Indian Journal of Agricultural Sciences **84** (2): 236–40, February 2014/Article

Effect of trunk cross sectional area of rootstock on growth, yield, quality and leaf nutrient status in apricot (*Prunus armeniaca*) cv CITH-Apricot-2

DINESH KUMAR[1], N AHMED[2], K K SRIVASTAVA[3] and T A DAR[4]

Central Institute of Temperate Horticulture, Old Air Field, Rangreth, Srinagar, J&K 190 007

Received: 16 May 2012; Revised accepted: 10 January 2014

ABSTRACT

Trunk Cross-sectional Area (TCSA) of rootstock of apricot tree is a simple and useful index for estimation of growth, yield and fruit quality of apricot. Studies were undertaken to find out the effect of TCSA of rootstock of bearing apricot trees indicated that canopy volume, fruit yield, quality and leaf nutrient status of apricot cv. CITH-Apricot-2 during 2010 and 2011. A progressive increase in canopy volume, fruit number, yield and leaf nutrient content were recorded with increasing TCSA of rootstock. Fruit weight and size decreased with increasing TCSA. The quality parameters such as TSS and TSS/acid ratio were also increased with increasing TCSA whereas acidity decreased with increasing TCSA. Thus, positive and linear relationship has been found with increasing TCSA for growth, yield, quality and leaf nutrient content while fruit weight, size and acidity content showed negative relationship in apricot.

Key words: Apricot, Fruit yield, Growth, Leaf NPK content, Quality, TCSA

Apricot *(Prunus armeniaca* L.) is one of the important stone fruit of temperate region of India, mostly grown in the states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand in an area of 18 400 ha with total production of 48 900 metric tonnes and national productivity is 2.65 tonnes/ha (NHB 2010). In J&K, it is cultivated over an area of 6051 ha with an annual production of 10310 metric tonnes and productivity is 1.70 tonnes/ha (Anonymous 2012) as compared to other apricot growing countries like Austria (33.46 tonnes/ha), Egypt (19.85 tonnes/ha) and Italy (12.94 tonnes/ha) respectively (FAO 2010). The chilling requirement of this crop ranges from 300 to 900 hours (chill unit) depending upon the variety. It is a nutritious fruit rich in vitamin-A (3600 IU), carbohydrate (11.6%), phosphorus (25 mg/100g) and calcium (20mg/100g) .The area under apricot cultivation is increasing in India due to its wider adaptability under changing climatic conditions.

TCSA of rootstock of fruit tree is a useful index for estimation of fruit yield and other parameters (Chapman *et al*. 1986). Several variations have been observed in the TCSA of apricot trees even when a single cultivar is planted on a large scale, which is mainly due to differences in root characteristics leading to nutrient uptake. The differences in trees size have shown differences in their performance in respect of growth and fruit yield (Oppenheimer 1960). The TCSA of the tree is directly related to transport of nutrient from root to different parts of the plant and the distribution of food materials from site of production to site of utilization (Hartmann and Kester 1989), which ultimately influences the vegetative growth and fruit yield. The purpose of our investigation was to determine the effect of trunk cross-sectional area of trees on growth, fruit yield, quality and leaf nutrient status under Kashmir climatic conditions of Jammu & Kashmir.

MATERIALS AND METHODS

The experiment was conducted on 7 years old trees of apricot cv. CITH-Apricot-2, planted at a spacing of 3.5m × 3.5m at Central Institute of Temperate Horticulture-ICAR, Srinagar, J&K, India. The Research farm at Srinagar is situated at a latitude of 34° 05'N and longitude of 74° 50'E and at an altitude of 1640 m above mean sea level. CITH-Apricot-2 is self fertile and early to mid season blooming type. Fruits are large, asymmetrical with slightly pointed beak, yellowish orange with redish on exposed surface, early maturing and superior quality (Sofi *et al.* 2010). The soils of this experimental field are silty loam (39.60% sand, 24.0% Silt and 36.40% clay; pH 7.5, 0.50% organic carbon, 462.1 kg N/ha, 9.59 kg P/ha and 278.85 kg K/ha) with poor drainage. The experimental farm falls under temperate region having cold conditions from November to February (Fig 1) and total

