



**Full Length Article**

## Pollen Parent Enhances Fruit Size and Quality in Intervarietal Crosses in Guava (*Psidium guajava*)

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### Abstract

Elite commercial guava cultivars Round and Pyriformed were reciprocally crossed to develop hybrids. The crossed fruit was analyzed to explore metaxenial effects on fruit quality. Use of cv. Round as pollen parent markedly enhanced different fruit quality related attributes including fruit diameter (up to 25.4%), Total soluble solids (4.01 Brix), titratable acidity (0.12%), ascorbic acid (upto 64 mg net increase per 100 gm pulp than female parent), total and non-reducing sugars (5.86% and 4.52%) in cv. Pyriformed. Since cv. Pyriformed has more fruit weight, its use as female parent with pollens from cv. Round enhanced fruit weight up to 10 gm per fruit. These findings suggest that cv. Round is more appropriate candidate as pollen parent when crossed with cv. Pyriformed and has strong metaxenial effect thus enhancing guava fruit size and quality. © 2013 Friends Science Publishers

**Keywords:** Metaxenia; Breeding; Qualitative characters; Pakistan; Guava

### Introduction

Guava (*Psidium guajava* L.) is a perennial tree fruit of tropics and subtropics offering great economic potential (Pathak and Ojha, 1993; Kosky *et al.*, 2005). It is commercially cultivated in Pakistan, Bangladesh, India, Thailand, Mexico, Brazil, USA and several other countries of the world (Watson and Dallwitz, 2007). Guava fruit is very popular owing to its delicious taste, high nutritional value and low price. The fruit is a rich source of citric acid, minerals and vitamins particularly vitamin C, which is even higher than oranges (Rahman *et al.*, 2003; Adrees *et al.*, 2012).

Leading world producers of guava include India and Mexico (Adsule and Kadam, 1995). Guava is the fourth most abundantly produced fruit crop in Pakistan with 0.55 million tons annual production. However, the per hectare yield of guava in Pakistan is merely 9 tons ha<sup>-1</sup> compared with leading world champs in guava production like Taiwan (30 tons ha<sup>-1</sup>) and Brazil (21 tons ha<sup>-1</sup>; FAO 2009; www.faostat.org). Among many other factors responsible key factors include seedling based guava industry that produces highly heterozygous plant population and lack of crop improvement programs. The availability of uniform plant progenies in bulk is only possible through efficient *in vitro* clonal propagation of selected elite plant material.

High heterozygosity could be a merit if stringent selection is made and selected plants could be used as parents for future breeding programs. Hybridization in guava holds great potential despite its heterozygous nature. Seedlings give same phenotype and it is mistakenly assumed that cultivar is genotypically homozygous. Wide

genetic variation could be obtained by employing hand pollination and using the external sources of variation (Zipori *et al.*, 2007). India and Cuba initiated breeding programs amongst selected germplasm and different guava cultivars have been commercially released as an outcome (Patel *et al.*, 2007; Rodriguez-Medina *et al.*, 2010). The hybrid guava significantly increased crop production resulting in an increased economic return to the farmers and ultimately to the countries.

It is known fact that pollen parent have strong impact on physical and biochemical quality of fruit as reported in some fruit crops like date (Al-Obeed and Abdul-Rehman, 2002; Awad and Al-Qurashi, 2012), apple (Nebel and Trump, 1932; Bodor *et al.*, 2008), blueberry (da-Silveira *et al.*, 2011), avocado (Robbertse *et al.*, 1996), loquat (Xu *et al.*, 2007) and certain nut crops like pecan, pistachio (Sedgley and Griffin, 1989), walnut (Golzari *et al.*, 2010) and almond (Sanchez-Perez *et al.*, 2012). Direct effect of pollen grain on the physical and chemical characteristics of the fruit is known as metaxenia. The metaxenial effect is reported to alter fruit ripening behavior, fruit size, color, fruit quality, fruit weight and seed weight in date (Al-Delamiy and Ali, 1970; El-Ghayaty, 1983; Abdelal *et al.*, 1983). Use of sweet pollinizer in almond is reported to reduce amygdalin content causing bitterness in almond up to 21% (Sanchez-Perez *et al.*, 2012). However, there is no known report on metaxenial effect of pollen parent in guava.

In Pakistan there is no work reported regarding any breeding program in guava and a few reports are available in the world. Above account of literature highlights potential of breeding in guava germplasm development. Thus, there

is a dire need to initiate indigenous guava hybridization program to select elite lines and hybridize them to come up with a high yielding better fruit quality guava cultivar. We initiated a comprehensive program of selection, breeding and clonal propagation in guava to widen its germplasm base. Here we present findings of metaxenial effect of pollen parent on the physico-chemical properties of guava fruit as first report.

