Comparative study of the agronomic and organoleptic performances of some varieties of papaya (*Caricapapaya* L.) grown outdoors and in polyhouse in Kerala (India)

ABSTRACT

The present study was undertaken with the objective to evaluate the performance of papaya varieties under two growing conditions (open and polyhouse) in terms of yield and quality attributes. The study wasconducted in Fruits Crops Research Station, Kerala Agricultural University, Thrissur during 2022-2023. The seedlings of seven papaya varieties, CO-3, CO-7, Arka Surya, Arka Prabhath, Coorg Honey Dew, Pusa Delicious and Red Lady were planted under both open field and polyhouse condition at a spacing of 2 m x 2 min CRD with five plants per variety.Compared to the plants grown in open field, the plants grown under polyhouse showed an early flowering (75.68 days), minimum fruit cavity index (15.47 %), zero disease incidence to PRSV, maximum TSS (13. 67 ˚B) and total sugars (11.26 %) in CO-7 while maximum fruit length (18.84 cm) and fruit mass (2605.34g)were observed in CO 7. It was also observed that CO-7 grown under polyhouse showed an increased yield (55.20 kg/plant) as compared to the plants under open condition. Hence, it can be concluded that CO-7 can be successfully cultivated under polyhouse condition in Kerala with good yield and quality.

Keywords:papaya; varieties; polyhouse; yield; quality

1. INTRODUCTION

Papaya (*Carica papaya* L.) is one of the important fruit cropsgrown in the tropical and subtropical regions of India (Ganesh, 2017) [1]. It has gained popularity due to its fast-growing nature, short pre bearing age,high yield potential and high nutrient content with long fruiting period (Sahu et al., 2023 [2]. The fruits are an excellent source of vitamins (A & C), flavonoids, minerals and fibres and are mainly used for table purpose (Mirza et al., 2023) [3]. It can be used as a vegetable, for production of value-added products and also for papain extraction (Kumar et al., 2019) [4].

India is the largest producer of papaya in the world with an area of 1.48 lakh ha with a production of 5.34 lakh MT and productivity of 35.9 MT/ha (Indiastat, 2023-2024) [5]. In India, the major papaya growing states are Andhra Pradesh, Kerala, Tamil Nadu, Gujarat and Maharashtra (Chaudhary and Sarkar, 2017) [6]). In Kerala it is mainly grown as a backyard crop,with less or no attention leading to a lot of wastage of this nutritious crop (Sereena, 2004) [7]). The major limiting factors for commercial cultivation of papaya in Kerala are heavy rainfall, excessive drought during summer and its susceptibility tomany viral diseases, among which Papaya Ringspot Virus (PRSV) is the serious one (Ganesh, 2017) [1]). These limitations can be overcome to a greaterextent by the adoption of protected cultivation technology (Ganesh, 2017) [1]. Optimum conditions for the growth and development of the plants can be provided when grown under protected structures which would make it possible to obtainhigh-quality cropsensuring year-round production of the crop irrespective of season along with an added benefit of elimination of viral diseases(Sauco and Pastor, 2007) [8]. Another major limiting factor is the lack of availability of suitable varieties adapted to the agroclimatic conditions of Kerala (Akhil, 2020) [9]. Currently, the farmers rely on private sector hybrid, Taiwan 786 (Red Lady) due to its superior fruit quality (Kaur and Kaur, 2017) [10]. Due to the above said reasons,open cultivation is becoming more and more difficult and the adoption of

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alternative methods, in particular the promotion of papaya cultivation in polyhouse, could significantly contribute to obtaining a quality yield (Ganesh, 2017) [1]. Therefore, the present study was undertaken to comparatively evaluate the performance of papaya varieties grown under open and polyhouse conditions and to identify the best variety and best growing conditions in terms of yield and quality.

