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Sweet cherry cultivars influencing the growth and productivity under HDP

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ABSTRACT

In a field experiment, to identify the best sweet cherry varieties for high density orcharding, maximum canopy volume (18.94 cm^3) was recorded in variety 'Steela' and minimum in 'Lambert' while, 'Bigarreau Napoleon' had maximum TCSA (213 cm^2). Trees grown under HDP have lower TCSA in comparison to normal density. Primary and secondary branch girth were maximum in 'Bigarreau Napoleon' whereas, annual extension growth and shoot thickness were high in 'Steela'. Yield, yield efficiency and cumulative yield efficiency were registered maximum in 'Bigarreau Napoleon' and 'Bigarreau Noir Grossa' cultivars. Largest fruit weight, fruit length and fruit diameter were found maximum (10.16 g/fruit), (25.51 mm) (25.20 mm) respectively in 'Bigarreau Napoleon'. Total soluble solids were found maximum in 'Bigarreau Noir Grossa' (17.30 ^{0}Brix) among the studied cultivars. Correlation matrix showed that TCSA had positive correlation with canopy volume, primary branch girth and secondary branch girth and fruit weight showed positive correlation with fruit length and fruit diameter.

Key words: Sweet cherry, *Prunus avium*, high density planting, TCSA, quality attributes, yield efficiency

INTRODUCTION

Sweet cherry (*Prunus avium* L.) an important stone fruit growing world-wide in temperate zone. Fruits are harvested in May-June, when no fresh fruits are available in the market, so it is sold at premium price. Sweet cherry fruits are consumed fresh as well as for processing purpose. The fruit has high medicinal properties and offers a good source of antioxidants. Total world's sweet cherry production was 2.25 mt out of it Turkey produced almost 20% of the world sweet cherry, whereas, highest sour cherry produced by Russia (1.98 MT), other important sweet cherry producers are USA, Iran, Spain, Italy, Chile, Romania, Uzbekistan, Russia, Greece (Anonymous, 2014). India produces 2.92 t ha^{-1} sweet cherry, which is far below than world average. Jammu and Kashmir is leading sweet cherry producer in India, accounting 2835 hectare area and 8282 mt production (2016-2017) (Anonymous, 2016). It is mainly grown in Srinagar, Ganderbal and Shopian, and sizeable area in Baramulla, Budgam, Anantnag in Jammu and Kashmir..

Cherry fruits are mainly used for table purpose and only 10% produce are used for processing purpose. Sour cherry fruits are smaller in size and bears 1-2 fruit per spur with acidic in taste. It is abundantly found at higher altitudes of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. The fruits are used for processing purpose and seeds for raising rootstock. The rootstock raised from the sour cherry have deep well developed tap root system, suitable for establishing orchard at adverse soil conditions where, clonal rootstocks won't do well. Most of the sweet cherry orchards in India have been raised on seedling rootstock of sour cherry (*Prunus pseudocerasus*), hence, they are heterozygous in nature. With the introduction of clonal rootstocks, most of the new plantations are coming up on high density system.

Rootstock has impact on growth, yield and quality attributes of the tree and hence, selecting a suitable rootstock is imperative for success of orchard. Dwarf trees have a greater proportion of well illuminated canopy, low spray solution and higher labor efficiency. Rootstock influenced the tree growth (Cantin *et al.,* 2010; Blazkova and Hlusickova, 2007), yield performance (Moreno *et al*., 2001), fruit quality (Whiting *et al*., 2005, Usenik *et al*., 2010, Lanauskas *et al*., 2012). Sansavini *et al*., (2001), reported, when 'Burlat 1', 'Durone Compatta di Vignola', 'Lapins' and 'Van' grafted on 20 clonal rootstock and planted in HDP system, bearing starts 4-5 years after planting and tree attained full bearing (10 kg tree^{-1}) after 7-8 years. The short statured trees are prone to frost damage. Semi dwarf rootstock gave best result rather dwarfing rootstock in apple. Apple cultivars 'Golden Reinders', 'Jonagored', 'Staymared', 'Braeburn' and 'Fuji' on M.9 rootstocks planted under HDP, orchard under HDP began early cropping, than low density (Guglielmo *et al*., 1997 and similar view was expressed by Wertheim *et al* (2001), that high density allows greater early productivity and earlier return on capital investment.

High early productivity in HDP is partly based on the fact that, greater leaf area per unit land area received greater light interception of photo synthetically active radiation (PAR), compared to lower density (Jackson, 1989). Tree height and canopy shape also influenced the light interaction and light penetration within the canopy. The present experiment was carried out with an aim to identify the best sweet cherry cultivars for intensive orcharding.