[1]Prinicipal Scientist (Fruit Science) (Email: dkches@rediffmail.com); [2]Director (Email: dnak59@rediffmail.com); [3]Senior Scientist (Fruit Science) (Email: kanchanpom@gmail.com); [4]Research Associate (Email: tanveer.dar30@yahoo.com)

average annual rainfall was 632.26 mm. Study was done for two consecutive years during 2010 and 2011 on the apricot. The treatment comprised of eight different TCSA of rootstock groups (86.70, 92.03, 99.15, 106.07, 112.24, 115.37, 118.35 and 121.09 cm^2) based on their trunk cross-sectional area at 15 cm above the ground. Two trees in each group with almost uniform trunk cross-sectional area were kept for recording observations in randomized block design with three replications. The trees were trained in Central Modified Leader system and pruning was done in dormant season (December –January month) depending upon the climatic condition. The trunk cross-sectional area of tree was calculated by using formula TCSA= $Girth^2/4p$ (Westwood *et al*.1963).

Observations on canopy volume, fruit number, size and yield were recorded during fruiting season. Fruit was harvested at maturity and yield per tree was estimated in kilogram. The productivity efficiency was calculated by formula:

$$\text{Productivity efficiency (kg/cm}^2\text{ TCSA)} = \frac{\text{Fruit yield (kg/tree)}}{\text{Trunk cross-sectional area (cm}^2\text{)}}$$

Fruit, stone and kernel size was determined by observing the length and diameter and measured by digital Vernier calliper. Ten mature fruits were randomly selected from each tree and pooled as per replication in all treatments for quality analysis. The Total Soluble Solids (TSS) of fruits was estimated by Hand Refractometer (0-93 range) and presented in terms of ^{0} Brix. To estimate TSS, fruit pulp was crushed in a pestle and mortar and then squeezed through a muslin cloth for extraction of juice. The titratable acidity expressed in terms of percentage of citric acid was recorded by titrating 2ml of juice against N/10 sodium hydroxide using phenolphthalein indicator. For total leaf number, leaf number per tree was counted at leaf fall stage and after collecting total leaf weight was calculated in kilogram per tree on dry weight basis. Leaf area was estimated by leaf area meter (Model-YMJ-B Portable). For nutrient analysis, leaf samples were collected as per the treatments from the middle portion of bearing shoots of the apricot tree (Singh *et al.* 2006). Fully developed 30 number of leaf samples were collected from the tree for estimation of major nutrients. The leaf samples were kept in hot oven for drying at 60 °C for 48 hr (Bhargava and Raghupati 1993). After drying the leaf sample ground to pass a 0.5 mm mesh and analysed for macro-nutrient content. Nitrogen, phosphorus and potassium were estimated by the modified micro-Kjeldahl Vanado-molybdate (Jackson 1967) and flame photometric methods respectively.The data were analyzed statistically as per Steel and Torrie (1986) and interpreted to develop the relationship between TCSA and growth, yield and quality.

RESULTS AND DISCUSSION

Plant growth and fruit yield

The data on tree canopy volume, fruit number, size and yield are presented in Table 1. The canopy volume of the trees increased with increase in the TCSA of tree. Significantly maximum tree canopy volume (33.12 m^3) was recorded when the TCSA was the highest (121.09 cm^2) and minimum canopy volume (20.46 m^3) was recorded with lowest TCSA (86.70 cm^2). There is positive and linear correlation between TCSA and volume of tree. The results are in conformity with the findings of Dhaliwal and Dhillon (2003). Fruit number and yield increased significantly with increase in TCSA area of tree. The trees with maximum TCSA recorded significantly higher fruit number (1450 number) and yield (81.54 kg/tree). The productivity efficiency also influenced by TCSA, maximum productivity efficiency (0.673 kg $^{-1}cm^2$ TCSA) of tree was recorded with both 118.35 cm^2 and 121.09 cm^2 TCSA of rootstock. Similar results were reported by Kumar *et al*. (2008) indicating that TCSA had significant and positive effect on fruit yield in guava and in Kinnow mandarin by Dalal and Brar (2012). Westwood and Roberts (1970) reported

Table 1 Effect of TCSA of rootstock on growth and yield of apricot cv CITH-Apricot-2