2. MATERIALS AND METHODS

The present study was carried out during the year 2022-2023 at Fruits Crops Research Station, Kerala Agricultural University, Thrissur situated at 10° 31' N latitude to 76° 3' E longitude and at an altitude of 22.25 m above MSL.The plants of seven varieties namely CO-3, CO-7, Arka Surya, Arka Prabhath, Coorg Honey Dew, Pusa Delicious and Red Lady were planted under both open and polyhouse conditions in a Completely Randomised Design with five plants per variety. The seeds were pre-treated with gibberellic acid at 200 ppm overnight and sown in polybags filled with a mixture of sand, soil and farm yard manure in the ratio of 1:1:1 (Ramteke et al., 2015) [11]. Gibberellins helps to promotes mobilization of food reserves during the germination process. Therefore, they contribute to increased and uniform seed germination, thus improving the performance of papaya seeds (Zanotti and Barros, 2014) [12]. Two months old seedlings were transplanted to the main field both under open and polyhouse at a spacing of 2m x 2m. The cultural practices were carried out as per the package of practice recommendation of Kerala Agricultural University. Observations on growth parameters such as plant height, stem diameter, number of leaves, number of days to first flowering, height to first flower, fruit shape, fruit colour were recorded as per the IPGRI (International Plant Genetic Resources Institute) descriptor for papaya. For fruit parameters such as fruit length and fruit width, five fruits from each variety were taken randomly and its length and breadth were measured using a thread and the length of the thread was measured using a scale and expressed in centimeters. To ascertain fruit mass, five fruits from each variety were selected and weighed on an electric balance and the mean fruit mass was expressed in grams. Fruit cavity index was determined by dividing the cavity volume by fruit volume and expressed in percentage (Dinesh et al., 1991) [13]). Yield per plant was determined by multiplying the mean fruit mass by the number of fruits and expressed in kg/plant. Quality attributes such as total soluble solids (TSS) were determined with the help of digital refractometer and then taking the average of the readings taken (Shadmani, 2013) [14]. Acidity was estimated by titrating against 0.1N NaOH using phenolphthalein as the indicator (Ranganna, 1997) [15]. The total sugar was determined by AOAC method by titrating against Fehling's solution using methylene blue as the indicator (Ranganna, 1997) [15]. Disease scoring for PRSV incidence and intensity were done as per the scale adopted by Dhanam (2006) [16]. The scale consisted of five levels based on symptoms ranging from resistant (R) with an intensity score of 0-1.0, tolerant (T) with 1.1-2.0, moderately susceptible (MS) with 2.1-3.0, susceptible (S) with 3.1-4.0 and highly susceptible (HS) with 4.1-5.0.The disease rating was done on a 0 to 5 scale as follows,

0 - no disease symptoms

1 - slight mosaic on leaves

2 -patches and/or necrotic spots on leaves

3 - leaves near apical meristem deformed slightly, yellow and reduced in size

4 - apical meristem with mosaic and deformation

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5 = extensive mosaic and serious leaf deformation or plant dead

The data obtained from various parameters were subjected to analysis of variance (ANOVA) and statistical analysis was carried out by Least Square Design (LSD) using KAU GRAPES software version 1.1.1. at a significance level of 5%.

