DOI : 10.5958/0974-0112.2015.00036.5

Indian J. Hort. 72(2), June 2015: 183-186

Comparison of plant growth, yield, fruit quality and biotic stress incidence in papaya var. Pusa Nanha under polyhouse and open field conditions

Jai Prakash*, Kanhaiya Singh, A.K. Goswami and A.K. Singh**

Division of Fruits and Horticultural Technology,ICAR-Indian Agricultural Research Institute, New Delhi 110012

ABSTRACT

Papaya is one of the most important fruit crop in the tropical and sub-tropical region of India .However, the production of this economically important fruit crop is limited by the various biotic and abiotic stresses like papaya ring spot & leaf curl virus and low temperature during winter season. The affected plant shows stunted growth, small fruits with ring spot blemishes and drastically reduced fruit yield and TSS content of fruits. Hence, to reduce the risk of the crop loss an evaluation was carried out to compare of plant growth, yield and fruit quality of papaya var. Pusa Nanha under polyhouse and open field conditions at New Delhi. The seedlings of papaya were grown in insect proof net house and transplanted (50 days after sowing) in two growing conditions, *viz.*, open field and polyhouse. The evaluation of papaya under polyhouse showed early flower initiation (64.67 days), higher number of leaf at flowering (18.33), petiole length (84.32), long fruiting zone (171.46), fruit set (46.23%), high fruit yield (34.56 kg/plant) compared to open field. The physical and chemical composition of papaya fruits, *i.e.* fruit firmness ((1.97 kg.cm^{-2}), total soluble solids (11.3°Brix), ascorbic acid (75.26 mg/100 g pulp) were significantly improved under polyhouse over open field production. Papaya grown in polyhouse was almost free from the papaya ring spot virus, papaya leaf curl virus and less infected by collar rot, stem rot.

Key words: Papaya, growth, quality, polyhouse, open field, papaya ring spot virus.

INTRODUCTION

Papaya (*Carica papaya* L.) is one of the most important fruit cultivated throughout the tropical and subtropical regions of the India and ranks fifth with regards to area and production among different fruit crops. Papaya has gained more importance owing to its high palatability, fruiting ability throughout the year, early fruiting and highest productivity per unit area and multifarious uses like food, medicine and industrial inputs. Polyhouse cultivation simultaneously provides both adequate temperatures and exclusion of *papaya leaf curl virus* (PaLCV) and *papaya ring spot virus* (PRSV). Growth and flowering benefit from the climate within green-houses, resulting in improved yields, both in fruit quantity and quality, with the critical additional benefit of the exclusion of frost damage, PaLCV and PRSV (Abe, 1; Allan, 2; Nakasone and Paul, 6).

Environmental factors such as light, wind, edaphic characteristics, temperature, relative humidity and biotic factors such as mycorrhizal fungi and genotype significantly affect the productivity and physiology of papaya (Nakasone and Paul, 6). Besides environmental factors, fruit chemical features are also affected by location, season, and maturity stage (Rancel Delgado *et al.*, 8). Temperatures below 20°C have a very negative effect, causing among other problems, carpelloidy, sex changes, reduced pollen viability, and low sugar content of the fruit (Prakash *et al.*, 7). Plants in open field conditions experience short growing season, unfavourable climatic conditions (too cold, too hot, too dry and cloudy) impairing photosynthetic activities, vulnerable to predators, pests, weeds, depleted soil moisture and plant nutrients leading to drastic reduction in fruit yields (Prakash *et al.*, 7) and Allan (2). Hence, there is a need to protect this popular crop to sustain its productivity. The challenges in producing fruit crops in protected systems are needed to be studied particularly in papaya, where pests and viruses are the serious threat to quality and productivity of the fruits. The objective of the present study was to evaluate Pusa Nanha-a dwarf papaya variety to compare fruit yields, yield attributing traits and fruit quality parameters under polyhouse and open field conditions.

