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Effect of tree spacing on fruit quality attributes of guava cv. Shweta

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Abstract
Effect of tree spacing on fruit quality attributes of guava cv. Shweta was carried out to standardize the planting density with respect to fruit qualities. The present investigation reveals that with an increase in plant density from 333 (6x5 m) to 833 (4x3 m) plants per hectare, the acidity in the fruits increased during both the rainy and winter crop seasons while, the total soluble solid, total sugars, vitamin C and pectin decreased. In the winter season crop (September to February), the total soluble solid, acidity, total sugars, vitamin C and pectin were found to be higher as compared to the rainy season crop (March to August). The quality based on the acidity of guava was found to be negatively correlated with fruit weight, pulp weight, TSS, total sugars, vitamin C and pectin content in both season crops (rainy and winter) whereas, other parameters positively correlated with each other. The total soluble solid, acidity, total sugars, vitamin C and pectin were highest in the orchard with 333 plants/ha (6x5 m) and least in 833 plants/ha (4x3 m). It may be concluded that guava planted at 5x5 m (400 trees/ ha) had a significantly improved fruit quality as compared to trees planted at recommended spacing i.e., 6x5 m.

Keywords: Guava, high density planting, Shweta, spacing, fruit quality

Introduction
Guava (*Psidium guajava* L.) is a tropical fruit native to tropical America. It belongs to the family Myrtaceous. It is a rich source of vitamin C and a moderately good source of Calcium, Iron and Phosphorus (Tanmoy *et al.* 2016) [16]. Apart from this it also helps in boosting immunity in the growing COVID-19 pandemic (Ferooz, 2021) [3] and is also an excellent source of carotenoids, lycopene, pectin and polyphenols. Guava fruits are rich in antioxidants which are effective against free radicals and thus help in preventing various diseases such as cancer and different coronary diseases (Kuldeep *et al.* 2019) [4]. Being a rich source of various nutrients, having a good aroma along with a pleasant taste and being available at a moderate price, broad adaptability and higher return per unit area, it is a preferred crop among fruit growers. Guava has gained considerable prominence all around the world. Due to this, it is also known as “poor man’s apple”.

In the northern states of the country, guava flowers once in the month of April-May during rainy season and in August- September during winter season. Among these, the rainy season crop is heavily borne as compared to the winter season crop, but its quality is poor as it gets severely affected by different pests and diseases, majorly fruit flies, which causes major loss to the growers. Additionally, these fruits have poor nutritional value and storage quality. As opposed to the rainy season produce, the quality of the winter crop is significantly better, free of pests and diseases, has a long storage life and commands higher market prices (Rathore and Singh, 1976) [8]. Taking crop solely during the winter season is always beneficial owing to these factors. Fruits harvested in peak winter (mid-December to early January) tend to be harder and of lower quality than those harvested in November. Fruit drops occur throughout the month of January due to the cold temperature and frost, which makes farmers' issues worse. Hard and frost-damaged guava fruit sells poorly in the market, which results in financial loss for the growers. Keeping these factors in mind, it is vital to create the technology necessary to allow the fruits of guava to be harvested in the first week of November and continue through December. Fruit that is harvested during this time will be good quality, free of fruit fly damage and sell for a premium price to the growers (Singh, 2019) [14].

Guava is often grown for a long period of time i.e., 50 to 60 years through standard orchard management, but it is challenging to reach the optimum output levels after 20 to 25 years of

plantation. Older guava orchards produce fewer fruits due to the large tree size, which delivers low production per unit area and requires considerable labor inputs (Mohammed *et al.* 1984, Araujo *et al.* 1999, Singh *et al.* 2003) [7, 1, 12]. Moreover, these large trees often take a while to bear fruits, which further pushes up the overall cost of production per unit area. Guava tree crowding and encroachment, along with the consequent inefficient use of light, are clear issues, especially in older orchards (Shirsath, 2013) [9]. Guava has a larger ratio of "shade" to "sun" leaves, and in the denser shade, its leaves are observed to be inactive for photosynthetic activity and serve as an unproductive sink (Singh and Singh, 2005) [15].

A significant advancement in orchard management technology has been made to maximize fruit production. The precocity and improved productivity of high-quality fruits, along with a decrease in production costs and labor requirements, have nearly completely changed the fruit industry of guava (Mali, 2015) [6]. In the current scenario of commercial agriculture, because of the rapidly increasing land and labor costs along with the urging need for rapid returns on the capital invested, this trend of high-density planting is becoming sensational worldwide.

