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Original Research Paper

Performance of Apple ber on different training systems in hot arid condition

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ABSTRACT

Ber is an indigenous and common fruit of India. It is commercially grown under wide climatic and soil conditions. Apple ber (*Zizyphus jujube* Mill) cultivar is gaining momentum in sub-tropical and tropical climatic conditions of West Bengal, Telangana, Andhra Pradesh, Maharashtra, Rajasthan, Gujarat and in several northern parts of India. It is precocious in bearing habit with bold and crispy fruits. Many factors including training practices affect vegetative and fruit quality parameters. Due to bolder and heavier fruits, the cultivar is prone for limbs breakage or complete tilting of plants which results in uneven fruiting, reduced fruit set, and higher fruit drop. Considering its appealing fruit taste and quality and to address the above mentioned issues, different training systems were evaluated to see its performance on three to four years old apple ber orchards. Plants were trained on different training systems *viz.* Y-Shape, Espalier training system and control. Observations were recorded on vegetative and fruit quality parameters. Training systems significantly influenced various vegetative, yield and fruit quality parameters. Vegetative parameters such as leaf area, physical and quality attributes *viz*., fruit weight and size, TSS, ascorbic acid, yield, and B: C ratio were better in Y-Shape training system. Hence, Y-Shape training system can be adopted to improve yield and fruit quality parameters in Apple ber.

Keywords : Ber, fruit quality, PAR, training system, yield

INTRODUCTION

Though ber is distributed worldwide *viz.*, Indian sub-continent, Southeast Asia, Australia, China, Africa, the Mediterranean region, and the American center, its cultivation is confined only to the drier parts of the globe. Ber (*Zizyphus mauritiana* Lamk.) is one of the most ancient and common indigenous fruit in India. It is cultivated under wide climatic and soil conditions. Though ber fruit contains 81% of moisture, it is rich in essential amino acids such as asparginine, arginine, glycine, glutamic acid, and serine (Azam-Ali, 2006). It is found that ber is rich in vitamin C and phosphorus than apples and oranges (Obeed, 2008). Ber is known as "Poor Man's Apple" as it contains all the nutritional benefits of apple and its affordable price to the poor people. Since, it is cultivated in drier regions, it is also called as 'the apple of arid zone' (Singh and Bal, 2006).

Apple ber cultivar was originated from Thailand, and is gaining momentum in sub-tropical and tropical regions of India. It is cultivated mainly in West Bengal, Telangana, Andhra Pradesh, Maharashtra, Rajasthan, and Gujarat. Unlike the Indian jujube, its name signifies the size and appearance of the fruit (green apple). Not only the shape, but the juiciness and crispiness of the fruit is also resembles to that of Apple. This cultivar has many advantages over the traditional ber varieties (Mathangi and Maran, 2020) such as fruit size, bearing potential, precocity in bearing, earliness, and crisp texture of fruit. No doubt the large size of the fruit is its prime attraction but, the total fruit yield per plant is less than normal popular varieties like Gola and Umran under irrigated condition. Ber growers of arid and semi-arid regions have started planting of Apple ber cultivar due to its bearing potential, precocity in bearing, earliness, large fruit size, etc. Some issues were noticed in Apple ber *i.e.*, breakage of branches or complete tilting of plants, poor organoleptic quality, less fruit set, more fruit drop and uneven fruiting. Among the different factors responsible for the sustainable production of quality ber fruits, the practice of training of plants in hot arid conditions is vital.

The adoption of training systems in the modern era of fruit growing is the most important factor in the areas where high yield is targeted which also leads to better fruit quality. The training system affects the photosynthetic efficiency of plants which is directly related to bearing efficiency and fruit quality (Sansavini and Corelli, 1997). Generally, Apple ber trees have a deep tap root system but tend to develop heavy and profuse canopy under sub-tropical and arid conditions. The high-velocity winds during the winter season which coincides with the time when there is considerable fruit load on the trees results in tilting of trees or in some cases trunk/limb breakage resulting in loss of fruit trees especially in Rajasthan. Hence, there was a need to develop an ideal and strong framework for Apple ber trees by adopting training systems which can not only bear heavy fruit load but also develop proper canopy to produce quality fruits as well as remain intact under conditions of high wind velocity. The practice of adopting training systems in cultivation of Apple ber is a completely new approach. Identification of a suitable training system will able to produce quality fruits, and expected sustainability in Apple ber growing under the arid conditions where high wind velocity is a common feature.