TCSA of rootstock (cm^2)	Tree volume (m^3)	Fruit number (/tree)	Fruit weight (g)	Fruit size (cm)	Fruit yield (kg/ tree)	Productivity efficiency (kg /cm^2 TCSA)
86.70	20.46	812	65.56	4.52 × 4.46	53.23	0.613
92.03	21.64	875	63.43	4.50 × 4.48	55.53	0.603
99.15	22.15	950	61.79	4.33 × 4.29	58.70	0.592
106.07	23.38	1100	60.53	4.21 × 4.15	66.50	0.627
112.24	24.03	1215	59.66	4.15 × 4.05	72.48	0.645
115.37	26.08	1302	58.77	4.11 × 3.98	76.51	0.663
118.35	30.15	1390	57.34	4.05 × 3.90	79.70	0.673
121.09	33.12	1450	56.24	3.87 × 3.75	81.54	0.673
LSD (P≤0.05)	6.33	303.5	4.72	0.23 × 0.25	10.19	
r with TCSA	0.877	0.983	–0.987	–0.975 × –0.981	0.997	

TCSA- Trunk cross sectional area of rootstock; r-Correlation coefficient

that cross-sectional area of trunk increases the yield in apple. The fruit weight and size decreased with increase in the TCSA due to more number of fruit/tree. Maximum fruit weight and size was recorded with minimum TCSA and it shows negative correlation. The improvement in fruit weight and fruit size due to lower TCSA might be attributed to the reduction in fruit number/tree which in turn diverted more nutrients for the development of limited number of fruits available on trees (Khan 1998).

Stone and kernel characters

Stone and kernel characters also influenced by TCSA of tree in apricot (Table 2). The stone weight and size; kernel weight and size increased with decreasing the TCSA. Maximum values were obtained with lower TCSA. Fruit weight and size is positively correlated to stone weight, size and kernel weight and size. The improvement in stone weight, size and kernel weight and size was due to lower TCSA might be attributed to the reduction in fruit number/tree, which in turn diverted more nutrients to the limited fruit number available on the tree. Stone weight is positively correlated with fruit weight. If fruit weight is more than stone weight will be more.

Fruit quality parameters

Data on fruit quality parameters like Total Soluble Solids (TSS), acidity and TSS/acid ratio as influenced by TCSA in apricot (Table 3). TSS and TSS: acid ratio increased with increasing the TCSA. Maximum TSS (14.5 ^{0}Brix) and TSS/acid ratio (27.88) in fruit was recorded from trees having highest TCSA. Similar results were also reported by Salvador *et al*. (2006) in apples. He observed that smaller fruit size had higher TSS probably because of lower cell volume and lower proportion of intercellular spaces. The fruit acidity decreased due to increase in the TCSA, maximum acidity (0.68%) was estimated with minimum TCSA. The fruit size decreased with increased TCSA, which might be due to the availability of less nutrients for the development of more number of fruits/tree. Similar relationship was also established by Kumar *et al.* (2008) in guava and Kumar and Pandey (2010) in banana.

Leaf area and dry matter

The total number, area and dry matter content in leaves were also influenced by TCSA (Table 4). The leaf number, area and dry matter content increased with increasing the TCSA. Maximum leaf number (8 935 nos/tree), leaf area (37.52 m^2/tree) and total leaf dry matter (3.53 kg/tree) were recorded with 121.09 cm ^{2} TCSA. Higher leaf number, leaf area and leaf dry matter contents were due to more uptake of nutrients from the soil and translocation through TCSA, which ultimately increased the photosynthetic activity

Table 2 Effect of TCSA on stone and kernel characters and tree biomass of apricot

TCSA of rootstock (cm^2)	Stone weigth (g)	Stone size	Kernel weight (g)	Kernel size (cm)
86.70	3.94	2.15 × 1.85	0.98	1.74 × 1.46
92.03	3.74	2.11 × 1.76	0.95	1.64 × 1.41
99.15	3.59	2.05 × 1.70	0.93	1.53 × 1.35
106.07	3.47	1.98 × 1.65	0.91	1.50 × 1.30
112.24	3.35	1.87 × 1.59	0.88	1.45 × 1.25
115.37	3.17	1.80 × 1.50	0.82	1.40 × 1.21
118.35	3.05	1.75 × 1.45	0.80	1.30 × 1.15
121.09	2.94	1.70 × 1.40	0.75	1.28 × 1.11
LSD (*P=0.05*)	0.42	0.21 × 0.22	0.11	0.21 × 0.18
r with TCSA	–0.932	–0.983 × –0.989	–0.949	–0.981 × –0.988