Materials and Methods

The study on the impact of Impact on fruit quality of guava cv. Shweta planted at different spacings (*Psidium guajava* L.) was carried out in the Fruit Research Farm, Department of Fruit Science, Punjab Agricultural University, Ludhiana during 2021-22. The observations were recorded on five-year-old plants of guava cv. Shweta was planted in September 2016 at different planting densities viz. 6x5 m, 5x5 m, 5x4 m, 5x3 m, 4x4 m, and 4x3 m. Each replication consisted of a unit of five trees. There were total of 90 experimental trees in this trial. Randomized block design was used to set up the experiment.

The observations were recorded on various quality characters of fruits. The quality characters of fruits of rainy as well as winter seasons were recorded in August-September and December-January, respectively during the year 2021-22. The fruit weight, pulp percentage, total sugars, total soluble solids, titratable acidity, vitamin C and pectin content were used to determine its quality characteristics. The data were subjected to analysis as per the standard procedure of Randomized Block Design and analysis of variance was computed by using SAS 9.3 version software.

Results and Discussions

The effect of different spacings on the fruit weight of guava in the rainy and winter seasons crops is shown in Figure 1. The plants produced the highest fruit weight at the widest (6x5 m) spacing 157.6 g and 163.1 g during the rainy and winter seasons respectively, which was at par with the 5x5 m spacing. Fruit weight was found to be lowest at the closest spacing (4x3 m) 130.3 g in rainy and 139.5 g in winter season crops. Similar results were found by the highest fruit weight observed in a wider spacing of 6x6 m (Singh and Bal 2002, Bal and Dhaliwal 2003) [13, 2]. Kundu, (2005) [5] noticed that the fruit weight in L-49 guava reduced from 134.4 to 125.7 g/fruit when planting density was increased from 278 to 1600 plants per hectare.

Likewise, the maximum average pulp percent of 91.56 percent and 93.72 percent were measured in 6x5 m spacing during rainy and winter seasons respectively, which was found to be at par with 5x5 m spacing. As the plants at the closest spacing of 4x3 m gave the lowest pulp percent content 74.73 and 70.37 percent, respectively. Singh and Bal, (2002) [13] studied the three distinct spacings in cv. Sardar and they found that at wider spacing the pulp weight of fruit was highest.

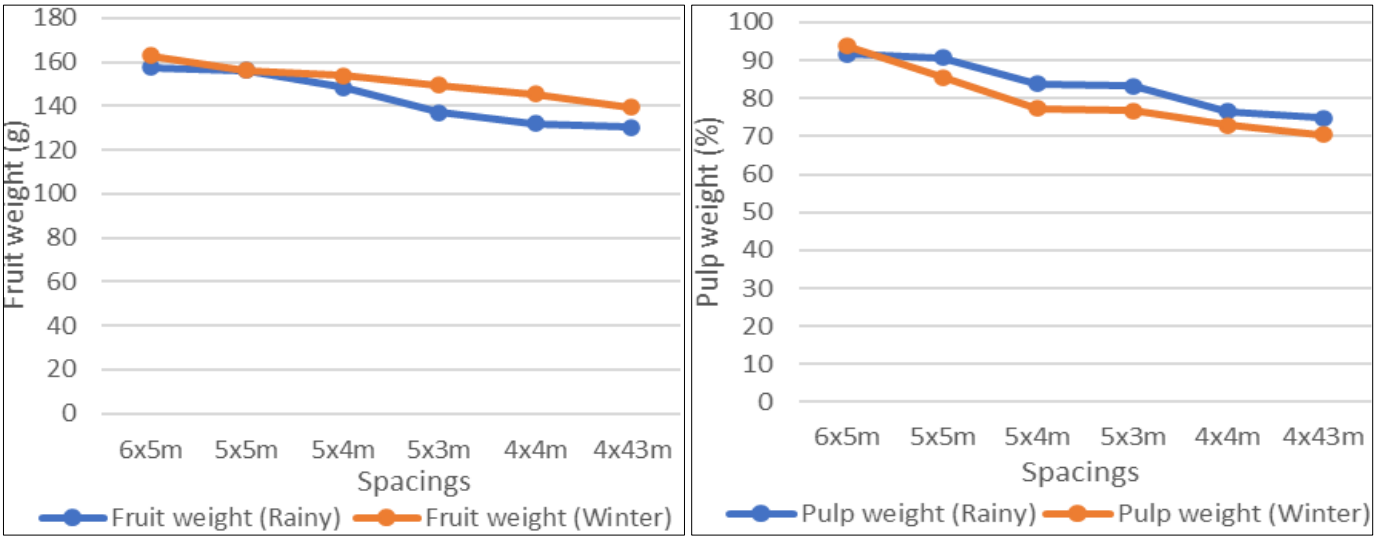


Fig 1: Effect on Fruit weight (g) and Pulp weight (%) of guava cv. Shweta under different spacings

