.3 Node at which first female flower emerged

During summer season, Poinsette produced female flower at lowest node (5.26) inside the rain shelter and in the open field AAUC-2 produced female flower at lowest node (6.45). Inside the rain shelter, AAUC-2 recorded value of 10.16 and Kuruppamthara Local 11.16. In the open field Poinsette recorded 6.59 and Kuruppamthara Lcal 9.37 and there was significant difference between the varieties. During rainy season also, Poinsette recorded minimum value inside the rain shelter (5.50) and in the open field (7.0). In the open field AAUC-2 (9.66) and

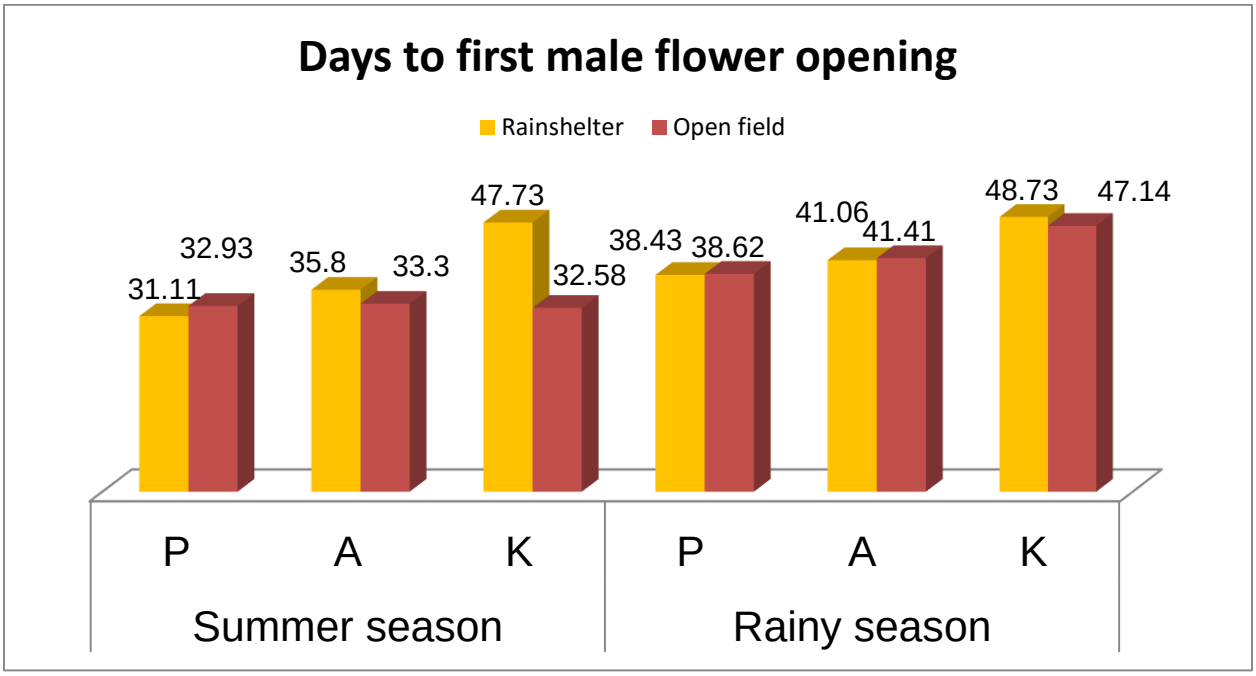


Fig 3. Comparison of days to first male flower opening during summer and rainy season

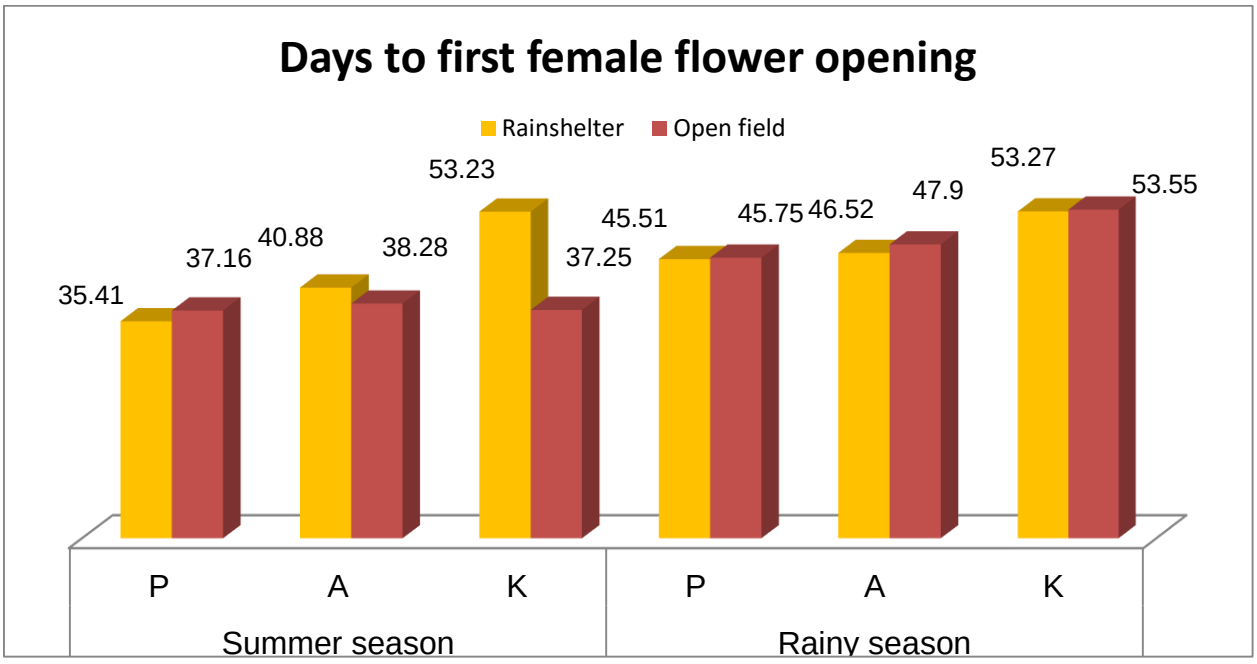


Fig 4. Comparison of days to first female flower opening during summer and rainy season

Kuruppamthara Local (8.75) was on par. Inside the rain shelter Poinsette was superior over AAUC-2 (6.89) and Kuruppamthara Local (13.52).

Summer season crop produced female flower at lowest node number than rainy season. In the open field Kuruppamthara Local produced female flower at lowest node during rainy season. Vegetative growth in terms of vine length and branches per plant were maximum for rainy season crop when compared to summer season crop. The prevailing high temperature during summer also caused early flower emergence in summer crop (Fig 5).

5.2.4 Days to first harvest

During summer season, Poinsette took minimum number of days to first harvest (43.83) inside the rain shelter and was significantly differed from AAUC-2 (50.83) and Kuruppamthara Local (62.0). But in the open field Kuruppamthara Local took minimum days (47.0) and AAUC-2 (49.0) and Poinsette (48.33) were on par. During rainy season, AAUC-2 took minimum number of days to first harvest (52.82) followed by Poinsette (56.01) and Kuruppamthara Local (60.86). In the open field Poinsette took minimum days (56.52) and AAUC-2 (56.82) was on par. Kuruppamthara Local took maximum days to first harvest (65.0). Poinsette was early to flower and harvest (Fig 6).

Expected earliness in cucumber in the plastic low tunnel technology is 30-35 days from the date of transplanting (Sidhu and Islam, 2008). Fast growth and development of crops under protected condition provide early harvest during off season due to which fruits fetch higher price in the market (Kumar *et al.,* 2009).