3. RESULTS AND DISCUSSION

The results in terms of growth parameters of different papaya varieties are presented in Table 1. The present study revealed that the plants grown under polyhouse produced maximum plantheight at first harvest when compared to the open field.Reduced plant height in papaya is a desirable character as it facilitates easy intercultural operations and harvesting. Under open field condition, the minimum plant height at first harvest was recorded in Red Lady (185.30 cm) followed by CO-7 (193. 50 cm), whereas maximum plant height at first harvest was observed in CO-3 (270.45 cm).The findings of the present study is in line with the findings of several researchers (Nguyen et al., 2011)[17], (Nirujogi and Dinesh, 2012) [18], (Das and Dinesh, 2014) [19] and Sharma et al. (2016) [20], which states that the difference in the genetic make-up of these different varieties might have contributed towards the variations in plant height. According to Ganesh (2017) [1], who studied the performance of papaya cultivars grown under net house and open field condition at IIHR, Bengalurureported that the increase in plant height under protected condition could be due to the partial etiolation effect, thereby encouraging the plant to grow taller in order to capture maximum light for photosynthesis.The plants under polyhouse produced maximum stem diameter at first harvest thanunder open condition.The cultivar, CO-7 grown in polyhouse showed maximum stem diameter at first harvest (55.83 cm) and minimum was observed in Coorg Honey Dew (47.35 cm). This result was in accordance with the findings of Ganesh (2017) [1], who reported that the difference among different varieties and differences in the microclimate prevailing in the polyhouse and open condition might have led to the variations in stem diameter. The data regarding the number of leaves at first harvest depicted that the plants under polyhouse produced more number of leaves as compared to plants in open field. The maximum number of leaves at first harvest was observed in the cultivar CO-7 (31.49) followed by Red Lady (29.72) and minimum in Pusa Delicious (22.88) under polyhouse. These findings are in corroboration with the reports of Kumar *et al*. (2007) [21], Muthulakshmiet al. (2007)[22], Ibitoye et al. (2011)[23] and Nirujogi and Dinesh (2012)[18], who observed variation in number of leaves between net house and open condition. The papaya varieties grown in polyhouse recorded early flowering when compared to the open field, as they took only minimum days to first flowering (75.86 days) in CO-7 when grown in polyhouse and early flowering was observed in Red Lady (81.62 days) under open condition. This could be due to the fact that the favourable microclimate prevailing in the polyhouse might have favouredplant growth in a better manner resulting in an early supply of photosynthates to sinkresulting in early bud opening (Chalaket al. 2016) [24] and Prakash (2016)[25].The plants grown under open condition showed minimum height to first flower than the plants under polyhouse. The minimum height to first flowering was observed in Red Lady (78.12 cm) grown in open field followed by Pusa Delicious (86.32 cm) and maximum was seen in Arka Prabhath (107.21 cm). Similar findings have been reported by Gunes and Gubbuk (2011)[26].

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As the plants being taller in the polyhouse, height to first flower in polyhouse also turned out to be the maximum.

The results on fruit characters, yield and disease scoring are given in Table 2(a) and 2(b). The data on fruit size revealed that the plants under open field produced bigger fruits with more fruit length and fruit width as compared to plants under polyhouse conditions. The maximum fruit length was seen in CO-7 (18.84 cm) followed by Red Lady (17.11 cm) grown in open field and minimum in CO-3 (9.61 cm). The papaya cv. CO-7 grown in open field showed maximum fruit width (16.07 cm) followed by Red Lady (13.00 cm) and minimum in CO-3 (7.48 cm). Similar results have been observed by Reddy and Gowda (2014) [27] in papaya cv. Honey Gold. With regard to fruit mass, the plants grown under open condition produced bigger and heavier fruits than under polyhouse. Maximum fruit mass was recorded in CO-7 (2605.34 g) grown in open field condition and minimum in Arka Surya (746.08 g). The reduction in the size of the fruits under polyhouse condition could be attributed to the findings of Kaur et al. (2017)[10]. His observation was that due to the production of more number of fruits under polyhouse condition, the compactness of fruits might have prevented them from growing to appropriate sizecausing reduction in fruit weight. The findings of the present study were also in accordance with the results of an earlier study by Prakash et al. (2016) [25] in papaya cv. Pusa Nanha. The cavity index recorded was higher in papaya varieties grown under open field than plants grown under polyhouse. Minimum fruit cavity is a desirable character in papaya as it indicates more pulp content. The minimum fruit cavity index was recorded in CO-7 (15.47 %) grown under polyhouse followed by Coorg Honey Dew (17.98 %) and maximum in Arka Prabhath (21.78 %). These findings are in line with the results of Nirujogi and Dinesh (2012)[18]. The differences in cavity index among different papaya varieties might be due to variation in fruit volume and cavity volume. The data regarding yield per plant under open field and polyhouse clearly indicated that significantly higher yield could be obtained from plants grown under polyhouse than under open condition. The cultivar, CO-7 grown under polyhouse recorded maximum fruit yield (55.20 kg/plant) followed by Red Lady (45.69 kg/plant) with minimum in Arka Surya (11.59 kg/plant). It could be due to the favourable microclimate that ledto the increased number of fruitsresulting in higher fruit yield under polyhouse (Ganesh, 2017)[1].The disease scoring at final harvest revealed that the papaya cultivars grown under polyhouse did not show any incidence of disease, while the cultivars grown under open field were affected by disease.The data of the present study revealed that Arka Surya grown under open condition wassusceptible to PRSV, whereas Arka Prabhath, Coorg Honey Dew and Pusa Delicious were found to be moderately susceptible. The cultivar CO-3 was found to be tolerant, whereas CO-7 and Red Lady emerged as resistant cultivars. Findings reported by Andrade et al. (1995)[28] and Kunkalikaret al. (2006)[29], stated that papaya cultivars did not show any disease incidence when grown under net house, while papaya cultivars expressed disease symptoms when grown under open condition, which supports the findings of the present study. In addition, they also observed severe disease incidence of PRSV in Arka Surya and Arka Prabhath grown under open condition and were categorised as susceptible.