MATERIALS AND METHODS

The present study was conducted during 2013 and 2014 in the experimental farm of the Division of Fruits & Horticultural Technology, IARI, New Delhi. An ultra-dwarf dioecious variety, Pusa Nanha was selected for evaluation. The plants start bearing from

*Corresponding author's E-mail: singhjai2001@rediffmail.com

**Managing Director, National Horticulture Board, Gurgaon, Haryana

25- 30 cm above ground level and much suitable for high density planting under open conditions. The greenhouse structure was made of galvanized steel iron; it was 5 m high at the centre and tapered down to 3 m at gutter level; it was covered with low density polyethylene plastic (UV+IR and 150-μm thick). The polyhouse was ventilated from the sides to the top cooling pool and also by exhaust fan during the months of April, May and June so that polyhouse was not over-heated during the growing seasons. Soil pH at 0-60 cm was 7.0, organic matter content was 0.4%, and soil texture was a clay-loam. Seeds were sown in black polythene bags (20 cm × 15 cm size with 150 gauge thickness) containing pot mixture (cocopeat, perlite and vermiculite; 2:1:1). Plants were watered at regular intervals. When the seedlings attained the 3-4 leaf stage (50 days after sowing) and height of 15 cm, they were transplanted in the polyhouse as well as in open field. Transplanting of seedlings was done in the experimental plot in the pits of 45 cm × 45 cm × 45 cm size. Plants were planted on March 2013 with a spacing was 1.4 m × 1.4 m (5,102 plants ha^{-1}) and a single-line drip irrigation system was installed for each row. Fertilization was applied to each plant during the vegetative phase for each plant with 250 g of urea (NH_2CONH_2), 250 g of single super phosphate (SSP), 350 g of potassium chloride (KCl) and 25 g of zinc ($ZnSO_4$).

Traits like plant height, fruiting zone, petiole length, days to flower initiation, number of leaves, fruit weight (g), length (cm) and width (cm) were measured. The fruits were harvested at a commercially ripe stage when the peel colour approached 25% yellow. Fruit pulp colour was measured by using colorimeter and reported as L^*, a^* and b^*. The flesh firmness was determined on three sides of the fruit using a penetrometer with a 1.5 cm diameter tip depressed 2 mm into the fruit after harvest. The juice extracted from the homogenized pulp of the fruits was used for monitoring total soluble solids (TSS) using a hand refractometer (Erma, Japan). Vitamin C and titratable acidity were measured using standard methods. All physico-chemical analyses were done from the fruit harvested during March-April. Disease severity index was based on a scale where; 0: no visible signs of infection; 1: 1-20% leaves distorted; no infection on fruits; 2: 20-40% leaves distorted + 20% fruits showing infection; 3: 40-60% leaves distorted + 20-40% fruits showing infection; 4: 60-80% leaves distorted + 40-60% fruits showing infection; 5: 80-100% leaves distorted + 60% fruits showing infection.

The experiment was laid out in a completely randomized design with six replications. Ten plants were sampled for plant growth, morphological characteristics and yield contributing traits. Ten fruits were randomly selected for evaluating fruit colour and physico-chemical traits of each treatment. The collected data were subjected to analysis of variance (ANOVA) in a completely randomized design. The analysis of data was done SPSS 10.0.

RESULTS AND DISCUSSION

The results presented in Table 1 showed that plant height was similar during the early growing period (March-April) in open and polyhouse conditions; it increased significantly in polyhouse and attained maximum height (258.39 cm) during the period August-September as compared with open planting (157.82 cm). A general view of the plants is shown in (Fig. 1). Number of leaves and petiole length showed significant differences in plants grown in polyhouse and open field. Maximum number of leaves (18.33) and petiole length (84.32 cm) were observed in

Fig. 1. A view of Pusa Nanha papaya plants in polyhouse.

Table 1. Influence of growing conditions on morphological, flowering and fruiting traits of 'Pusa Nanha' papaya.

Treatment	Days taken for first flowering	Plant height at flowering (cm)	No. of leaves at flowering	Petiole length (cm)	Fruiting zone (cm)	Plant height (at 11 month)	Days taken for fruit maturity	Fruit retention (%)
Open field	81.50	65.25	14.12	78.65	89.08	157.82	139.33	28.20
Polyhouse	64.67	93.36	18.33	84.32	171.46	285.39	148.25	46.23
$LSD_{0.05}$	2.46	3.21	1.89	2.56	6.75	5.82	5.35	4.56

polyhouse grown plants as compared to open field for number of leaves (4.12) and petiole length (78.65 cm), respectively.