MATERIALS AND METHODS

Present experiment was carried out on 6-7 years old sweet cherry orchard at ICAR-Central Institute of Temperate Horticulture, Srinagar, J&K, during 2011 to 2013. The orchard was established in early spring 2003-04 on sour cherry (*Prunus reases*) rootstock. Well feathered grafted plants of 'Van', 'Lambert' 'Steela', 'Bigarreau Noir Grossa' and 'Bigarrean Napoleon' were planted at 3 x 3m (1111 trees ha^{-1}) at north-south row orientation, trained on modified central leader. Dormant pruning was carried out in February-March regularly for making balance in tree growth and flowering. Trunk girth was recorded 20 cm above union and primary and secondary branch girth, annual shoot thickness, annual shoot extension growth were recorded at cessation of tree growth by digital vernier caliper of 0-6 inch capacity. For recording total yields (t ha^{-2}), individual tree was harvest and weighted the yield on tree basis calculated. Yield efficiency and cumulative yield efficiency were determined as per the methods described by Fioravanço *et al*. (2016). Yield efficiency (YE) = Average yield per tree (kg)/ average TCSA (area of trunk cross section (cm^2) and cumulative yield efficiency (©YE) = sum of annual yield, area of trunk cross section (average of 3 years). Trunk cross sectional area was calculated by using standard formulae, TCSA=Girth^2/4π (Westwood 1970). Canopy volume (V) was determined from individual measurements of tree height (H) and width in parallel (Dl) and perpendicular (Dr) directions to the tree row, assuming that the tree shape was one half prolate spheroid, using the formulae: V = (pi/6) × H × Dl × Dr (Zekri, 2000). Other routine cultural practices were performed uniformly in all the trees. Fruits were harvested at proper maturity and twenty fruits were taken randomly for recording the fruit length (mm) and fruit breadth (mm) using digital vernier caliper. Weight of the fruit (g) was recorded as mean of 20 fruits using digital electronic balance. Total soluble solids contents (^{0}Brix) were assessed with hand refractometer at 20^0 C. Experiment were laid out in randomized block design with 4 replications and each replication comprised 2 trees. Data recorded were subjected to statistical analysis using O P Stat software for drawing the conclusion.

RESULTS AND DISCUSSION

Significant variations were observed on the canopy volume, maximum volume (18.94 m^3) was recorded in 'Steela' which was statistically on par to 'Bigarreau, Noir Grossa' and 'Bigarreu Napolean', minimum volume (5.39 m^3) noted in Lambert. As expected high TCSA (0.213 cm^2) were recorded in 'Bigarreau Napoleon' and 'Steela' (0.213 cm^2), whereas, minimum TCSA (0.086 cm^2) in Lambert. Variations in tree canopy volume and TCSA with respect to cultivars may be due to difference in genetic constituents of the cultivars. Higher the planting density lower the trunk cross sectional area (TCSA), as the tree density increases, TCSA decreases because of the competition among the closely planted trees (Musacchi *et al*., 2015). Melosevic *et al*., (2014) reported similar variation with respect to TCSA in different sweet cherry cultivars on semi dwarf and vigorous root stocks. Primary and secondary branch girth were found maximum in 'Bigarreau Napoleon' (49.61 and 33.14), which was on par to 'Bigarreau Noir Grossa' and 'Steela', and it was minimum (27.43 cm) and (15.44 cm) in Lambert (**Table 1**). AEG, tree canopy and annual shoot thickness (AST) have direct effect on tree canopy growth. AEG and AST were found maximum in 'Steela'. 79.17 cm and 8.47 cm and minimum 35.08 and 4.08 cm respectively found in 'Van'. Overall results showed that the cultivars which are vigorous in nature have higher AEG and AST.

Table 1. Tree growth parameters of sweet cherry varieties under HDP (3 years pooled data)

Variety	Tree growth parameters					
	Canopy volume (m^3) (cm)	TCSA (m^2)	Primary branch girth (cm)	Secondary branch girth	AEG (cm)	Annual shoot thickness (cm)
Van	7.41±0.23	0.103±0.003	39.52±1.12	19.79±0.44	35.08±0.78	4.08±0.12
Lambert	5.39±0.31	0.086±0.002	27.43±0.88	15.44±0.90	52.11±0.61	6.32±0.27
Steela	18.94±5.36*	0.208±0.003	48.40±1.71*	55.68±20.25	79.17±1.32*	8.47±0.17*
Bigarreau Noir Grossa	13.43±0.86*	0.164±0.003	45.73±0.59	27.06±0.57	68.30±3.80	7.65±0.24
Bigarreau Napoleon	12.84±0.20*	0.213±0.003*	49.61±0.80*	33.14±0.33	46.44±1.11	6.01±0.17
SEM ±	2.43	0.006	1.25	-	1.84	0.23
LSD (p= 0.05)	7.30	0.002	3.66	NS	5.47	0.69

It is obvious from **Table 2** that maximum yield (10.83 t ha^{-1}) was recorded in 'Bigarreau Napoleon' followed by 'Bigarreau Noir Grossa' (7.18 t ha^{-1}), which was statistically on par to 'Steela' and minimum yield (4.42 t ha^{-1}**)** was registered in Lambert. This indicated that 'Bigarreau Napoleon', 'Bigarreau Noir Grossa' and 'Steela' are most suitable cultivars for growing under HDP so for as yield attributes are concerned.