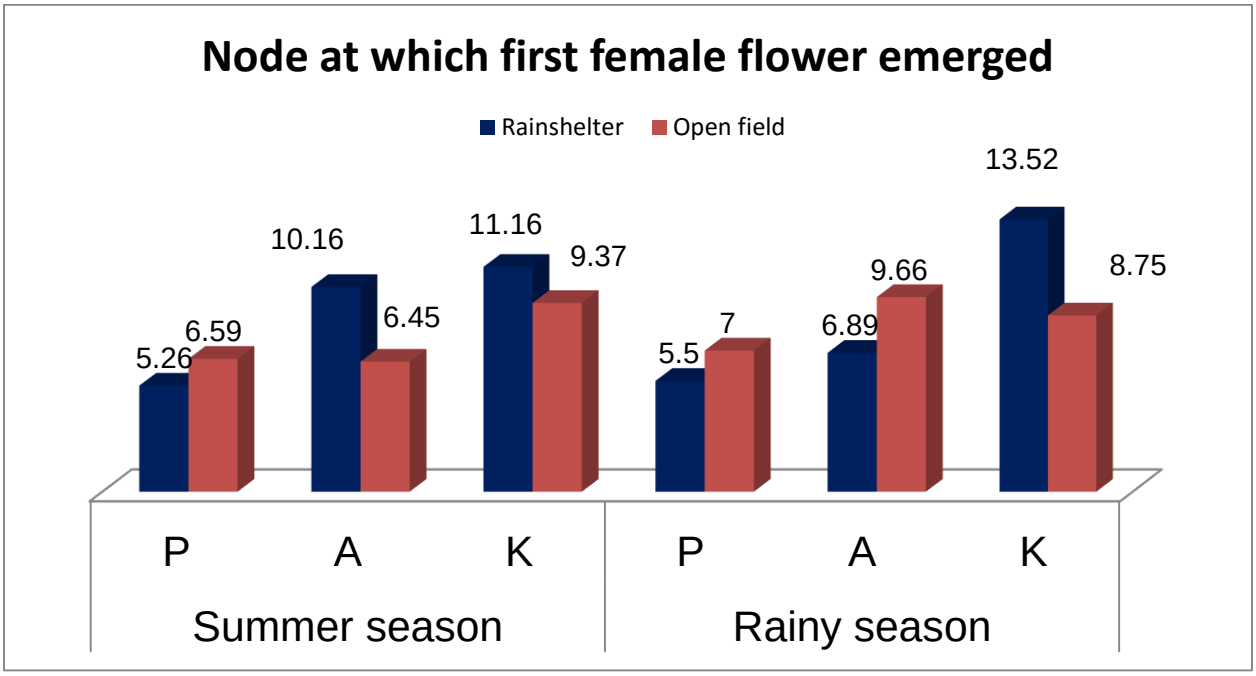


Fig 5. Comparison of node at which first female flower emerged during summer and rainy season

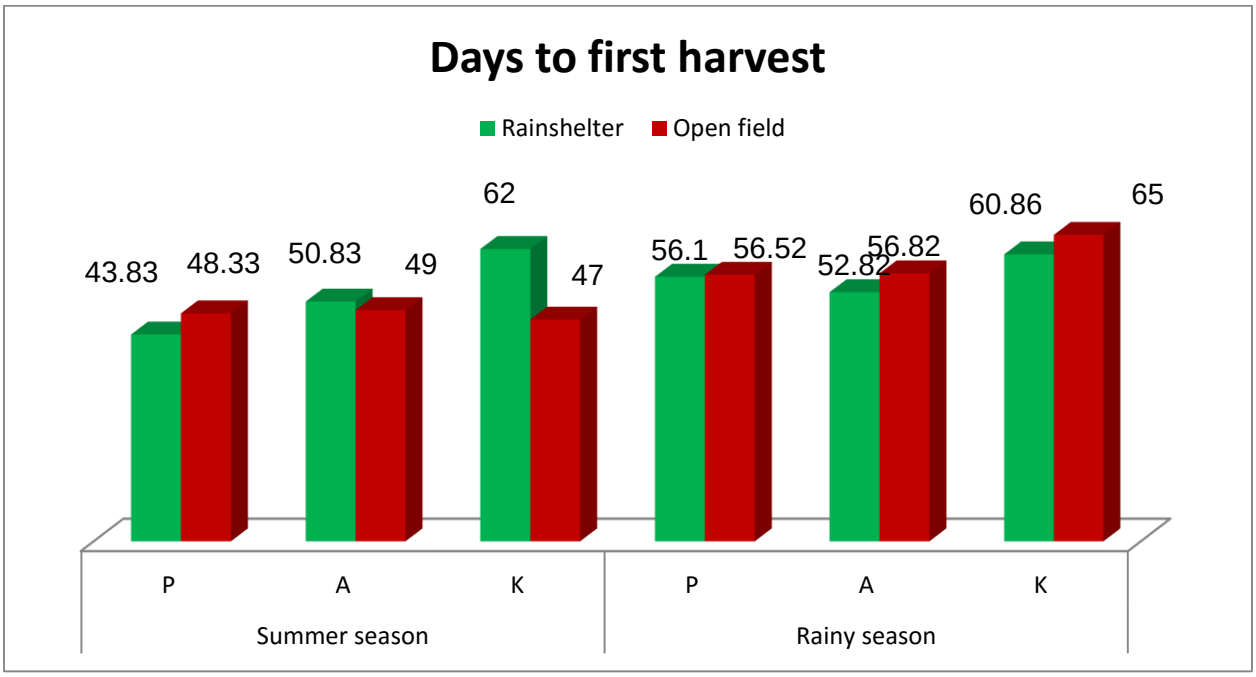


Fig 6. Comparison of days to first harvest during summer and rainy season

5.2.5 Duration of crop

AAUC-2 recorded maximum crop duration inside the rain shelter (89.33) and in the open field (85.50) during summer season. Abraham (2006) reported that AAUC-2 recorded maximum crop duration with 86.5 days in the open field. Kuruppamthara Local variety was on par with AAUC-2 inside the rain shelter (87.50) and in the open field (84.50) and significantly superior over Poinsette. During rainy season, Kuruppamthara Local showed maximum crop duration both in open field (88) and inside the rain shelter (79.04). In the rain shelter AAUC-2 (72.57) was on par with Kuruppamthara Local and significantly superior over Poinsette (69.26). In the open field Kuruppamthara Local was superior over other varieties. Rajput *et al.* (1991) reported that kharif season crop of a cucumber variety Pusa Sheetal matured in 92 days and summer crop in 65 days and Pusa Sheetal is suited for slopes receiving high rainfall (Fig 7).

Increased vine length in cucumber leads to longer harvest duration and more number of female flowers. Suitable environmental conditions in the greenhouse prolonged the reproductive phase and delayed the senescence of okra plants (Mishra *et al.*, 2003). Longer crop duration is desirable for continuous supply of fresh cucumber fruits to the market over long period and also avoids market glut.

5.2.6 Number of harvest

During summer season, AAUC-2 recorded maximum number of harvest inside rain shelter (11.16) and in the open field (11.66). Inside the rain shelter there was significant difference and AAUC-2 followed by Kuruppamthara Local (9.33) and Poinsette (9.0). But in the open field, there was no significant differenece and AAUC-2 was followed by Kuruppamthara Local and Poinsette with same value (10.66). During rainy season also AAUC-2 recorded maximum value (7.50) followed by Kuruppamthara Local (5.0) and Poinsette (4.0) and showed significance

