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Effect of spacing on canopy microclimate, vegetative growth and yield attributes in guava (*Psidium guajava* L.)

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ABSTRACT

The present investigation was conducted to examine the effect of spacing on variation in canopy microclimate, vegetative growth and yield attributes in guava (cv. Allahabad Safeda). Oservations revealed that with wide plant spacing (from 6x2m to 6x4m), interception of solar radiation increased significantly. Similarly, with increase in spacing between plants, mean canopy temperature was need to increase while relative humidity decreased. Plant growth in terms of stock and scion girth, tree spread (N-S) and canopy volume increased with wide plant spacing, while tree height decreased with increase in plant spacing. Number of fruits per plant, yield per plant and fruiting density was higher at 6x5m and least in 6x2m spacing. Wider plant spacing was found to be better owing to maximum absorption of solar radiation and optimum microclimate in the orchard leading to better yield in plants, higher fruiting density and yield efficiency. However, yield/ha was maximum in 6x2m spacing during rainy season and in 6x3m spacing during winter.

Key words: Guava, plant spacing, microclimate, growth, yield

INTRODUCTION

Guava (*Psidium guajava* L.) is an important tropical fruit crop of India. Although area and production of guava gas increased in the last decade, there has been no significant increase in productivity. Therefore, to increase productivity level to its maximum potential, certain important strategies have been identified. These involve adoption of modern, innovative and hi-tech methods. It also includes planting at appropriate plant density, canopy management, quality planting material, support and management system, with appropriate inputs. High density plantations (HDP) have been attempted in various tropical, sub-tropical and temperate fruit crops. HDP technology results in maximization of yield per unit area. However, in high density planting, light interception and other microclimatic conditions (canopy temperature and relative humidity) are important aspects that directly or indirectly affect vegetative growth, yield and quality of the fruit. Guava has a higher proportion of 'shade' to 'sun' leaves and leaves are found photosynthetically inactive under deeper shade constituting an unproductive sink (Singh and Singh, 2007). Singh *et al* (2005) reported that light interception was higher in guava trees planted at wider spacing and decreased significantly with depth of the canopy irrespective of planting density. Therefore, the present investigation was initiated to study the effect of plant spacing on microclimatic parameters, plant growth and fruit yield in guava.

MATERIAL AND METHODS

Investigations were carried out at the Department of Horticulture, Punjab Agricultural University, Ludhiana (India). Plants of guava cv. '*Allahabad Safeda*' budded onto 'L-49' rootstock were planted with four spacings, viz., 6x2m, 6x3m, 6x4m and 6x5m. Observations were recorded on growth, fruiting and various meteorological parameters during both rainy (March-September) and winter season (October-February) crop.

Growth parameters in terms of stock girth, scion girth, tree height, tree spread (East-West and North-South directions) and tree canopy volume were recorded as per standard methods. Fruit yields in both rainy and winter season were recorded in terms of number of fruits per tree, yield per tree (kg), fruiting density (per m^3) and yield efficiency (kg/m^3).

Observations on light interception, canopy temperature and relative humidity were recorded at 15 day

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intervals from April to March by dividing the plant canopy into upper, middle and lower parts. Solar radiation was measured thrice a day at 8.00-10.00am, 12.00-2.00pm and 4.00-6.00pm using Pyranometer. Incoming solar radiation measurements (Calcm^{-2}min^{-1}) were made at 30cm above the canopy and at the centre of the upper, middle and lower parts of the tree by turning the face of the Pyranometer upwards. The Pyranometer was inverted at a height of 30cm above the canopy to point to the tree canopy below and, thus, the quantum of reflected shortwave radiation [Albedo (A)] was recorded. Radiation/light interception was calculated as difference between incoming radiation received in each of the three parts of tree canopy and was expressed as intercepted radiation at the particular time of observation.

$$\text{Radiation intercepted in the upper part} = \frac{I-(I_1+A)}{I} \times 100 = X\%$$

$$\text{Radiation intercepted in the middle part} = \frac{I-(I_2+A)}{I} \times 100 - X\% = Y\%$$

$$\text{Radiation intercepted in the lower part} = \frac{I-(I_3+A)}{I} \times 100 - (X\%+Y\%) = Z\%$$

Total light intercepted by the tree canopy = X+Y+Z

where,

I denotes the incoming solar radiation received 30cm above the top of tree canopy, and I_1, I_2 and I_3 in the upper, middle and lower parts of canopy , respectively.