## Materials and Methods

### Plant Selection and Pollination

Guava hybridization was carried out in guava cultivars round and pyriformed (cv. Gola and cv. Surahi, respectively) in the Experimental Fruit Garden Square No. 9 of the Institute during 2008-2009. Un-opened floral buds of mature bearing branches from 4-5 years old plants were selected for pollination. Anthers from the unopened floral buds of the female parent were completely removed by sharp pointed forceps. Anthers of buds used as male parent were dried in shade for dehiscence. Reciprocal crosses were made following Negi and Rajan (2007) in the indigenous guava cultivars round and pyriformed (cv. Gola and cv. Surahi, respectively) as 200 crosses per parentage (Total 400 crosses). Data were collected to record effect of pollen parent on fruit quality for following parameters in crossed fruit.

### Physical Characteristics

Fruit length and diameter at maturity (mm), fruit firmness, fruit weight, pulp weight, seed core weight and pulp to core ratio were studied in randomly selected fruits (20 per plant) from each plant of different genotypes and their crosses. Average of 20 fruits was calculated and data were subjected to statistical analysis.

### Biochemical Characteristics

All the fruits of each replication were peeled off with a stainless steel knife. The juice of the guava fruits (20 grams in 40 mL distilled water) was extracted from each sample (small choked pieces blended in juicer machine by diluting two times with distilled water) and homogenized to study the biochemical parameters i.e., Total Soluble Solids (TSS), titratable acidity, sugars (total sugars, reducing and non-reducing sugars) and ascorbic acid.

**TSS, TA and TSS:TA ratio:** The TSS of the guava juice were estimated at harvest. Digital refractometer (RX 5000, ATAGO, Japan) was used for the determination of total soluble solids (TSS) and were expressed as °Brix. Percent total titratable acidity was determined following Hortwitz (1960). The TA of the fruit juice was determined by titrating the sample to pH 8.2 with 0.1 N NaOH by adding 2-3 drops of phenolphthalein (C<sub>20</sub>H<sub>14</sub>O<sub>4</sub>) as an indicator and was expressed as % citric acid. The TSS:TA ratio was calculated

by dividing TSS by corresponding TA value.

**Sugars:** The fruit sugars were described as the sum of reducing and non-reducing sugars (Hortwitz, 1960) to estimate the pulp sugars.

**Ascorbic Acid:** Ten ml of juice was diluted with 0.4% oxalic acid solution and 5 mL of filtered aliquot was titrated against 2, 6-dichlorophenol indophenol dye to light pink color end point. Ascorbic acid contents were determined as mg 100 mL<sup>-1</sup> FW as reported by Ruck (1969).

### Statistical Analysis

The experiment was laid out in RCBD. Treatment means were compared with using Duncan's Multiple Range Test (Steel *et al.*, 1997) and data were subjected to statistical analysis using MSTAT-C software (Russel and Eisensmith, 1983).

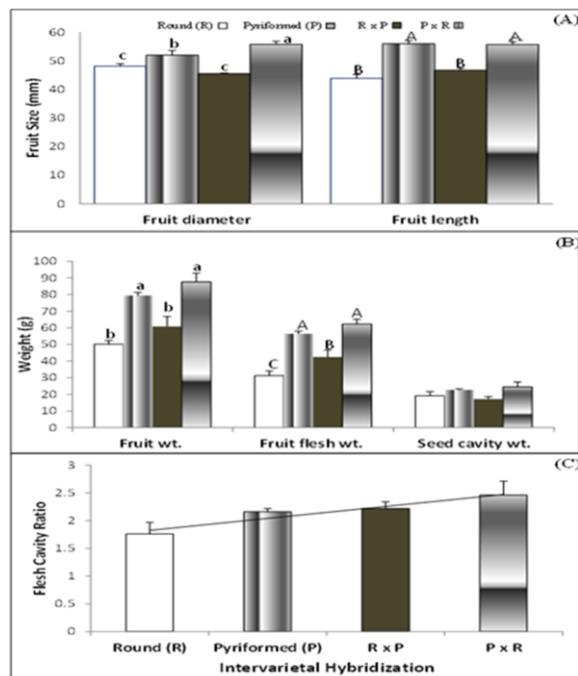
## Results

### Physical Characteristics

As regards fruit size the effect of use of pollen parent was found to be more profound in terms of fruit diameter compared with fruit length. The pollens of cv. Round showed an increase in fruit diameter when used as female parent (55.77 mm) rather than male parent (45.50 mm). However, this trend was not observed in fruit length. Fruit length of the female parent dominated over male parent in both crosses as well (Fig. 1A). These findings suggest that fruit diameter could be enhanced using cv. Round as male parent rather than female parent with cv. Pyriformed.