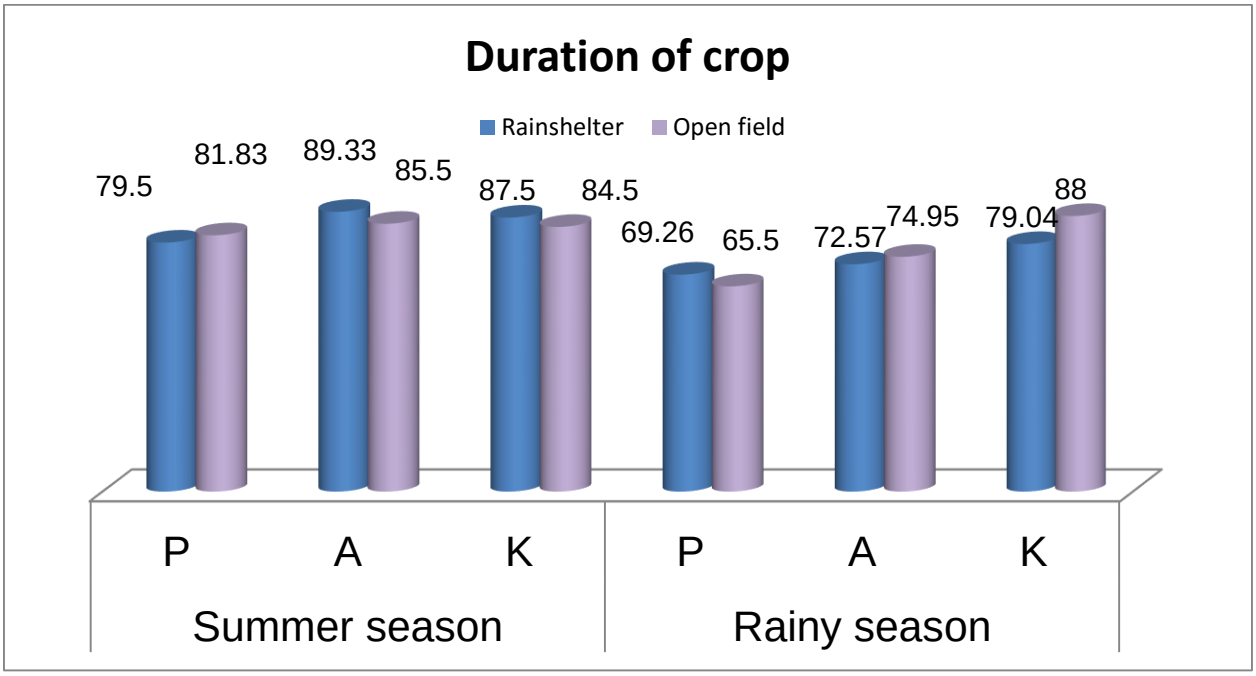


Fig 7. Comparison of duration of the crop during summer and rainy season

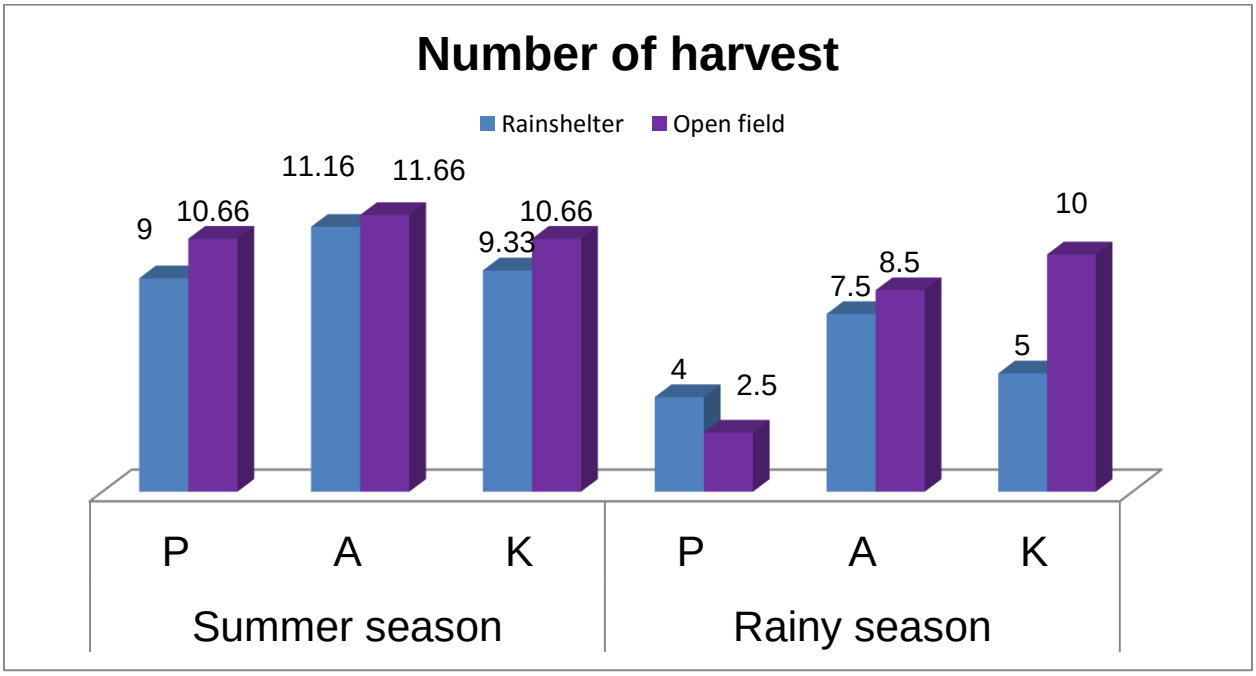


Fig 8. Comparison of number of harvests during summer and rainy season

difference inside rain shelter. But in the open field Kuruppamthara Local recorded maximum value (10.00) and was significantly different from Poinsette (2.50). Abraham (2006) reported maximum number of harvests for AAUC-2 (12.80) in open field (Fig 8).

Number of harvest was more in the summer season, than rainy season. This may be due to the longer reproductive phase during summer season when compared to the rainy season. Summer crop was early to form female flowers and also for harvesting. But in the rainy season, crop was having more vegetative phase than reproductive phase.

5.2.7 Fruits per plot

AAUC-2 recorded maximum number of fruits per plot inside the rain shelter (84.33) and in the open field (68.33) during summer season. Poinsette (67.16) was on par with AAUC-2 and Kuruppamthara Local showed significant difference with AAUC-2 inside rain shelter. But in the open field, there was no significant difference between other two varieties. During rainy season AAUC-2 recorded highest value inside the rain shelter (25.75) and Kuruppamthara Local (19.25) was on par with AAUC-2. In the open field, Kuruppamthara Local (59.75) was significantly superior over AAUC-2 (28.25) and Poinsette (9.50) (Fig 9).

The fruits per plot were more during summer season than rainy season, except open field grown Kuruppamthara local. This may be due to higher female flower production and fruit set during summer season. Jaksungnaro and Sema (2001) reported that March sown crop resulted best vegetative growth, fruit number and fruit yield for variety AAUC-2.

5.2.8 Yield per plot (kg)

AAUC-2 recorded maximum yield per plot inside the rain shelter (34.23kg) and in the open field (25.77kg) and significantly superior over other two varieties under two growing conditions during summer season. Saikia *et al.* (2001) reported that AAUC-2 recorded highest mean values for characters such as number of fruits per plant, fruit length, average fruit weight and yield per plant. AAUC-2 recorded maximum value inside the rain shelter (9.76kg) and Kuruppamthara Local was on par (8.0kg) and significantly superior over Poinsette (0.98kg) during rainy season. There is varietal difference in the performance during both seasons. In the open field Kuruppamthara Local recorded maximum value (22.85kg) and was superior over other varieties. Sharma *et al.* (2001) got higher yield under open field than greenhouse during rainy season. Early sowing of cucumber immediately after the onset of monsoon produced significantly highest fruit yield over the late sowings carried out after first, second and third week of monsoon onset (Yadav and Patil, 2008) (Fig 10).

Yield per plot was maximum in the summer season than rainy season, both in rain shelter and open field except Kuruppamthara Local. The higher yield of cucumber inside the greenhouse might be due to congenial temperature and microclimate for proper crop growth and development (Kumar *et al.,* 2009). He observed that diurnal variation of temperature is less inside the greenhouse as compared to open field condition. The increase in yield may be due to increased fruit length and girth, average fruit weight and number of fruits per vine. Prolonged period of harvest also contributed substantially towards the higher yield in greenhouse. Total yield and fruit yield per plant was highest in polyhouse grown tomato, chilli, brinjal, cluster bean and okra compared to open field grown crops (Kumar and Arumugam, 2010).