The total soluble solid content, total sugars, vitamin C and pectin content of the rainy season was lower than crops grown during the winter season due to considerable fruit bearing during the rainy season, resulting in relatively low bearing in the winter season. The contents of fruits were higher at wider spacing as trees were fully exposed to sunlight to produce photosynthates which provide them with developing fruits. Trees with wider spacing had large root systems to get the greatest amount of vital nutrients from the soil.

In the rainy season crop, at widest (6x5 m) spacing resulted in a higher average TSS during both the cropping seasons (rainy and winter) and the least average TSS (7.6% and 10.9% in rainy and winter seasons, respectively) was recorded in the closest spacing of 4x3 m. These findings are consistent with

Tripathi, (2018) [17] observed a similar trend that the fruit quality in terms of TSS was considerably impacted by plant spacing. TSS content was significantly increased during both seasons (winter and rainy) with an increase in spacing. In comparison to all other spacings, the fruits obtained from the widest spaced trees at 6x6 m had the highest level of TSS.

The maximum average acidity was 0.46 and 0.53 percent in the rainy and winter season respectively noted in 4x3 m spacing. The plants at the wider spacing of 6x5 m measured the lowest acidity of 0.33 percent in rainy and 0.29 percent in winter season crops. Tripathi, (2018) (17) observed that fruit collected from trees that were spaced closely had more acid than fruit picked from trees that were spread widely.

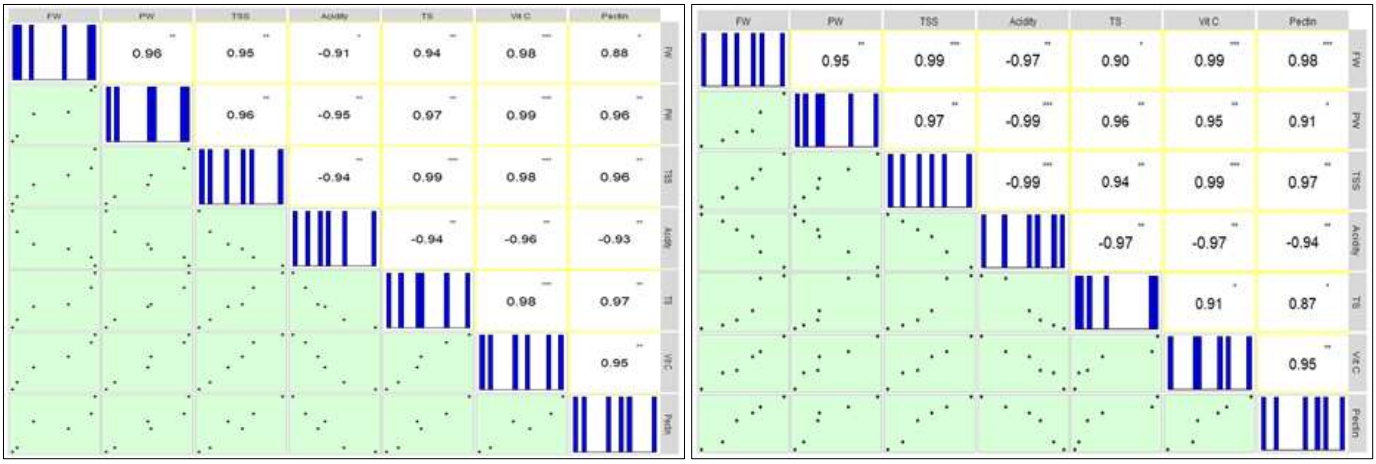
The effect of different spacings on guava cv. Shweta with respect to total sugar content is shown in Table 1 for the rainy and winter season crops. The average maximum total sugars content (6.51% in rainy and 8.42% in winter) of guava fruits were in the wider spacing of 6x5 m in both seasons and as planting density increased resulted in a decrease in total sugars content (lowest in 4x3 m spaced plants). Similar results were recorded by Singh and Dhaliwal, (2004) [11] who observed that the fruits picked from trees spaced at 6×6 m had considerably superior fruit quality in terms of total sugar than fruits picked from trees spaced at 6x4 m and 6x5 m. Singh, (2003) [10] the more vigorous and healthy trees that could produce more photosynthates and provide them to the developing fruits as a significant sink may be the cause of the larger amounts of sugars in the wider spacing.