Plants grown in greenhouse recorded early flower initiation after transplanting (64.67 days) with maximum fruit retention (46.23%) and long fruiting zone (171.46 cm). Whereas, late flower initiation (81.5 days), minimum fruit set (28.20%) and small fruiting zone (89.08) was recorded in open field plants. Compared to polyhouse, early fruit maturity (139.33 days) was observed in open field conditions. This may be due to the increased hormonal metabolism and photosynthesis in plants, which may be due to the presence of more favourable modified growing conditions under polyhouse resulting in early flowering and higher fruit set. Similar results were observed by Galan and Rodriguez Pastor (4), and Esma and Hamide (3). The increase in plant height under polyhouse with organic production system was also reported by Martelleto *et al*. (5)

Highly significant differences were noticed in open field raised plants for fruit weight (1150.14 g), fruit length (16.34 cm) and fruit breadth (12.53 cm) compared to polyhouse raised plants (fruit weight 875.67 g, fruit length 14.25 cm and fruit breadth 12.53 cm). Maximum pulp (754.25 g) and peel weight (175.12 g) were recorded in open field grown plants compared to polyhouse. However, maximum number of fruits per plant (41.25) and yield per plant (34.56 kg) were recorded in polyhouse grown plants as compared to open field conditions (Table 2). A general view of the fruiting is given in Fig. 2. In polyhouse, the increased yield recorded might be due to the no incidence of papaya ring spot virus (PRSV), continuous and healthy growth, higher number of fruits and enhanced fruiting zone. These findings are corroborated with the reports of Galan Sauco and Rodriguez Pastor (4), Reddy and Gowda (9) and Allan (2) with 'Honey Gold' papaya from South Africa.

Fig. 2. Papaya plants in fruiting under polyhouse.

The data presented in Table 3 revealed significant differences for TSS and ascorbic acid content of fruits of Pusa Nanha. Compared to open field, maximum TSS (11.2°Brix), ascorbic acid (75.26 mg/100 g pulp) with minimum titratable acidity (0.22%) were recorded in polyhouse cultivated papaya. Fruit firmness of is also more in polyhouse (1.97 kg·cm^2) as compared to open field cultivated papaya. As regards colour of fruits, polyhouse cultivated papaya has the maximum values of L* (61.0), a*(12.5) and b* (50.3) as compared to open field cultivated papaya. This indicates that fruits of papaya grown in polyhouse are more firm and bright yellow in colour at the time of ripening. This may be due to the congenial micro-climatic conditions maintained in polyhouse, which influenced the production of more photosynthates that might result in sweeter fruits with less acid. The findings are similar to the report of Esma and Hamide (3)

Table 2. Influence of growing conditions on physical composition of fruit and yield of 'Pusa Nanha' papaya.

Treatment	No. of fruits/ plant	Fruit wt. (g)	Fruit length (cm)	Fruit breadth (cm)	Fruit yield (kg/plant)	Pulp wt. (g)	Peel wt. (g)
Open field	21.20	1150.14	16.34	13.16	24.65	754.25	175.12
Polyhouse	41.25	875.67	14.25	12.53	34.56	605.56	112.43
$LSD_{0.05}$	2.34	16.36	1.96	1.02	4.09	12.65	8.62

Table 3. Influence of growing conditions on fruit colour and biochemical composition of 'Pusa Nanha' papaya fruits.

Treatment	Fruit colour			Fruit firmness (kg.cm^{-2})	TSS (°Brix)	Titratable acidity (%)	Ascorbic acid (mg/100 g pulp)
	L*	a*	b*				
Open field	58	12.4	51.2	1.95	9.0	0.24	69.52
Polyhouse	61	12.5	50.3	1.97	11.2	0.22	75.26
$LSD_{0.05}$	1.24	NS	NS	NS	0.85	NS	1.86

Table 4. Influence of growing conditions on pest and disease incidences in 'Pusa Nanha' papaya.

Treatment	Mite infestation (%)	Mealy bug infestation (%)	PRSV incidence (%)	PaLCV incidence (%)	Collar rot (%)	Stem rot (%)
Open field	1.25	1.36	12.85	8.65	12.65	8.65
Polyhouse	16.50	4.26	00.00	0.25	8.25	2.25
$LSD_{0.05}$	4.56	0.72	00.00	1.25	1.76	2.03

with three papaya cultivars in Turkey and Reddy and Gowda (9) on 'Red Lady' papaya.