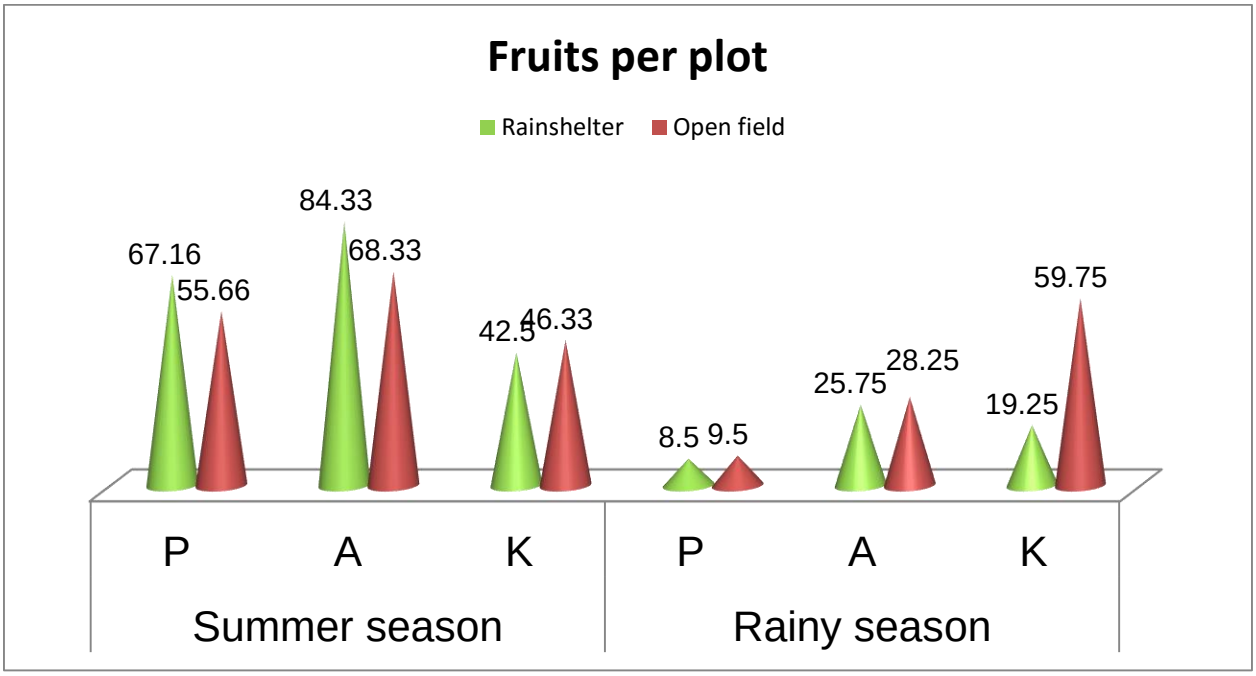


Fig 9. Comparison of fruits per plot during summer and rainy season

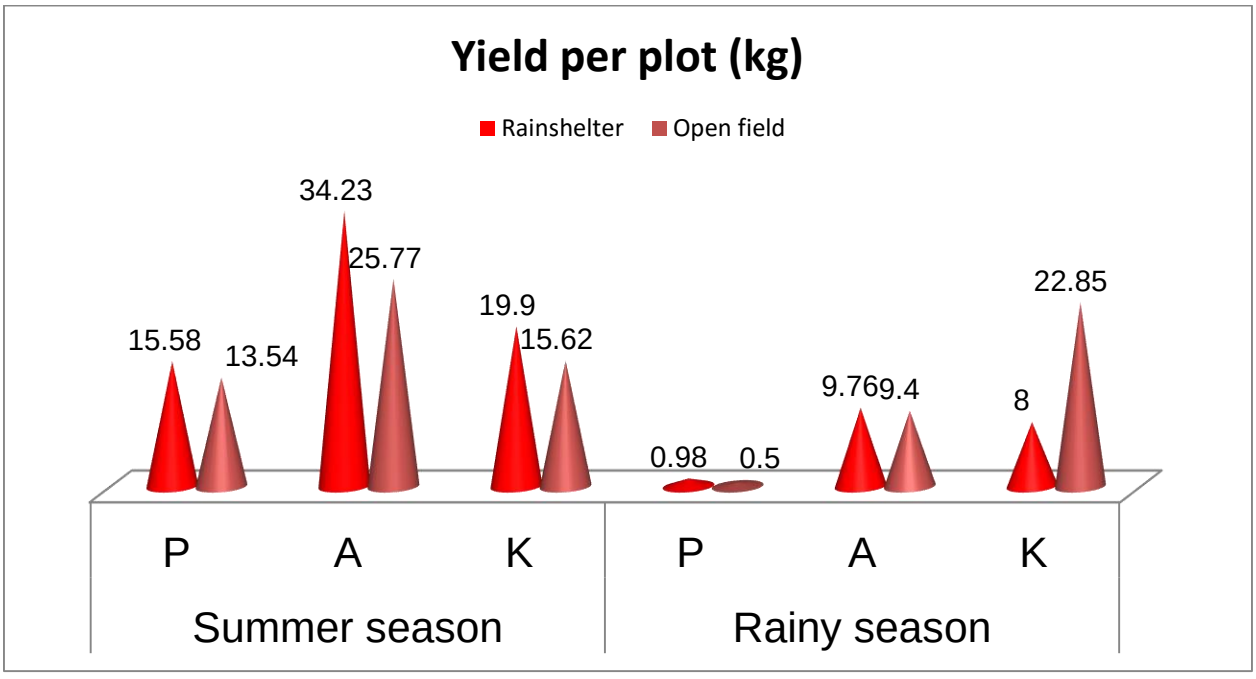


Fig 10. Comparison of yield per plot during summer and rainy season

5.2.9 Average fruit weight

During summer season, Kuruppamthara Local recorded maximum average fruit weight inside the rain shelter (481.66g) and in the open field (431.25g). Inside the rain shelter Kurupppamthara local was superior over the other two varieties. But in the open field AAUC-2 was on par with Kuruppamthara local and Poinsette showed significant difference. During rainy season AAUC-2 recorded the highest value inside the rain shelter (471.25g) and Kuruppamthara Local recorded maximum value in the open field (487.50g). Inside the rain shelter Kuruppamthara Local was on par and significantly superior over Poinsette (Fig 11). Kumar *et al*. (2009) reported that in summer squash the total number of fruits and average fruit weight were higher under polyhouse as compared to open field in mid hills of north western Himalaya.

During summer season, there was a reduction in average fruit weight for Poinsette inside the rain shelter. There was a reduction in average fruit weight of Poinsette and AAUC-2 in the open field during rainy season. Average fruit weight is an outcome of higher fruit length and girth.

5.2.10. Fruit length

During summer season, AAUC-2 produced lengthy fruits inside the rain shelter (22.68cm) and in the open field (22.22cm) and was significantly superior over other varieties. During rainy season also, AAUC-2 recorded the highest value inside the rain shelter (23.74cm) and in the open field (21.82cm) and was significantly superior over other varieties. Saikia *et al.* (2001) reported that AAUC-2 recorded the highest mean values for fruit length inside the low cost greenhouses. There was a reduction in fruit length of rain shelter grown Poinsette and Kuruppamthara Local during summer season. Productivity and quality of cucumber produced under polyhouse is largely dependent on increased fruit length. Das *et al.*