MATERIALS AND METHODS

The present experiment was conducted at ICAR-Central Arid Zone Research Institute, Jodhpur, Rajasthan during 2018 to 2020. Three to four years old Apple ber plants were planted at a spacing of 6 m x 6 m. The soil was sandy loamy and initial soil EC (0.31 and 0.24 ds/m), pH (8.4 and 8.1), organic carbon (0.30 and 0.12 %), N (101.14 and 89.05 kg ha^{-1}) and P_2O_5 (11.51 and 10.50 kg ha^{-1}). The average temperature of 38°C and 58% relative humidity was recorded during the growth and fruit development stage in the orchard. The experiment was carried out in randomized block with three treatments replicated eight times, to standardize the training systems for obtaining quality fruits. Each replication consists of 15 uniform plants. The trees were trained according to three training systems i.e. Y-Shape (T1), Espalier (T2) and control/conventional system (T3) (Fig. 1, 2 and 3). Regular horticultural practices *i.e.*, pruning, fertilizer application, irrigation and plant protection operations were followed uniformly.

Plant growth parameters

Data was recorded on plant growth parameters such as primary shoot diameter (cm), shoot length (cm) and leaf area (cm^2) at the time of fruit maturity. The fruit size (fruit length and diameter) was recorded using digital Vernier calliper and screw gauge. The same sample was weighed using an electronic weighing scale and the mean value is registered for the analysis. The weight was measured in different ways based on the requirements for the calculations. Whole fruit weight, weight of flesh and weight of stone was measured to calculate pulp-stone ratio. The leaf area was recorded using digital leaf area meter (Biovis PSM - L3000).

Physio-biochemical parameters

The biochemical parameter such as TSS was recorded by refractometer and the acidity of the berry was estimated by potentiometric titration method. The total sugar content was measured by hydrolyzing the polysaccharides into simple sugars by acid hydrolysis and estimating the resultant monosaccharides by Anthrone method (Hedge and Hofrieter, 1962). Ascorbic acid was recorded by a spectrophotometric method. PAR was measured by a digital canopy analyzer. The yield attributes of experimental ber plants were recorded twice in both the years. Fruit yield per hectare was calculated by using following formula:

$$\text{Yield (ton/ha)} = \frac{\text{Yield per plant (kg)}}{1000} \times 278 \text{ (plant/ha)}$$

Fig. 1 : Y-Shape (T1)

Fig. 2 : Espalier (T2)

Fig. 3 : Control/Conventional system (T3)

Statistical analysis

All calculations were carried out by the standard method of analysis of variance as described by Panse and Sukhatme (1995). The critical difference at 5 *per cent* level of significance was calculated.

RESULTS AND DISCUSSION

Training systems *i.e.*, Y-Shape (T1), Espalier (T2) and control/conventional system (T3) were evaluated in the Apple ber orchard for two years. Morphological, physical, biochemical and yield parameters were influenced by training systems. Concerning growth parameters, the minimum primary shoot length (103.8 cm) and maximum primary shoot diameter (2.47 cm) and leaf area (26.33 cm^2) were recorded in T1 which is significantly different than other training systems, whereas, the least growth observations were recorded on T3. Among the fruit quality parameters, the highest fruit weight (66.88 g), fruit length and breadth (5.05 cm and 4.57 cm) and higher pulp: stone ratio (13.08) were found to be in T1 *i.e.*, Y-shape training which is significantly higher than the other two training systems (Table 1). Likewise, Gill *et al.* (2011) reported that bush-trained plants improve the productivity of pomegranate and offer the possibility to obtain high-quality fruits. The highest fruit length, breadth and weight of 6.62 cm, 6.97 cm and 283.9 g and TSS and juice percentage were recorded in fruits harvested from trained trees compared to other systems of training (Fig. 4).

Among, biochemical parameters, significantly higher TSS (15.64 ^{o}B) total sugars (11.34 %), and ascorbic acid (89.30 mg/100 g) were recorded in T1 compared to other treatments (Table 2). These results are similar to the finding of Kalkan *et al.* (2022) and Yin *et al.* (2022) who reported that vines trained to Y shaped support system had greater total soluble solids and sugar composition in berries than those trained to closing Y-shaped trellis.