Data on fruit and pulp weight, seed core weight and pulp/core ratio showed that intervarietal hybridization had significant impact on fruit weight in parents and hybrids. Though 8-10 gm per fruit increase was observed in fruit weight in parents and hybrids compared with the female parent in both cultivars however, the rise was statistically non-significant (Fig. 1B). Both cultivars showed increase in the fruit pulp weight however, this increase was more significant when cv. Pyriformed was used as male parent compared with Round as female parent. No significant change was observed in the seed core weight and pulp/core ratio in reciprocal crosses compared with their parentage. These findings highlighted that fruit pulp weight can be enhanced when cv. Pyriformed is used as male parent compared with cv. Round as male parent.

Cultivar Pyriformed was significantly low in TSS and TA (2.94 °Brix, 0.08%) compared with cv. Round (3.69 °Brix, 0.09%). Use of Round as pollen parent significantly enhanced the TSS and TA (4.01 °Brix, 0.12%) and reduced the TSS/TA ratio (Fig. 2A-D) thus, enhancing taste in elite guava cultivar Pyriformed making fruit slightly acidic reducing its pH from 4.39 to 4.15 (Fig. 3A-B). Use of different pollen parent did not show any significant impact on fruit firmness; though, a sharp rise was observed in the



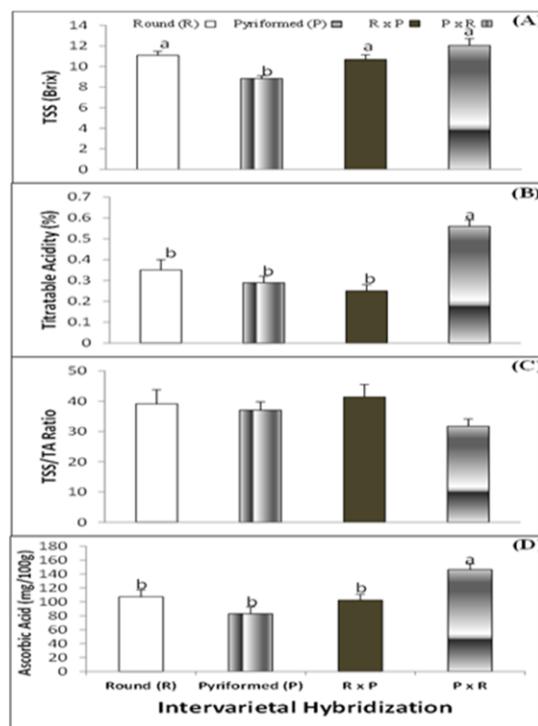
**Fig. 1A-C:** Pollen parent effect on fruit size (A) and weight attributes (B-C) in intervarietal hybridization in guava  
 Bars sharing different letters in a fig. are significantly different from each other at < 5% probability using DMR test

vitamin C content of the cv. Pyriformed when used as female parent suggesting that the pollen source holds great potential enhancing ascorbic acid content of cv. Pyriformed (Fig. 2A-D). This finding was further confirmed when cv. Pyriformed was used as pollen parent that drastically reduced the ascorbic acid content in cv. Round.

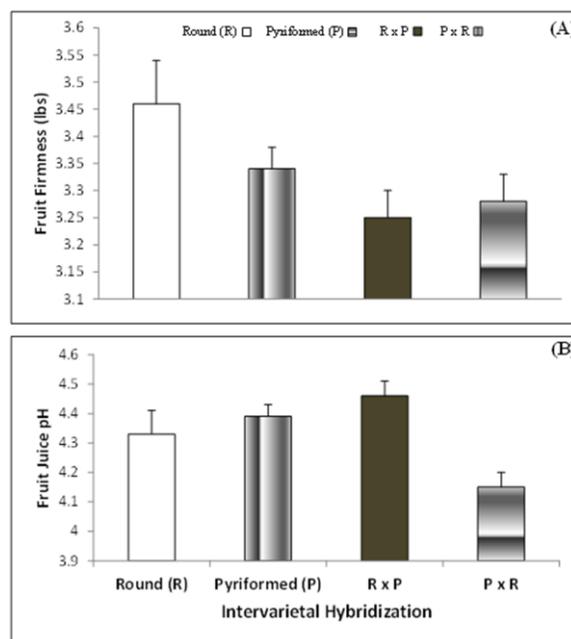
Significant differences were observed for total sugars, reducing and non-reducing sugars among parents and crossed fruit. In all the three related characters, significant increase was observed in sugar content when cv. Round was used as pollen parent with Pyriformed as egg donor (5.86, 1.09 and 4.52, respectively) suggesting that pollen parent plays significant role in fruit development and effects sugar contents as well (Fig. 4A-C).