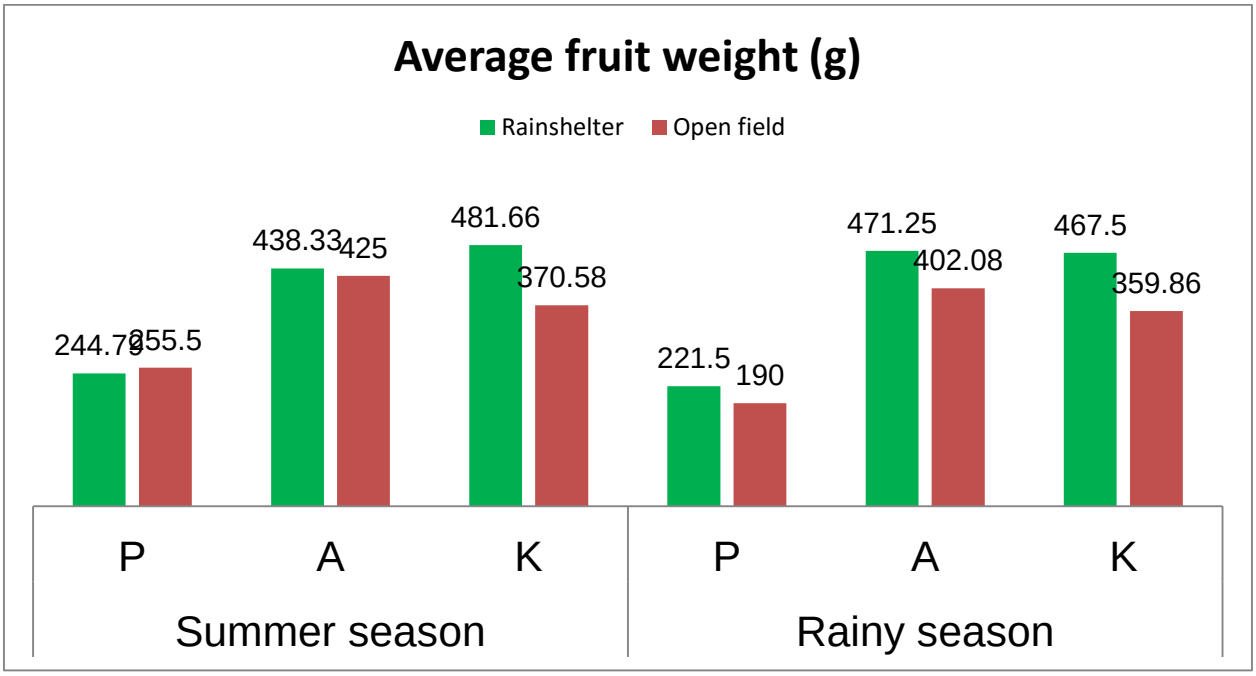


Fig 11. Comparison of average fruit weight during summer and rainy season

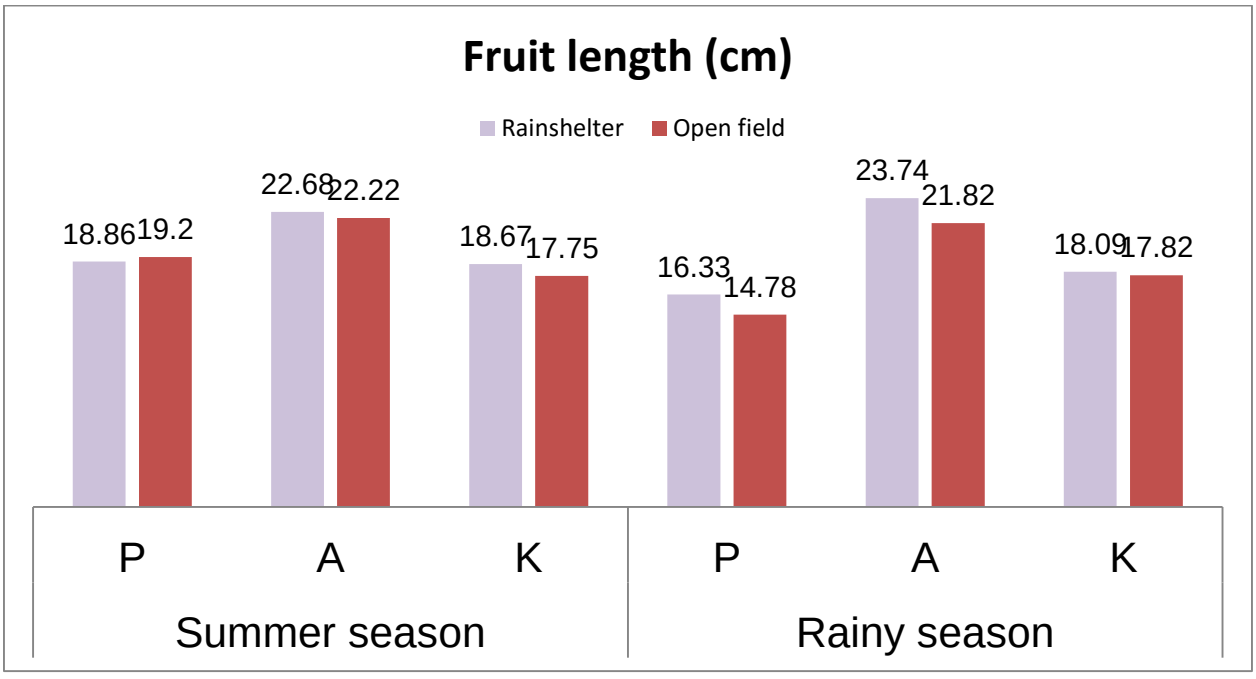


Fig 12. Comparison of fruit length during summer and rainy season

(2003) reported that out of 18 genotypes only three varieties were suited for cultivation during summer and rainy seasons in Bhagalpur region due to better yield, fruit weight and fruit length (Fig 12).

5.2.11 Fruit girth

During summer season, Kuruppamthara Local had maximum fruit girth inside the rain shelter (22.46cm) and in the open field (21.10cm). During rainy season also Kuruppamthara Local recorded maximum value in the open field (21.79cm) and inside the rain shelter (21.32cm) and was significantly superior over the other two varieties. There was reduction in fruit girth of rain shelter grown Poinsette and AAUC-2 during rainy season and open field grown AAUC-2 and Kuruppamthara Local (Fig 13). According to Jaksungnaro and Sema (2001) the first sowing date (21 March) gave the best results in almost all parameters, except for the size of fruit in Nagaland condition for cucumber AAUC-2. The increase in fruit mass results from a higher average growth rate (Heuvelink and Dorais, 2005).

5.2.12 Flesh thickness

During summer season, Kuruppamthara Local produced maximum flesh thickness inside the rain shelter (2.15cm) and outside (2.03cm) and was significantly superior over other varieties. During rainy season also Kuruppamthara Local recorded maximum flesh thickness under the rain shelter (2.18cm) and in the open field (2.10cm) and was significantly superior over other varieties (Fig 14). Maximum flesh thickness was due to maximum fruit girth.

5.2.13 Number of seeds per fruit

AAUC-2 recorded maximum seed number inside the rain shelter (371.66) during summer season and in the open field Poinsette (335.16) recorded maximum value. Inside the rain shelter Kuruppamthara Local (355.0) was on par with AAUC-