The data pertaining to quality parameters are presented in Table 3. Maximum TSS were recorded in fruits obtained from plants under polyhouse than in open field. Maximum TSS was recorded in CO-7 (13.67 ˚B) grown under polyhouse and minimum in Arka Surya (10.08 ˚B).These results were in accordancewith the earlier findings of Prakash et al. (2015) [25],

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Das (2013) [30] and Chalaket al. (2016)[24], according to which he favourable microclimatic condition under polyhouse could have facilitated in the production of more photosynthatesresulting in fruits with maximum TSS in the present study (Reddy and Gowda, 2014) [27].Acidity did not show any significant difference among varieties grown in open condition. Under polyhouse conditions,acidity was found to be minimum in Red Lady (0.19 %)followed by CO-7 (0.21%), while maximum acidity was recorded in CO-3 (0.27%). This was in line with the findings of Choudhury et al (2022) [31], who reported minimum acidity in the juice of papaya grown under net house which might be due to the high sugar content in the fruit grown under net house

The papaya varieties grown in polyhouse recorded maximum total sugars than in the open field. The maximum value for total sugars was noted in the fruits of CO-7 (11.26 %) followed by Red Lady (11.12%) and Arka Prabhath (11.04%) and minimum in Pusa Delicious (9.06%) under polyhouse. This can be attributed to the high photosynthetic efficiency under polyhouse conditions due to the increased number of leaves that had led to the assimilation of high amount of total sugars in fruits grown under polyhouse (Zhou et al., 2000) [32]).

4. CONCLUSION

The papaya varieties showed significant variation for most of the characters. Among the seven varieties studied in the present investigation, the variety CO-7 had shown good results in terms of yield and quality attributes both in open and polyhouse conditions. But CO-7 exhibited maximum yield and quality characters along with no PRSV incidence inside the polyhouse throughout the period of study. Therefore, it could be concluded that CO-7 can be successfully cultivated in the polyhouse condition to obtain good yield and quality fruits.