The responses to yield efficiency and cumulative yield per tree was significantly affected by cultivars (**Table 2**) being highest in 'Bigarreau Noir Grossa' (43.27 kg cm^{-2} TCSA) which was statistically on par to 'Bigarreau Napoleon' and 'Van'. The cumulative yield efficiency, more or less followed the pattern of yield efficiency over the years. 'Bigarreau Noir Grossa' exhibited highest (129.80 kg cm^{-2}) cumulative yield efficiency which was on par to 'Bigarreau Napoleon' and 'Van', 'Steela' and 'Lambert' showed minimum YE and cumulative yield efficiency (**Table 3**). Quality parameters showed significant variations, maximum fruit weight (10.16 g/fruit), fruit length (25.51 mm) and fruit diameter (25.20mm) were noticed in 'Bigarreau Napoleon', while as total soluble solids were found maximum in 'Bigarreau Noir Grossa'. Correlation matrix showed that TCSA had positive correlation with canopy volume, primary branch girth and secondary branch girth. AEG also exhibited significant positive correlation with AST and fruit weight showed positive correlation with fruit length and fruit diameter. Fruit weight has negative correlation with TSS as fruit weight increase TSS decreases (**Table 4**). These results are in consonance with the findings of Szot and Meland (2001) and Kappel *et al.* (1996). Similarly Manolova and Kolev (2013) observed that high density of Sweet cherry he observed that HDP exhibited greater precocity, high annual yield per unit area along with faster financial returns. Similar results were reported in some previous studies by Radunic *et al*., 2011, Aglar *et al.*, 2016; in contrary Srivastava *et al. (*2017) noticed low YE in HDP apple having 1600 trees ha^{-1} and high YE in 952 trees $ha^{-1.}$

It can be concluded that Steela exhibited maximum canopy volume, annual extension growth and annual shoot thickness over the years; however, yield efficiency, cumulative yield efficiency and TSS were found maximum in 'Bigarreau Noir Grossa'. Larrgest fruits were produced by 'Bigarreau Napoleon' cultivar. The 'Steela', 'Van', 'Bigarreau Noir Grossa' and 'Bigarreau Napoleon' can be selected for high density planting on the basis of tree growth, yield and quality attributes.

Table 2. Yield attributes of sweet cherry varieties under HDP (3 years pooled data)

Variety	Yield (t/ ha)	YE (kg/cm^2)	©YE (kg/cm^2)
Van	5.39±0.11	43.08±1.88*	129.23±5.63*
Lambert	4.42±0.16	31.93±1.28	95.78±3.85
Steela	7.05±0.39	31.27±2.30	93.80±6.91
Bigarreau Noir Grossa	7.18±0.23	43.27±2.15*	129.80±6.45*
Bigarreau Napoleon	10.83±0.45*	43.13±1.57*	129.38±4.73*
SEM ±	0.31	2.03	6.10
LSD (p= 0.05)	0.93	6.04	18.13

Note: Value represents mean ± S.Em; * indicates significant difference at LSD (*P* d" 0.05)

Table 3. Pearson's correlation matrix for tree growth and yield attributes

Factor	Canopy volume (m^3)	TCSA (cm^2)	PBG (cm)	SBG (cm)	AEG (cm)	AST (cm)	Yield (t/ ha)	Fruit length (mm)	Fruit diameter (mm)	Fruit weight (g)	T.S.S (^{0} Brix)
Canopy volume (m^3)	1.00										
TCSA(cm^2)	**0.90***	1.00									
PBG (cm)	0.84	**0.91***	1.00								
SBG (cm)	**0.95***	0.83	0.72	1.00							
AEG (cm)	0.78	0.52	0.36	0.72	1.00						
AST (cm)	0.75	0.57	0.36	0.69	**0.98***	1.00					
Yield (t/ ha)	0.54	0.85	0.81	0.43	0.06	0.17	1.00				
Fruit length (mm)	-0.14	0.32	0.20	-0.13	-0.49	-0.33	0.72	1.00			
Fruit breadth (mm)	-0.12	0.33	0.22	-0.10	-0.49	-0.34	0.73	**1.00***	1.00		
Fruit weight (g)	0.08	0.50	0.31	0.08	-0.24	-0.06	0.81	**0.96***	**0.96***	1.00	
T.S.S (^{0} Brix)	0.31	0.14	0.47	0.07	0.21	0.11	0.05	-0.46	-0.47	-0.48	1.00

Note: * and NS indicate significant and non-significant difference at LSD (*P* d" 0.05)

Table 4. Fruit quality attributes of sweet cherry varieties under HDP (3 years pooled data)

Variety	Fruit length (mm)	Fruit diameter (mm)	Fruit wt. (g)	T.S.S (° Brix)
Van	21.99±0.26	21.49±0.33	5.00±0.07	15.11±0.28
Lambert	22.50±0.08	21.89±0.14	6.44±0.20	11.11±0.44
Steela	21.25±0.28	20.75±0.32	5.70±0.15	13.73±0.50
Bigarreau Noir Grossa	21.54±0.06	20.80±0.10	5.50±0.19	17.30±0.13*
Bigarreau Napoleon	25.51±0.14*	25.20±0.08*	10.16±0.46*	12.68±0.36
SEM ±	0.21	0.25	0.23	0.35
LSD (p= 0.05)	0.65	0.75	0.69	1.03

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