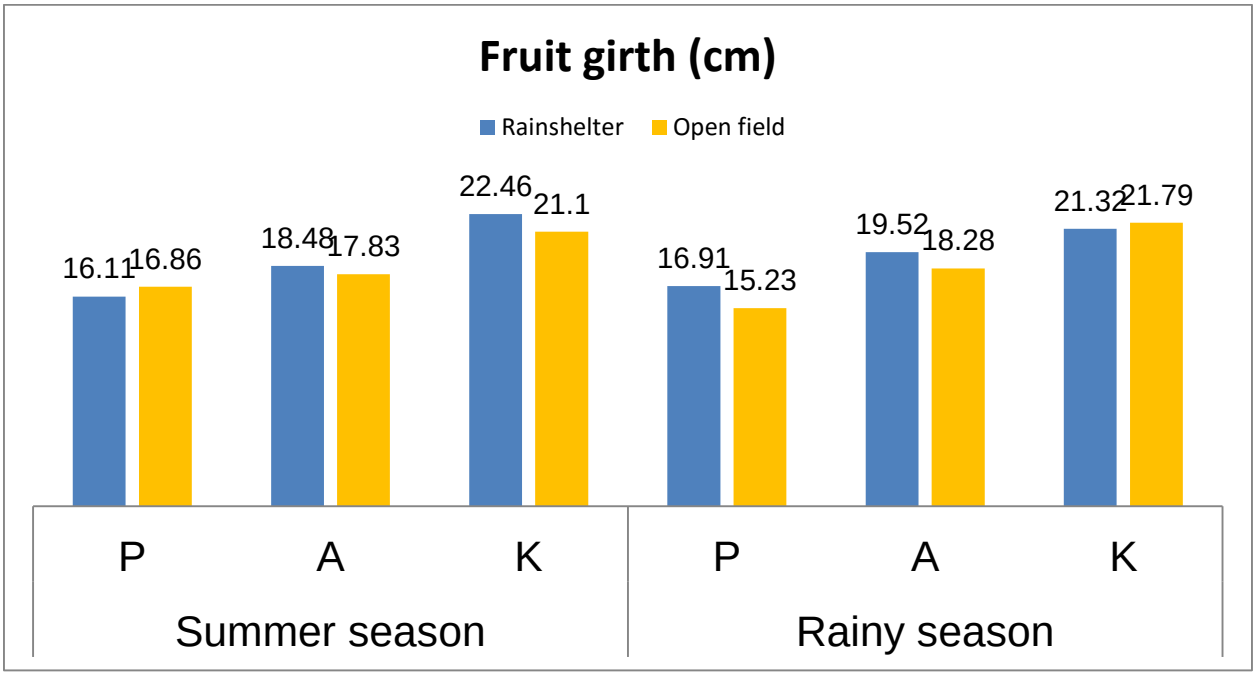


Fig 13. Comparison of fruit girth during summer and rainy season

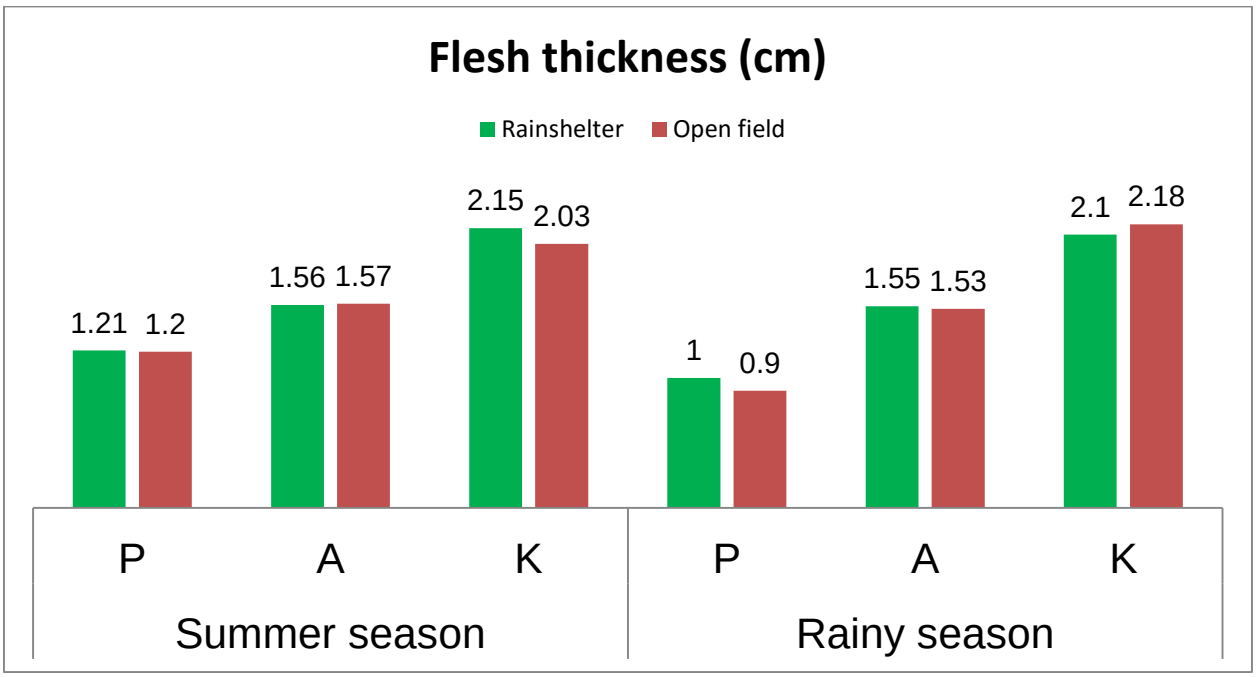


Fig 14. Comparison of flesh thickness during summer and rainy season

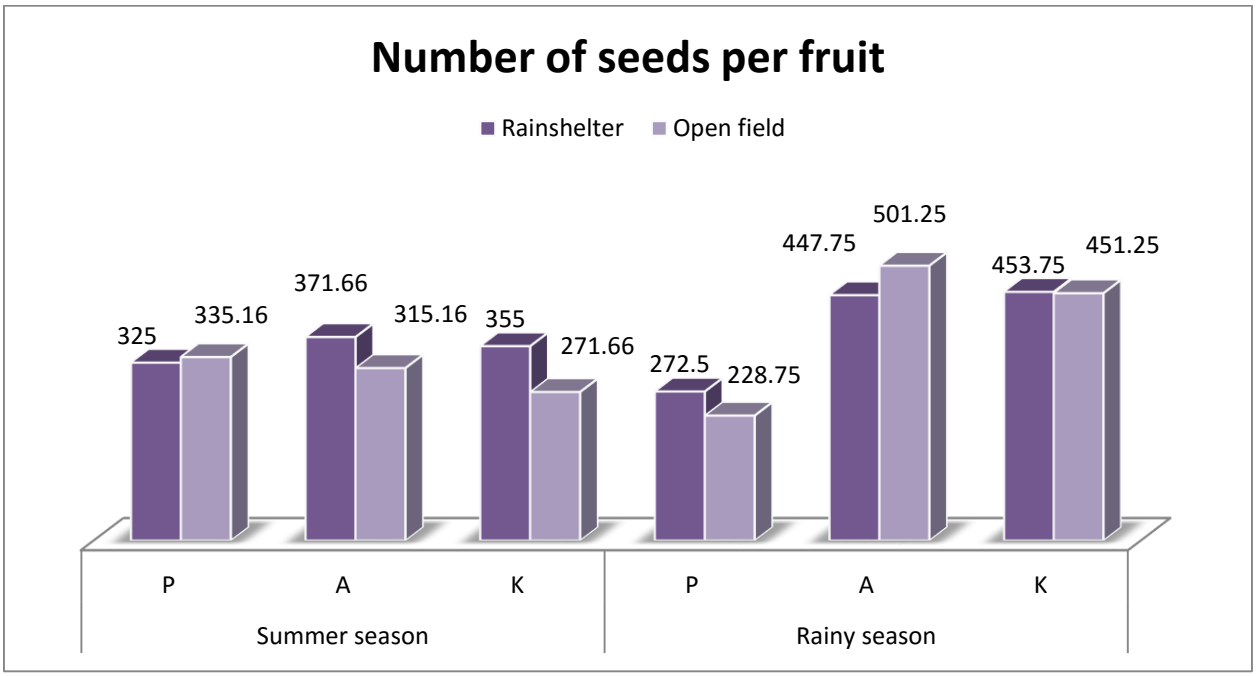


Fig 15. Comparison of number of seeds per fruit during summer an

2 and Poinsette was significantly different. In the open field, AAUC-2 was on par with Poinsette (335.16) and Kuruppamthara local (271.66) was superior to Poinsette. During rainy season also, AAUC-2 recorded the highest value (447.75) inside the rain shelter and in the open field (501.25) also (Fig 15).

Ravikumar *et al.* (2003) reported the seed yield in cucumber Poinsette during the kharif season with narrow spacing recorded the highest percentage of filled seeds per fruit (67.5%) and seed yield (76.6 kg/ha) and in the summer season with narrow spacing also recorded the highest percentage of filled seeds per fruit (51.6%) and seed yield (60.8 kg/ha).

5.3 Influence of weather parameters on vegetative, reproductive and pest and disease incidence

5.3.1 Vegetative characters

Cucurbits are warm season crops requiring a minimum of about 15-18^{0}C and 30-35^{0}C maximum temperature for successful cultivation. Environmental factors greatly affect the vegetative and reproductive characters in cucumber (Frankel and Galun, 1977). Temperature, light intensity and relative humidity are the main factors which influence the growth and development of plants considerably (Reddy, 1999). Modification of the above factors is possible inside green house structures. Temperature is the one of the most easily and frequently modified environmental factors influencing plant growth.

During summer season maximum temperature inside the rain shelter ranged from 33.2^{0}C to 36.4^{0}C and while in the open field it ranged from 33.0^{0}C to 37.0^{0}C. The minimum temperature ranged from 20.4^{0}C to 26.5^{0}C inside the rain shelter and from 21.8^{0}C to 26 ^{0}C in the open field. Relative humidity (morning) ranged from 62.8% to 97% inside the rain shelter and in the open field it varied from 69% to 94%. The total rainfall received during the summer season was 223.60mm.

During summer season vegetative characters like vine length and number of branches were more for rain shelter crops than open field crops. High temperature and low humidity inside the rain shelter in the early stages of the crops favoured vegetative growth. Karlsen (1981) observed maximum growth of aerial parts in cucumber at 30^0C air and 20^0C root temperature. According to Nagoaka *et al.* (1984) optimum temperature range for photosynthesis in cucumber was 28-33^0C and transpiration rate in cucumber was not increased with temperature. Morning humidity was more in the open field when compared to rain shelter. This may be due to the summer showers received from March to May.

Higher temperature inside the rain shelter increased vine length during summer season. As the temperature increases node number or formation rate also increases and so also vine length. Number of branches is highly influenced by light intensity. Auxin (IAA) concentration is low under high light intensity prevailing during summer season. The reduction in auxin concentration may induce GA production which in turn increases the number of branches during summer season inside the rain shelter.

During rainy season maximum temperature inside the rain shelter ranged from 29.5^0C to 33.62^0C and minimum temperature ranged from 21.0 to 28.9^0C. In the open field maximum temperature ranged from 27.1^0C to 31.1^0C and minimum temperature range was 22.5^0C to 23.7^0C. Relative humidity ranged from 85% to 93.4% inside rain shelter and 92-96% in the open field. Total rainfall received during the rainy season was 2083.0mm.

During rainy season main vine length was more inside the rain shelter than open field but number of branches was more in the open field. Bakker (1988) reported that the vegetative growth of cucumber was enhanced by either high day or night humidity. High rainfall and high humidity induced more vegetative growth in the open field crop.

5.3.2 Reproductive characters

Summer season crop was early to flower and harvest when compared to rainy season. Similarly rain shelter grown Poinsette flowered earlier than open field crop during both season. High temperature and long days promoted the production of staminate flower during summer season. Heavy monsoon and higher relative humidity during rainy season caused delayed flowering. High temperature, bright sunshine and low humidity caused early flowering in summer season. High light intensity is needed for optimum flowering. Vooren (1980) reported that increasing night temperature from12^{0}C to 20^{0}C under greenhouse condition decreased the number of days taken for first flower production.