Similarly, canopy temperature was recorded midway in the upper, middle and lower parts of trees with the help of an infra-red thermometer (Model AG-42) and Psychron (Belfort Inst. Company, Model No 556) was used to record dry and wet bulb temperatures. Relative humidity was calculated from dry and wet bulb temperatures using psychrometric tables on the same day and time as solar radiation and tree canopy temperature were recorded.

Table 1. Effect of plant spacing on vegetative characters in 'Allahabad Safeda' guava

Character	Plant spacing (m)				CD at 5%
	6x2	6x3	6x4	6x5	
Stock girth (cm)	40.16	43.50	43.75	47.50	1.18
Scion girth (cm)	37.50	38.33	40.08	46.30	1.10
Tree height (m)	3.98	3.92	3.76	3.49	0.05
Canopy spread (m) (E-W)	6.46	6.25	5.83	5.98	0.98
Canopy spread (m) (N-S)	3.00	4.05	4.72	5.31	0.05
Canopy volume (m^3)	46.79	54.87	55.23	58.35	1.23

RESULTS AND DISCUSSION

Vegetative growth: Stock and scion girth was significantly affected by different spacings (Table 1). With increase in plant spacing, stock and scion girth was found to increase. Maximum stock (47.50cm) and scion girth (46.36cm) was recorded in plants at a spacing of 6x5\m and minimum stock (40.16cm) and scion (37.50cm) girth was recorded in plants at a spacing of 6x2m. Increase in stock and scion girth with higher plant spacing may be due to less competition between plants for moisture, nutrients and sunlight. Similar results were reported by Singh and Bal (2002), Bal and Dhaliwal (2003) in plants of guava at a wider spacing. However, tree height decreased with increase in plant spacing. Maximum tree height (3.98m) was recorded at 6x2m spacing, while, minimum plant height (3.49m) was recorded at 6x5m spacing. It was observed that wider spacing reduced plant height perhaps due to greater availability of light and space. Yadav et al (1981), Bal and Dhaliwal (2003), Gaur *et al* (2005) and Singh *et al* (2007) also recorded reduced tree height in guava plants in wider spacing. Closest spacing, i.e. 6x2m, resulted in highest canopy spread (6.46m), followed by 6.25m spread at 6x3m spacing. Minimum canopy spread (5.83m) was observed in plants at 6x4m spacing. Canopy spread (N-S) was found to increase significantly with increase in plant spacing. Maximum mean tree-spread (5.31m) was observed in 6x5m spacing, which was significantly higher than in 6x3m and 6x4m spacings. This condition results in increased lateral growth at the expense of apical growth (Mohammed et al 1984). Mitra and Bose (1990) also observed greater spread between rows in guava at low-planting density. Singh and Bal (2002) reported maximum tree spread at wider spacing (6x6m) in E-W direction. Maximum mean tree volume (58.35m^3) was observed in plants at 6x5m spacing, followed by 55.23m^{3}at 6x4m spacing. Trees at closest (6x2m) spacing had minimum (46.79m^3) tree canopy.

Yield characters: In the rainy season crop (Table 2), highest number of fruits (521) was recorded in plants at wider (6x5m) spacing. In winter season, the number of fruits per tree recorded highest (130) at 6x4m spacing. Minimum number of fruits (61) was found in the closer spacing of 6x2m. Similarly, highest yield of 35.20kg plant^{-1} was obtained with 6x5m spacing during rainy season. Fruit yield was lowest (15.10kg plant^{-1}) at the closest spacing (6x2m). Similar trend was seen in the winter season. Higher fruit number and yield per tree in plants at wider spacing may be due to their larger canopies. Similar results were reported

Table 2. Effect of plant spacing on yield characters in 'Allahabad Safeda' guava

Treatment / Character	Plant spacing (m)								CD at 5%	
	6x2		6x3		6x4		6x5			
	R	W	R	W	R	W	R	W	R	W
Fruit numbers	256	61	299	110	392	130	521	115	67.2	15.3
Fruit yield (kg/plant)	15.1	6.83	18.1	13.4	25.9	17.3	35.2	16.2	4.64	2.24
Fruiting density	5.97	1.8	5.88	1.09	6.84	1.46	9.64	2.61	1.08	0.33
Yield efficiency	32.2	14.6	32.9	24.3	46.8	31.2	60.2	27.8	23.9	13.9
Yield / ha	12.5	5.69	10.6	7.44	10.74	7.21	11.97	5.40		