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Sl. No.	Varieties	Plant height at 1st harvest (cm)		Stem diameter at 1st harvest (cm)		Number of leaves at 1st harvest		Days to first flowering (days)		Height to first flower (cm)	
		Open	Polyhouse	Open	Polyhouse	Open	Polyhouse	Open	Polyhouse	Open	Polyhouse
1	CO-3	270.45	299.41	50.45	52.64	24.93	27.09	90.41	85.73	104.35	108.19
2	CO-7	193.50	219.14	53.20	55.83	28.10	31.49	83.36	75.68	102.19	105.09
3	Arka Surya	241.65	271.44	51.50	52.27	24.14	26.12	89.40	81.39	104.30	111.93
4	Arka Prabhath	249.10[i]	273.79	48.75	49.15	23.79	25.81	85.29	80.78	107.21	108.56
5	Coorg Honey Dew	260.45	286.36	46.15	47.35	25.84	25.29	94.29	88.27	93.05	98.06
6	Pusa Delicious	204.60	228.52	46.20	48.16	22.47	22.88	90.76	85.16	86.32	87.85
7	Red Lady	185.30	210.41	50.60	53.46	27.36	29.72	81.62	78.49	78.12	80.90
SE(m)		5.25	3.93	3.71	0.84	0.74	0.85	1.00	0.99	2.26	0.55
CD (5%)		17.55	13.16	NS	2.82	2.47	2.84	3.35	3.33	7.58	1.85

Table 1. Mean performance of papaya varieties on growth and flowering characters

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Sl. No.	Varieties	Fruit length (cm)		Fruit width (cm)		Fruit weight (g)	
		Open	Polyhouse	Open	Polyhouse	Open	Polyhouse
1	CO-3	9.61	8.88	7.48	7.15	788.12	670.02
2	CO-7	18.84	15.60	16.07	13.31	2605.34	1045.16
3	Arka Surya	14.48	14.31	12.71	10.11	746.08	702.27
4	Arka Prabhath	14.68	12.28	11.61	11.18	1479.53	1167.32
5	Coorg Honey Dew	15.09	13.44	10.78	8.79	972.41	904.18
6	Pusa Delicious	14.17	12.03	9.99	8.47	938.50	897.34
7	Red Lady	17.11	13.46	13.00	10.68	1743.16	1540.32
SE(m)		0.13	0.14	0.08	0.03	40.09	30.99
CD (5%)		0.45	0.48	0.27	0.11	134.09	103.64

Table 2a. Mean performance of papaya varieties on fruiting characters

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Sl. No.	Varieties	Fruit cavity index (%)		Fruit yield (kg/plant)		Disease scoring	
		Open	Polyhouse	Open	Polyhouse	Open	Polyhouse
1	CO-3	24.00	19.27	17.78	19.70	2	0
2	CO-7	19.55	15.47	53.06	55.20	1	0
3	Arka Surya	24.03	20.23	11.22	11.59	4	0
4	Arka Prabhath	25.50	21.78	36.88	40.15	3	0
5	Coorg Honey Dew	22.70	17.98	40.08	44.20	3	0
6	Pusa Delicious	24.30	20.31	22.43	24.93	3	0
7	Red Lady	20.70	18.78	42.74	45.69	1	0
SE(m)		0.34	0.03	0.31	0.26		
CD (5%)		1.14	0.12	1.04	0.87	NA	NA

Table 2b. Mean performance of papaya varieties on yield and disease incidence

Sl. No.	Varieties	TSS (˚Brix)		Acidity (%)		Total sugars (%)	
		Open	Polyhouse	Open	Polyhouse	Open	Polyhouse
1	CO-3	9.75	10.21	0.24	0.27	9.21	10.40
2	CO-7	12.32	13.67	0.19	0.21	10.75	11.26
3	Arka Surya	9.06	10.08	0.20	0.22	8.55	10.41
4	Arka Prabhath	11.07	12.45	0.21	0.24	9.50	11.04
5	Coorg Honey Dew	10.25	10.56	0.24	0.27	9.05	9.78
6	Pusa Delicious	10.14	11.23	0.21	0.23	7.70	9.06
7	Red Lady	11.25	12.89	0.17	0.19	9.65	11.12
SE(m)		0.02	0.23	0.01	0.09	0.05	0.04
CD (0.05)		0.09	0.78	NS	0.02	0.19	0.13

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