High rainfall and relative humidity delayed the days to first harvest and reduced the duration of the crop during rainy season. Heavy monsoon rains and decreased photoperiod reduced the reproductive phase of the crop and reduced the number of harvest. As the immature fruits are harvested there was continuous and simultaneous female flower production and fruit set during summer season. Yield per plot was highest during summer season due to optimum climatic condition. Low night temperature (<17^{0}C) increased fruit set in cucumber but high temperature (35^{0}C) reduced fruit set to 30% (Drews, 1980).

5.3.3 Pest and disease incidence

During summer season damping off was the major disease and it was more severe in open field when compared to rain shelter. This may be due to high soil temperature during that period. Mosaic incidence was more inside the rain shelter. This may be due to high temperature prevailing in the rain shelter during summer season. Fruit cracking was also noticed both in rain shelter and open field during summer season. Boron deficiency can cause longitudinal corky cracks in the fruits (Basak, 2005). Under high temperature, the neck of cucumber fruits became longer,

abnormal fruits increased, skin of fruits became harder and ascorbic acid concentration decreased and yield also decreased (Ling Bo *et al*., 2004). Here also high temperature might have influenced fruit cracking under both growing conditions. Pest incidence was minimum during both seasons. Leaf miner and fruit fly incidence was seen towards the end of cropping season during summer. The incidence of biotic stress (insect pests), plant mortality and use of chemical insecticides were found minimum under protected condition (Singh and Kumar, 2004). Borah (2001) investigated the effect of different sowing dates of cucumber on the incidence of fruit fly and reported that sowing from 20 April to 20 May recorded significantly lower pest infestation than sowing crops from 20 June to 20 July in hill zone of Assam. .

During rainy season, also mosaic incidence was noticed both inside the rain shelter and open field. Kuruppamthara Local was almost free from mosaic under both growing seasons. Downy mildew was also observed during rainy season which could be controlled in the initial stages. The incidence of downy mildew was first observed in 29th MW (0.25%) on the crop sown in 24th MW (Yadav and Patil, 2008). In the present study also the crop was affected by the above disease on 23rd MW. Excessive humid weather will promote diseases like downy mildew and viruses and pest like fruit flies. Mosaic incidence was occurred during rainy season due to high relative humidity prevalent in that season.

There was varietal difference with respect to mosaic severity. Poinsette was severely affected during rainy season both in rain shelter and open field. But Kuruppamthara Local was resistant during rainy season. Severely affected plants of Poinsette were uprooted and hence it affected the total yield also.

5.4 Influence of trailing methods on vegetative, reproductive characters and pest and disease incidence

5.4.1 Vegetative characters

In order to get maximum photosynthetic area per unit of ground area, indeterminate vegetables such as tomato and cucumber are trained on to strings suspended from an overhead wire. Cucumber can be trained on number of training systems.

During summer season, horizontally trailed Poinsette showed significant difference from vertically trailed Poinsette in the open field whereas in rainy season vertically trailed plant produced maximum vine length than horizontally trailed plant in the open field. Inside the rain shelter there was no significant difference between trailing systems. Trellising or training increased vine length in cucumber (Al Harbi *et al.*, 1996 and Shetty and Wehner, 1998). Reduction in vine length in staked vine is due to the disturbance of the normal auxin movement which in turn affects phloem transport (Janick, 1972).

During summer season also, in the open field horizontally trailed Poinsette recorded maximum number of branches and was significantly superior over vertically trailed Poinsette. During rainy season horizontal trailing was superior over vertical trailing inside the rain shelter.

5.4.2 Reproductive characters

During summer season, in the open field, horizontally trailed Poinsette took minimum days for male flower production and was significantly different from vertically trailed crop. There was no significant difference between trailing methods under two growing conditions in the case of days to first male flower opening, days to first female flower opening, node at which first female flower emerged, days to

first harvest and duration of crop under two seasons in this study during both seasons.

During rainy season trailing methods had significant influence on number of harvest inside the rain shelter. Horizontally trailed cucumber varieties were significantly superior over vertically trailed varieties in rain shelter. But in the open field no significant difference was observed. During summer season trailing methods had no significant influence on number of harvest.

During rainy season, trailing methods had significant influence on fruits per plot inside the rain shelter and open field. Horizontally trailed cucumber produced more fruits than vertically trailed plants inside the rain shelter but in the open field vertically trailed plants produced more number of fruits than horizontally trailed plants. This may be due to high rainfall and water logging during rainy season which affect the horizontally trailed crop. Coiling of stem around the growing bag at a spacing of 45X60cm produced better leaf growth, total yield and marketable yield in green house grown cucumber (Premalatha *et al.,* 2006). Photosynthetic measurements in horizontally growing cucumbers showed that there was no decline in photosynthetic capacity when cucumber leaves were developing under good light conditions and in traditional high wire cultivation system photosynthetic measurements showed that the lower leaves have a significant reduction in photosynthetic capacity due to reduced light conditions (Petterson *et al.,* 2010). During summer season trailing methods had no significant influence on fruits per plant.

During rainy season, inside the rain shelter horizontally trailed plants had highest yield than vertically trailed varieties and there was no significant difference in the open field. During summer season trailing methods had no significant influence on yield per plant. Jaiswal *et al.* (1997) observed that staking system did not influence the days required to first harvest and staking using bamboo sticks or

tree branches produced more fruits than jute string and no staking. But staking with jute string gave 5.6 and 29% more marketable fruits than the farmers' practice of staking and no staking respectively.

During both seasons, trailing methods had no significant influence on average fruit weight and fruit length inside the rain shelter and open field. During rainy season, trailing methods had significant influence on fruit girth in the open field and flesh thickness inside the rain shelter. Vertical trailing produced fruits with maximum girth in the open field and flesh thickness was more in the vertical trailing method inside the rain shelter. Vertical training or staking cucumber plants increased yield, enhanced fruit quality and improved the control of foliar and fruit diseases as compared to the traditional method of growing cucumber on the ground (Konsler and Strider, 1973). Vertical training was superior in quality, and it reduced the harvest time but inferior to pinching in total yield (Masahiro *et al.*, 2001). Farmers in Kerala grow cucurbits like bitter gourd, snake gourd, ridge gourd and ivy gourd on pandals which result in enhanced yield. Fruit quality is also superior (Peter *et al.,* 2008).

During summer seasons, vertical trailing produced more number of seeds inside the rain shelter and there was no significant difference between trailing methods in the open field. During rainy season, trailing methods had no significant influence on number of seeds inside the rain shelter and open field.

5.4.3 Pest and disease incidence

Damping off was noticed at seedling stage and this had no influence on the trailing systems. Mosaic was noticed more in the vertically trailed plants of rain shelter during summer season. Cracking was also more in vertical trailing than horizontal trailing. During rainy season, mosaic incidence was observed more in horizontally trailed varieties. Shetty and Wehner (1998) reported that cucumber cultivars grown on trellis support possessed higher incidence of powdery mildew.

5.5 Economics of cultivation

During rainy season, inside the rain shelter, the total cost of cultivation was recorded as Rs 32 per m^2 and the total benefit was Rs 45 per m^2. Cost benefit ratio of rain shelter crop was 1:1.40. In the open field, the total cost for cultivation was recorded as RS 12 per $m^2$and the total benefit was Rs 72 per m^2 and the cost benefit ratio of open field crop during rainy season was 1:6.0. During summer season, total benefit was Rs 165 per m^2 and cost benefit ratio inside the rain shelter was 1:5.15. The total cost for cultivation was recorded as RS 15 per m^2 in the open field the benefit was Rs 72 per m^2 and cost benefit ratio was calculated as 1:6.0.

During rainy season rain shelter cultivation was not remunerative. It was due to the high incidence of mosaic disease inside rain shelter. Out of the three varieties only Kuruppamthara Local was free from this disease.

In the summer season performance was almost equal under both conditions. There is only a small margin in the benefit in rain shelter grown crop. Though the yield was high inside rain shelter the open field crop also performed well. The intermittent summer showers received by the open field crop from March to May promoted its reproductive phase and also the yield.

Most of the studies on economics of cucumber cultivation revealed that this technology is quite feasible and cost effective (Singh *et al*., 2004). But under the climatic condition of Kerala it was not cost effective. If we are selecting specific varieties for specific season it will be remunerative. From this experiment it was clear that AAUC-2 is ideal for rain shelter during summer season and it will be cost effective during that season. During rainy season open field cultivation of Kuruppamthara Local under vertical trailing system is remunerative than rain shelter cultivation (Plate 14 and Plate 15).