R- Rainy season; W- Winter season

by Chundawat *et al* (1992) and Kalra *et al* (1994) in terms of number of fruits and yield per tree in guava. Bal and Dhaliwal (2002) also obtained maximum fruit number per tree in 6x5m spacing in *Sardar* guava. Maximum fruiting density was recorded in 6x5m spacing. Lowest fruiting density during both rainy & winter seasons was obtained in plants at 6x3m spacing. Spacing had significant effect on yield efficiency in the rainy season crop. Yield efficiency significantly increased with increase in plant spacing. Maximum yield efficiency was recorded in 6x5m spacing during rainy season (60.2%) and in 6x4m spacing in the winter season (31.2%). Least yield efficiency (32.2% and 14.6%) was obtained in plants at 6x2m spacing in the rainy and winter season, respectively. Higher FBD, fruit set, fruit retention and optimum microclimatic conditions lead to higher fruiting density in plants at wider spacing. However, Singh and Bal (2002) reported maximum fruiting density in closer spacing in guava plants. Higher fruiting efficiency (yield/ ha) was lower at wider spacing (6x5m) compared to 6x2m spacing.

Solar radiation interception: Plant spacing had significant impact on total annual solar-radiation interception in guava trees. Significant increment in radiation received was recorded with increase in plant spacing from 6x2m (59.39%) to 6x4m (70.35%); but, under 6x5m spacing, it reduced to 68.77%. About 80% radiation was intercepted in the top one meter periphery of guava trees, followed by 15-20% in the middle, and, upto 5-10% in the lower parts of plant canopy during both rainy (Fig. 1) and winter (Fig. 2) crop seasons. Reduction in radiation interception at the closest spacing(6x2m) may be due the somewhat vertical orientation of axillary shoots and leaves, leading to reduced interception. Plants at 6x4m spacing were found to intercept higher amount of radiation due to increased foliage and relatively greater horizontal orientation of shoots and leaves. Reduction of solar radiation interception at the widest spacing (6x5m) may be due to presence of less dense foliage per unit exposed area. Higher tree-density leads to increased light interception

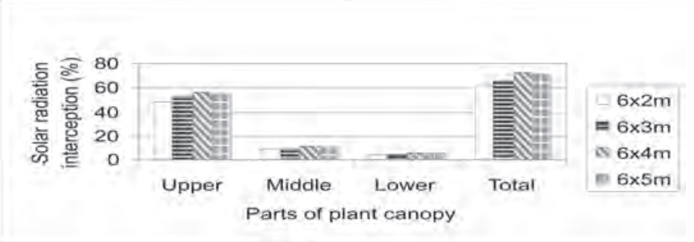

Fig 1. Effect of plant spacing on solar radiation interception during rainy season (March-September) in different parts of 'Allahabad Safeda' guava trees

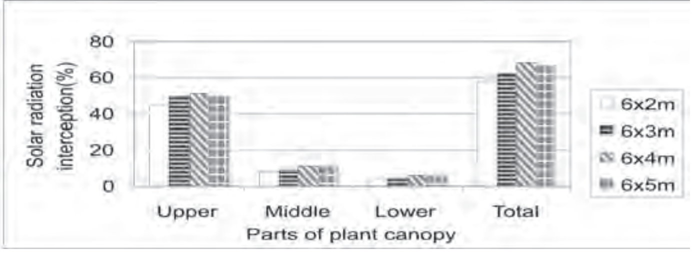

Fig 2. Effect of plant spacing on solar radiation interception during winter season (October- February) in different parts of 'Allahabad Safeda' guava trees

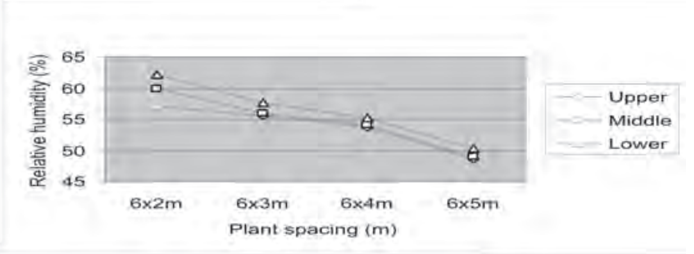

Fig 3. Effect of plant spacing on relative humidity during rainy season crop (March-September) in different parts of 'Allahabad Safeda' guava trees