### Discussion

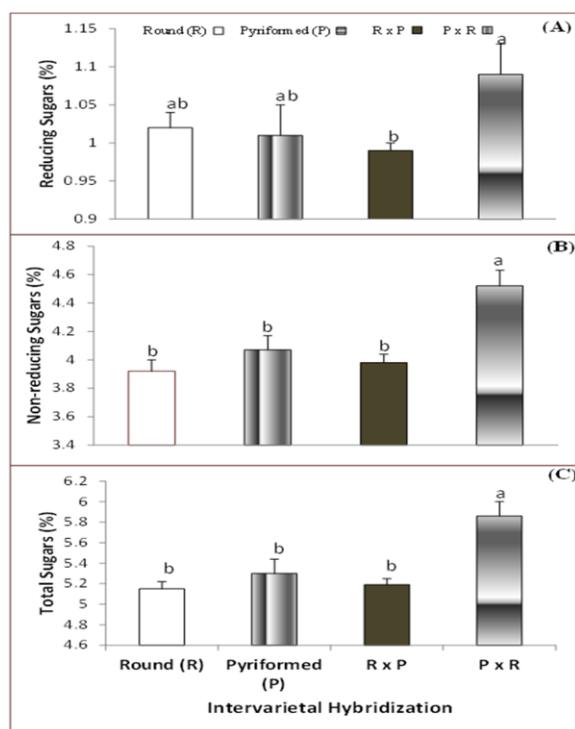
Pollen source plays a pivotal role in the fruit ripening, fruit development and quality and this effect is known as metaxenia. Since fruit development is regulated by hormones produced by seed, the pollen genotype could directly influence fruit size and Metaxenia is reported in date (Al-Obeed and Abdul-Rehman, 2002), apple (Nebel and Trump, 1932; Bodor *et al.*, 2008), blueberry (da-Silveira *et al.*, 2011), avacado (Robbertse *et al.*, 1996) and loquat (Xu *et al.*, 2007). There is no report in literature



**Fig. 2A-D:** Pollen parent effect on TSS (A), Acidity (B), TSS/TA ratio (C) and Ascorbic Acid content (D) in intervarietal guava hybrids  
 Bars sharing different letters in a fig. are significantly different from each other at < 5% probability using DMR test



**Fig. 3A-B:** Pollen parent effect on fruit firmness (A) and fruit juice pH (B) in intervarietal guava hybrids  
 Bars sharing different letters in a fig. are significantly different from each other at < 5% probability using DMR test



**Fig. 4A-C:** Pollen parent effect on reducing (A), non-reducing (B) and Total Sugars % (C) in intervarietal guava hybrids

Bars sharing different letters in a fig. are significantly different from each other at < 5% probability using DMR test

about pollen parent effect on the maternal tissues in guava fruit. We observed strong metaxenial effect on fruit size and fruit quality. Pollen parent Round significantly enhanced fruit diameter compared with fruit length. In fruit weight and pulp weight, pollen parent cv. Pyriformed gave better response compared with cv. Round and showed 9-10 gm rise in weight per fruit. TSS and TA were also increased using cv. Round as pollen parent however, TSS/TA ratio was better when cv. Pyriformed was used as pollen parent with cv. Round. Interestingly vitamin C content was markedly enhanced up to 15 mg/100 g of fruit. Similar trend was observed in total sugars and upto 0.6% rise in total sugars was observed. Similar to our findings pollen source increased fruit diameter and TSS in Powderblue cv. of Blueberry (da- Silveira *et al.*, 2011) and authors concluded that pollen source strongly influence the fruit quality. In support to our results increase in fruit size is also reported by Ansari and Davarynejad (2010) in Hungarian Sour cherries. Pollen genotype plays very important role in fruit maturity and fruit size as reported in date (Al-Khalifa, 2006; Muhtaseb and Ghnaim, 2006). In loquat, out crossing significantly increased fruit weight only when cv. Moriowase, Baili, Golden Nugget and Taicheng were used as pollen source and there was no increase in loquat fruit size in contrast we found a marked rise in guava fruit diameter.

Conclusively, use of cv. Round as pollen parent showed better fruit size and quality compared with cv. Pyriformed as pollen parent suggesting that fruit quality of cv. Pyriformed could be further enhanced using Round as male parent. These findings suggest that pollen source play a key role in fruit development and maturity however, causes of metaxenial effect yet need to be further explored.

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