Plate 14. Horizontal trailing inside the rain shelter

Plate 15. Vertical trailing in the open field

Summary

6. SUMMARY

The present investigation on "Productivity of cucumber (*Cucumis sativus* L.) as influenced by seasons and growing systems" was conducted in the Department of Olericulture, College of Horticulture, Vellanikkara during 2009 with the objective of studying the feasibility of off season production of cucumber in rain shelter, to identify ideal variety for protected cultivation and to study the comparative performance of crops in rain shelter and open field.

The experiment was laid out in a randomized block design with three replications. Three varieties viz., Poinsette, AAUC-2 and Kuruppamthara Local were used for the study. Observations on vegetative growth, reproductive characters were recorded during the course of investigation. The daily weather parameters were recorded inside and outside the rain shelter. The salient results obtained during the course of investigation are summarized below.

*During summer season, rain shelter crop had maximum vine length than open field crop. AAUC-2 produced maximum vine length inside the rain shelter and open field. AAUC-2 recorded maximum number of branches inside the rain shelter during summer season than open field.

* All the varieties produced maximum vine length in the open field during rainy season Kuruppamthara Local produced maximum number of branches inside the rain shelter than open field during rainy season

* Variety Poinsette produced male flower earlier than other varieties during summer season inside the rain shelter but in the open field Kuruppamthara Local was earlier than other varieties

*During rainy season, Poinsette was earlier than other varieties under both growing condition

*During summer season, Poinsette produced female flower at lowest node inside the rain shelter and in the open field, AAUC-2 recorded lowest value

*Poinsette was early to first harvest inside the rain shelter during summer season and Kurupamthara Local in the open field

*Poinsette recorded minimum days to first harvest inside the rain shelter and in the open field during rainy season.

*AAUC-2 had maximum crop duration inside the rain shelter and in the open field during summer season. Kuruppamthara Local recorded maximum crop duration during rainy season under both the conditions

*AAUC-2 had maximum number of harvest during summer season both in the rain shelter and open field and during rainy season, AAUC-2 recorded maximum value inside the rain shelter and Kuruppamthara Local in the open field

*During summer season, AAUC-2 had highest yield both under rain shelter and open field, but in rainy season Kuruppamthara Local produced maximum yield in the open field and inside rain shelter.

*During summer season both AAUC-2 and Kuruppamthara Local produced maximum average fruit weight inside the rain shelter.

*During rainy season, AAUC-2 produced fruits with maximum average fruit weight inside the rain shelter. AAUC-2 produced more lengthy fruit inside the rain shelter and open field under two seasons

* Kuruppamthara Local produced fruits with maximum girth and flesh thickness inside the rain shelter and open field under two seasons

*During rainy season, Kuruppamthara Local produced more seeds (453.75) inside the rain shelter and AAUC-2 (501.25) in the open field. During summer season,

AAUC-2 produced more seeds (371.66) inside the rain shelter and Poinsette (335.16) in the open field.

* During rainy season, inside the rain shelter horizontally trailed varieties had highest yield than vertically trailed varieties and there was no significant difference in the open field. During summer season trailing methods had no significant influence on yield per plant.

* During both seasons, trailing methods had no significant influence on average fruit weight and fruit length inside the rain shelter and open field.

* Vertical trailing produced fruits with maximum girth in the open field and flesh thickness was more in the vertical trailing method inside the rain shelter during summer season.

*Pest attack was minimum during both seasons under two growing conditions and the main diseases were damping off and mosaic during both seasons. Severity of mosaic diseases were high during rainy season.

* During summer season, cost benefit ratio inside the rain shelter was 1:5.15 and in the open field cost benefit ratio was calculated as 1:4.8.

* During rainy season, cost benefit ratio of rain shelter crop was 1:1.40. In the open field, the cost benefit ratio of open field crop during rainy season was 1:6.0

*From the present study it can be concluded that AAUC-2 is the ideal variety for off season (summer) in rain shelter. Kuruppamthara Local is ideal for open field cultivation during rainy season under vertical trailing system. Rain shelter cultivation is not cost effective during rainy season.

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Appendices

APPENDIX-I

Cost of cultivation of salad cucumber inside the rain shelter and open field

Construction cost of Rain shelter (100m^2): Rs 50,000/-

Maintenance cost for 10 years : Rs. 10000/-

Total cost: Rs 60,000/-

Life span of rain shelter - 10years

Cost/year = Rs 6000/-

Number of crops per year = 3

Cost/season: Rs 2000/-

Cost/m^2/season: Rs. 20/-

Cost of cultivation = Rs 12/m^2 @1.2 lakh/ha

Total cost: Rs 32/m^2

Open field (summer season)

Total cost : Rs. 15/m^2

Open field (rainy season)

Total cost : Rs. 12/m^2

Benefits

Summer season : Rain shelter: 11kg/m^2 and open field: 6kg/m^2

Rainy season: Rain shelter: 3kg/m^2 and open field: 6kg/m^2

PRODUCTIVITY OF CUCUMBER (*Cucumis sativus* L.) AS INFLUENCED BY SEASONS AND GROWING SYSTEMS

by

AMBILY SADANANDAN

(2008-12-103)

ABSTRACT OF THE THESIS

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DEPARTMENT OF OLERICULTURE

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ABSTRACT

The present study entitled “Productivity of cucumber (*Cucumis sativus* L.) as influenced by seasons and growing systems” was undertaken in the Department of Olericulture, College of Horticulture, Vellanikkara during 2009. The objectives of the study were to investigate the feasibility of off season production of cucumber in rain shelter, to identify ideal variety for protected cultivation and to study the comparative performance of crops in rain shelter and open field.

The experiment was laid out in a randomized block design with three replications inside the rain shelter and open field. Three varieties Poinsette, AAUC-2 and Kuruppamthara Local were used for the study during summer season (February to April) and rainy season (June to August). Protected condition was provided using a rain shelter of $100m^2$ floor area. Observations on vegetative and reproductive characters were recorded during the course of investigation. The daily weather parameters were recorded inside and outside the rain shelter.

During summer season, rain shelter crop had maximum vine length than open field crop. AAUC-2 recorded maximum vine length inside the rain shelter and open field. AAUC-2 recorded maximum number of branches also inside the rain shelter than open field. During rainy season Kuruppamthara Local had more vine length and number of branches inside the rain shelter and open field.

Variety Poinsette produced male flower earlier than other varieties during summer season inside the rain shelter but in the open field Kuruppamthara Local was earlier than other varieties. During rainy season, Poinsette was earlier than other varieties under both growing condition. During both season, this variety produced female flower earlier than other varieties under two growing conditions. During summer season, AAUC-2 produced female flower at lowest node in the open field.

Poinsette was early to harvest inside the rain shelter during summer and Kuruppamthara Local was early in the open field. But during rainy season, AAUC-2 was early inside the rain shelter and Poinsette in the open field. AAUC-2 recorded highest crop duration under two growing condition during summer season and Kuruppamthara Local had maximum duration during rainy season. AAUC-2 recorded maximum number of harvests under two growing conditions during summer season and inside the rain shelter during rainy season. Kuruppamthara Local recorded maximum number of harvests in the open field during rainy season. Same pattern was observed in the case of fruits per plot and yield per plot. During summer season maximum fruit weight was recorded by variety Kuruppamthara Local under two growing condition and rainy also this variety recorded maximum fruit weight in the open field. But inside the rain shelter AAUC-2 recorded maximum fruit weight. AAUC-2 recorded maximum fruit length under two growing conditions during two seasons. Kuruppamthara Local recorded maximum fruit girth and flesh thickness under two growing conditions during two seasons. AAUC-2 produced maximum number of seeds in the open field during rainy season than summer season.

During rainy season, inside the rain shelter horizontally trailed varieties had highest yield than vertically trailed varieties and there was no significant difference in the open field. During summer season trailing methods had no significant influence on yield per plant.

Pest attack was minimum during both seasons under two growing conditions and the main diseases were damping off and mosaic. Severity of mosaic diseases was high during rainy season. Cracking was observed during summer season and variety Poinsette inside the rain shelter recorded highest percentage of cracking.

During summer season, cost benefit ratio inside the rain shelter was 1:5.15 and in the open field cost benefit ratio was calculated as 1:4.8. During rainy season,

cost benefit ratio of rain shelter crop was 1:1.4. In the open field, the cost benefit ratio during rainy season was 1:6.0.

From this study it can be concluded that AAUC-2 is the ideal variety for off season (summer) cultivation inside rain shelter. Kuruppamthara Local is ideal for open field cultivation during rainy season under vertical trailing system.