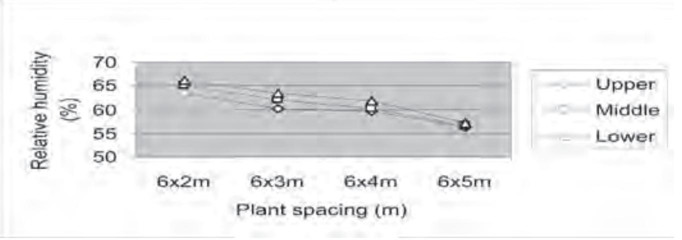

Fig 4. Effect of plant spacing on relative humidity during winter season crop (October-February) in different parts of 'Allahabad Safeda' guava trees

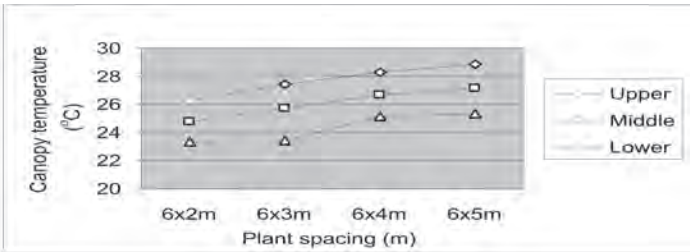

Fig 5. Effect of plant spacing on canopy temperature during rainy season crop (March- September) in different parts of 'Allahabad Safeda' guava trees

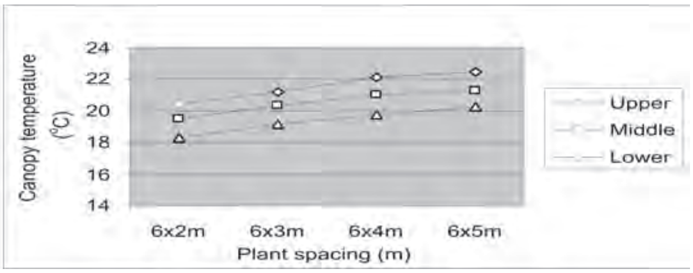

Fig 6. Effect of plant spacing on canopy temperature during winter season crop (October-February) in different parts of 'Allahabad Safeda' guava trees

through greater leaf area and a more even distribution of light (Palmer *et al*, 1992). Singh *et al* (2005) and Singh and Dhaliwal (2007) found that radiation interception by the guava tree increased with increased spacing. Other related findings are also in accordance with the present investigation, eg., intensity of full sunlight (100 per cent) available at the periphery of the round-headed apple tree canopy fell to 34% at a depth of 1m (Jackson, 1970, 1976) and 42% at a depth of 2m (Heinicke, 1966). In citrus, 90% of the incident solar radiation is absorbed by the first 3 feet (0.9m) of the tree canopy (Green and Gerber, 1967).

Relative humidity: Relative humidity (RH) in plants exhibited a trend opposite to that canopy temperature. RH reduced as spacing between plants increased. Maximum relative humidity (62.3%) was noted in the dense planting and minimum (53.0%) in the widest spacing. Relative humidity in the upper 1/3rd part of plant canopy was slightly lower than in the middle and lower parts of the canopy in the rainy season crop (Fig. 3) and winter season crop (Fig. 4). Relative humidity in the upper, middle and lower parts of plants was maximum at 6x2m spacing, i.e., 57.0, 60.0 and 62.1% during rainy season crop and 63.5, 65.2 and 66.1% during the winter season crop, respectively. Decrease in relative humidity with increase in plant spacing and depth of plant canopy may be attributable to greater penetration of solar radiation and increased circulation of air, leading to decrease relative humidity. In a similar study, Singh and Dhaliwal (2007) also recorded maximum average relative humidity in trees of guava cv. Sardar planted at the closest spacing.

Canopy temperature: Canopy temperature increased significantly with increase in plant spacing showing maximum temperature of 24.2°C in the widest spacing (6x5m) and minimum of 22.1°C at 6x2m spacing. Similarly, canopy temperature was found to decrease constantly with depth of the plant canopy. Higher temperature in plants at wider spacing and in the upper parts of plant canopies at all spacing levels may be ascribed toincreased solar radiation penetration. Lesser relative humidity may be due to greater hot-air circulation, leading to increase in temperature. Singh and Singh (2007) also reported that in guava cv. Allahabad Safeda, canopy temperature was maximum at 2.0m pruning height and minimum in the unpruned trees. Singh et al (2007) and Singh and Dhaliwal (2007) also in canopy temperature with increase in plant spacing.

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