The data presented in Table 4 showed significant differences in infestation of mites and infection of papaya plants with PRSV, PaLCV, collar rot and foot rot grown under polyhouse as compared to open field grown papaya. Maximum infestation (16.5%) of mite was found in polyhouse as compared to open field grown papaya (1.25%). As regards diseases, open field grown papaya are more vulnerable to PRSV, PaLCV, collar rot and foot rot as compared to polyhouse. Maximum infection of PRSV (12.85%), PaLCV (8.65%), collar rot (12.65%) and stem rot (8.65%) was observed in open field, while polyhouse grown plants were almost free of PRSV and PaLCV. Maximum infestation of mites in polyhouse grown papaya may be due to distribution throughout the polyhouse as hitchhikers on workers, equipment and even on insects such as whitefly. Polyhouse grown papayas were found almost free from infection of PRSV and PaLCV due to absence of vectors like aphids and white fly and better management of temperature and humidity while high infection of diseases in open field grown papaya is due to free movement of insect vectors and pathogens. Whereas, in open field the rapid spread of disease was due to presence of most favourable climate (cool hours), host crop plants and also free movement of aphids and whiteflies. Similar results were observed by Galan Sauco and Rodriguez Pastor (4), Sheen *et al*. (10), and Reddy and Gowda (9) on PRSV with 'Red Lady' papaya.

From the present study, it may be concluded that papaya can be grown under polyhouse with higher fruiting zone, medium sized fruit, and higher percentage of fruit set, high fruit yield, better quality fruits and minimum outbreaks of viral disease. However, further research work required to reduce the infestation of mites in polyhouse cultivation of papaya.

REFERENCES

1. Abe. 1998. Greenhouse cultivation of papayas in Okinawa. Appropriate Agriculture International Co., Ltd., *AAI News*, **4**: 1.
2. Allan, P. 2007. Phenology and production of *Carica papaya* 'Honey Gold' under cool subtropical conditions. *Acta Hort.* **740**: 217-24.
3. Esma, Gunes and Hamide, Gubbuk. 2012. Growth, yield and fruit quality of three papaya cultivars grown under protected cultivation. *Fruits*, **67**: 23-29.
4. Galan Sauco, V. and Rodriguez Pastor, M.A.C. 2007. Greenhouse cultivation of papaya. *Acta Hort*. **740**: 191-95.
5. Martelleto, L.A.P., Rebeiro, R.D.D., Sudo-Martelleto, M., Vasconcellos, M.A., Marin, S.L.D. and Pareira, M.B. 2008. Cycle development and agronomic performance of organic papaya cultivation in protected environment. *Rev. Bras. Fruticult*. **30**: 662-66.
6. Nakasone, H.Y. and Paul, R.E. 1998. *Tropical Fruits*, CABI, Wallingford, UK, 432 p.
7. Prakash, J., Goswami, A.K., Singh, A.K., Singh, K. and Verma, A.P.S. 2013. Protected cultivation of papaya (*Carica papaya* L.) in North India". Abstract in *National Seminar on Protected Cultivation of Horticultural Crops and Value Addition* organized by SHIATS, Allahabad, 29-30th November, 2013, pp. 145.
8. Rancel Delgado, J., Lobo Rodrigo, M.A.G., Rodríguez Pastor, M.A.C. and Gonzalez, M. 2007. Postharvest behaviour of three papaya cultivars produced in mesh greenhouse in Tenerife (Canary Islands, Spain). *Acta Hort*. **740**: 211-15.
9. Reddy, P.V.K. and Gowda, V.N. 2014. Influence of greenhouse cultivation on fruit quality of 'Red Lady' papaya. *Acta Hort*. **1024**: 109-14.
10. Sheen, T.F., Wang, H.L. and Wang, D.N. 1998. Control of papaya ringspot virus by Cross protection and cultivation techniques. *J. Japan Soc. Hort. Sci*. **67**: 1232-35.

Received : October, 2014; Revised : February, 2015; Accepted : May, 2015