In the rainy and winter season crop, the average vitamin C content of guava fruits was higher i.e., 204.7 and 228.1 mg per 100 g, respectively in the wider spacing of 6x5 m, which was found to be at par with 5x5 m in the rainy season crop and least were 155.4 and 172.6 mg per 100 grams, respectively in closely spaced (4x3 m) plants. Similarly, Tripathi, (2018) [17] recorded that fruit quality in terms of vitamin C was considerably impacted by plant spacing. Vitamin C content was significantly increased during both seasons (winter and rainy) with increased spacing. In comparison to all other spacings, the fruits obtained from the widest spaced trees at 6x6 m had the highest levels of vitamin C content.

Table 1: Effect on Total Soluble Solid, Acidity, Total Sugars, Vitamin C and Pectin of guava cv. Shweta under different spacings

Characters	Plant Spacings													
	6x5m		5x5m		5x4m		5x3m		4x4m		4x3m		CD at 5%	
	Rainy	Winter	Rainy	Winter	Rainy	Winter	Rainy	Winter	Rainy	Winter	Rainy	Winter	Rainy	Winter
Total Soluble Solid (%)	9.9	12.6	9.1	12.1	8.8	11.8	8.4	11.5	7.9	11.2	7.6	10.9	**0.60**	**0.92**
Acidity (%)	0.33	0.29	0.35	0.36	0.37	0.43	0.38	0.46	0.41	0.50	0.46	0.53	**0.02**	**0.01**
Total Sugars (%)	6.51	8.42	6.32	8.31	6.11	7.24	6.08	6.92	5.92	6.74	5.82	6.65	**0.23**	**0.40**
Vitamin C (mg/100 g)	204.7	228.1	198.1	211.9	185.1	206.1	175.2	192.3	161.9	189.1	155.4	172.6	**9.39**	**14.49**
Pectin (%)	0.98	1.01	0.89	0.97	0.81	0.95	0.85	0.92	0.71	0.84	0.69	0.81	**0.01**	**0.02**

The average pectin content was found higher in the winter season crop than in rainy season crops. In the wider spacing plants, pectin content noticed was 0.98 and 1.01 percent in rainy and winter seasons crop, respectively. This was found to be significant to other spacings and the least amount of pectin (0.69% in rainy and 0.81% in winter) was recorded in the closer spacing of 4x3 m. Similar results were observed by Singh, (2003) [10] observed that pectin content was found to be much greater (l.07%) in fruits picked from trees at wider spacing (6x2 m) than in fruits picked from trees at closer spacing (6x4 m). Seasonality has an impact on pectin content as fruits taken in the winter have much more pectin than those picked in the rainy season crop.



*FW- Fruit weight, PW- Pulp weight, TSS- Total Soluble Solid, TS- Total Sugars and vit. C- Vitamin C

(a) Rainy season (b) Winter season crop

Fig 2: Pearson's correlation coefficients of Fruit weight, Pulp weight, Acidity, TSS, Total sugars, vitamin C and pectin

The correlation studies have revealed a significant relationship between planting densities and fruit quality. The quality based on the acidity of guava was found to be negatively correlated with fruit weight, pulp weight, TSS, total sugars, vitamin C and pectin content in both seasons of the crop (rainy and winter) as shown in Fig 2. This clearly indicates that as planting densities increase from 6x5 m to 4x3 m, the acidity content in fruits increases, while others

decrease. Whereas other quality parameters were positively and significantly correlated with each other. The highest correlation in the rainy season crop was observed between Total Sugars and TSS (r = 0.99***), Whereas in the winter season crop, the highest positive correlation was observed between TSS and Vitamin C (r = 0.99***).

Conclusion

It may be concluded that guava planted at 5x5 m (400 trees/ ha) had a significantly improved fruit quality as compared to trees planted at recommended spacing i.e., 6x5 m.

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