TCSA- Trunk cross sectional area of rootstock; r- correlation coefficient

Table 3 Effect of TCSA on quality characters of apricot cv. CITH-Apricot-2

TCSA of root stock (cm^2)	TSS (^{0}Brix)	Acidity (%)	TSS/acidity ratio
86.70	12.4	0.68	18.23
92.03	12.6	0.65	19.38
99.15	12.9	0.63	20.47
106.07	13.2	0.62	21.90
112.24	13.4	0.60	22.33
115.37	13.8	0.58	23.79
118.35	14.1	0.55	25.63
121.09	14.5	0.52	27.88
LSD (*P=0.05*)	1.02	0.08	
r with TCSA	0.968	–0.959	

TCSA- Trunk cross sectional area of rootstock; r-correlation coefficient

Table 4 Effect of TCSA on leaf number area and dry matter content in CITH-Apricot-2

TCSA of root-stock (cm^2)	Total leaf (number/tree)	Total leaf area (m^2 /tree)	Leaf dry matter (kg /tree)
86.70	2 452	10.29	0.97
92.03	3 251	13.65	1.28
99.15	4 251	17.85	1.68
106.07	5 123	21.51	2.02
112.24	6 531	27.43	2.58
115.37	7 654	32.14	3.03
118.35	8 252	34.65	3.26
121.09	8 935	37.52	3.53
LSD (*P≤0.05*)	2 125.5	11.32	1.45
r with TCSA	0.988	0.988	0.987

TCSA- Trunk cross sectional area of rootstock; r- correlation coefficient

of leaves. Similar findings were reported by Kumar *et al*. (2008), Kumar and Pandey (2010) and Strong and Azarenko (2000).

Leaf nutrient status

The nitrogen, phosphorus and potassium content of leaves during leaf fall stage as influenced by TCSA. Leaf NPK content increased with increasing the TCSA of tree. Maximum leaf N (1.28%), P (0.141%) and K (1.72%) were estimated with highest TCSA of tree. Higher leaf NPK contents were recorded due to increase in TCSA of apricot trees. Similarly, the increased leaf area and dry matter content might be responsible for improvement in the rate of photosynthesis and thereby enhanced growth rate of plants. The trees having higher TCSA might be responsible for higher uptake and translocation of nutrients from the soil to aerial part of the tree. Similar findings were reported by Kumar *et al*. (2008).

Correlation studies

Correlations drawn between different dependent and independent variables of plant growth in apricot revealed that the parameters of growth, yield and fruit quality were inter-related. Positive and significant correlation was observed between TCSA and tree canopy volume (0.877), TCSA and fruit number (0.983) and TCSA and fruit yield (0.997) whereas, there was negative correlation between TCSA and fruit weight (-0.987), TCSA and fruit size (–0.975 × –0.981), TCSA and stone weight (–0.932), TCSA and stone size (–0.983 × –0.989),TCSA and kernel weight (-0.949), kernel size (–0.981 × –0.988). Positive correlation was obtained between TCSA and TSS (0.968), whereas negative correlation (–0.959) was observed between TCSA and fruit acidity. Positive correlation between TCSA and leaf number (0.988), total leaf area (0.988) and leaf dry matter (0.987) was observed.

Table 5 Multivariate analysis of different parameters in apricot

Characters	Mean	Intercept	Corrected Model
Tree volume	25.13	15151.88	448.86
Fruit number	1096.00	28802886.00	2234918.00
Fruit wt	60.42	87599.33	252.47
Fruit size (L)	4.22	426.98	1.05
Fruit size(B)	4.13	409.86	1.48
Fruit yield	68.02	111053.53	2656.81
Stone wt	3.41	278.46	2.52
Kernel wt	0.88	18.48	0.14
TSS	13.37	4288.03	11.49
Acidity	0.60	8.74	0.06
Total leaf no	5806.00	809066100.38	121179664.63
Leaf area	24.38	14265.23	2153.27
Dry matter	2.29	126.27	18.99
Leaf N	1.16	32.22	0.14
Leaf P	0.14	0.47	0.03
Leaf K	1.59	60.96	0.17

Similar correlations were established in guava reported by Kumar *et al*. (2008).

Multivariate analysis of growth parameter

Multivariate analysis of growth parameters as influenced by TCSA of rootstock in apricot (Table 5). The growth parameters such as tree volume, fruit number, fruit weight, fruit size, stone weight, kernel weight, TSS, acidity, total leaf, leaf area, leaf dry matter and leaf NPK content were analyzed and found considerable variations in all the parameters.

It is evident from the results that the TCSA of rootstock had a pronounced effect on the canopy volume, fruit yield and quality of apricot var CITH-Apricot-2 under Kashmir condition.

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