Fig. 4 : Apple ber fruits

Table 1 : Effect of different training systems on the growth and fruit quality in Apple ber

Treatment	Primary shoot length (cm)	Primary breadth shoot (cm)	Leaf area (cm^2)	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Pulp: Stone ratio
T1 (Y-Shape)	103.8	2.47	26.33	66.88	5.05	4.57	13.08
T2 (Espalier)	106.3	2.18	25.47	55.98	4.82	4.33	12.69
T3 (Control)	165.9	2.07	24.94	44.24	4.57	4.10	10.93
SE (m)±	2.81	0.08	0.005	0.95	0.06	0.04	0.14
CD at 5%	8.22	0.23	0.015	2.79	0.17	0.14	0.43

Table 2 : Effect of different training systems on quality of fruit, yield and B: C ratio in Apple ber

Treatment	TSS (^{o}B)	Acidity (%)	Total sugar (%)	Ascorbic acid (mg/100g)	Fruit yield/plant (kg)	Fruit yield/ha (ton)	Increase in yield over control (%)	B:C ratio
T1 (Y-Shape)	15.64	0.12	11.34	89.30	63.44	18.27	58.04	3.52
T2 (Espalier)	13.60	0.13	10.56	87.20	46.58	13.42	16.08	2.58
T3 (Control)	13.29	0.13	9.50	71.15	40.13	11.56	-	2.21
SE (m)±	0.26	0.004	0.63	1.21	1.72	1.46	-	0.10
CD at 5%	0.54	NS	1.06	3.63	5.07	0.50	-	0.28

In addition, photosynthetically active radiation (PAR) was recorded from flowering to fruit maturity (November to February) phase and it was varied significantly according to the training system, wherein, maximum PAR (µmols^{-1}·m^{-2}) was recorded in T1 (Fig. 5). Modification of vine training systems to achieve a balance between vine vigor and yield has led to divided canopy systems that might simultaneously increase yield and improve fruit composition through optimization of canopy light microclimate (Reynolds and Vanden Heuvel, 2009).

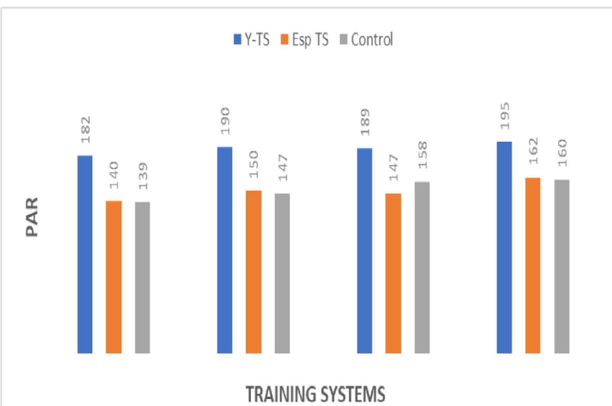

Fig. 5 : Effect of different training systems on PAR values (µmol s^{-1}·m^{-2}) in plant canopy

With respect to fruit yield parameters, highest fruit yield was recorded in T1 (63.44 kg plant^{-1} and 18.27 t ha^{-1}) followed by T2 (46.58 kg plant^{-1} and 13.42 t ha^{-1}), while, T3 *i.e.*, control treatment recorded lowest (40.13 kg plant^{-1} and 11.56 t ha^{-1}) yield. Increase in good quality yield over untreated control was recorded in T1 (58.04 %) followed by T2 (16.08 %). The economics of different treatments revealed significantly higher B: C ratio in T1 (3.52) (Table 2). These results are in partial agreement with the findings of Caruso *et al.* (1998) *i.e.*, trees trained to 'Y shape' yielded more and recorded highest fruit quality. Almost similar results were obtained by Palliotti (2012) who reported that vines trained to the 'Y system' recorded about 13% more fruit due to the 15% higher cluster weight and 13% berry mass compared to vertically shoot-positioned (VSP) vines over 5 years of study. Similar results were also obtained by Abrosca *et al.* (2017) who recorded the highest cumulative efficiency yield in slender spindle training system compared to the others *i.e.*, oblique palmette, free palmette, V-shaped, Tatura trellis, Bibaum, modified Bibaum, triple leader and Solaxe.

CONCLUSION

The performance of Apple ber cultivar on different training systems in hot arid conditions was studied. Based on the results, it can be concluded that Y-shape training system showed a significant positive effect on qualitative and quantitative growth parameters, light penetration into the canopy, fruit quality and yield attributes. Thus, Y-Shape training system can be a good option for yield and quality improvement in Apple ber which can fetch good market price for ber growers.

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