# Residual Effect of Partial Girdling on Quality of Satsuma Mandarin Fruit

A.K. Shrestha[1] and W. Kibet[2]

## ABSTRACT

*An experiment was carried out to evaluate the residual effect of partial girdling on fruit quality and bark recovery of Satsuma mandarin three years after the date of girdling operation. In 2003, fruit trees located in the University Farm of Ehime University received the girdling treatment of 10 cm and 20 cm width to compare the effect with ungirdled (control) branch. After three years, the bark recovery was found to be significantly higher in the branches that received girdling of 10 cm width than 20 cm girdling treatment. The fruit size, total soluble solid content and the titratable acidity were not significantly different among the three treatments. However, the largest fruits (98.4±3.52 g) were obtained from the ungirdled branch while the highest brix (10.5 ± 0.25 %) was recorded in the fruits harvested from the 10 cm girdled branches.*

Key Words: **Acidity, Brix, Girdling, Satsuma mandarin**

## INTRODUCTION

Satsuma mandarin (*Citrus unshiu* Marc.) is the leading seedless citrus species in Japan owing to its excellent fruit quality and easiness . However, citrus production in Japan has been declining since 1970 due to competition both by citrus exported from other countries and other fruits like apples, bananas, melons and strawberries. In addition, citrus fruits face competition from industrial/processed products like candy, soft drinks and ice creams, which are more preferred by younger people (Iwagaki, 1995). Therefore, Japanese citrus growers are expected to produce high quality Satsuma mandarin in order to achieve handsome profits (Morinaga et al., 2005). In general, consumers prefer fruits of medium to large size (Wright, 2000; Harty and Anderson, 1997) containing 10-14% sugars and about 1-0.8% titratable acid (Morinaga et al., 2005; Harty and Anderson, 1997). The qualities including the TSS and size of fruits at harvesting are of considerable importance in commercial cultivation since these aspects influence the marketability of fruit.

Improvement in quality of fruit like higher sugar content in a fruit can be achieved either by decreasing water or increasing carbohydrate availability to fruit along with increase in fruit sink strength. It has been observed that water stress during ripening concentrates fruit sugar resulting fruits with higher TSS (Iwagaki 1997). Candido et al. (2000) found higher t soluble solids in unirrigated fruits of tomato than in irrigated plots. Kriedemann and Ian (2003), reported that Brix in over watered 'Okitsu' Satsuma mandarins were lowest (7.7 %) while water stressed trees produced fruits with the highest Brix (13.2 %), the fruit size however reduced with water stress.

[1] Institute of Agriculture and Animal Science, Rampur, Chitwan, Nepal

[2] Ehime University, Matsuyama, Japan

Carbohydrate partitioning to the fruit is considered as one of the principal factors influencing the fruit growth (Wright, 2000). It is commonly accepted that the availability of carbohydrates to any particular fruit is dependent upon the presence of carbohydrate source, i.e. leaves and the number of competitive sinks such as other fruit, rapidly growing shoots and roots. Elimination of competition for the carbohydrate to other parts than the growing fruits is one of the primary methods for improving the fruit quality. Girdling has been tried in several fruit species to improve fruit quality. It involves the removal of a ring of a bark from a trunk or major limbs of a fruit tree hence blocking the downward transport of photosynthates and metabolites through the phloem to the roots, resulting in more carbohydrates being available for the fruits and young leaves/shoots (Wright, 1996; , Li et al., 2003; Onguso et al., 2005). The size of the girdled portion vary from a single cut without removing a bark to larger sizes that involves removal of a strip of bark of up to 20 cm or more. The technique involves temporary disruption of the conductive vessels, the phloem that carry carbohydrates to the roots. It has also been stated that this practice intensifies the moisture stress in the plant (Goell and Cohen, 1981). In peach, rambutan, 'Ponkan' mandarin and sour orange girdling increased carbohydrates above the girdled portion and reduced it below the girdle ( Poerwanto and Irdiastuti, 2005; Onguso et al., 2005) which benefits the sinks above the girdle - the fruits and the shoots.

In 'on' trees, Li et al. (2003) observed that there was no increase in total non structural carbohydrates in leaves of girdled trees and slight increase in barks above the girdle while in 'off' trees the concentration of starch in leaves was 3 times higher than in control. This indicates that in 'on' year the fruits use the photosynthates that increase above the girdle. Wiliams and Ayars (2005) observed that girdling Thompson seedless grapevines decreased water use approximately 15% until the girdle healed. This indicates that girdling may also affect water availability to the fruit.

Wright (2000), in 'Fairchild' mandarin observed a reduction in titratable acidity due to girdling in first year but no effect was observed in second and third year. Peng and Rabe (1996) also noted improved fruit colour and TSS 'Mihowase' SatsumaNotwithstanding, girdling has the potential to injure the trees to some extent and these girdles take considerable duration of time to heal the wound completely. Since residual effect of this girdling on quality of Satsuma mandarin have not been studied this experiment was carried out to study the residual effects of partial girdling on fruit quality, three years after girdling in Satsuma mandarin.

## MATERIALS AND METHOD

The present experiment was conducted in Satsuma mandarin trees at the Ehime University Experimental Farm, Hojo located in southern Japan, 33°57' N, 132° 47' E at an elevation of about 20 m above sea level. The region has a mild temperate climate characterized by hot humid summers and cold dry winters. The soil at the experimental site is sandy loam (eutric fluvisol) with a pH of 5.7, a bulk density of a 1.08 g $cm^{-3}$ and horizon A thickness of 0.15 m. The mandarin fruits trees used for this study had received 10 cm girdling and 20 cm girdling in 2003 and the girdled wound had not been fully recovered by the third year when they were evaluated. Five Satsuma mandarin trees (replications) were used for the experiment. Each tree had 3 treatment units, 10 cm partially girdled branch, 20 cm partially girdled branch and ungirdled branch as control. The experiment was laid out in Randomized Complete Block Design.

For the evaluation of fruit quality, 20 fruits from each treatment branch were picked from all the replication. The fruits were weighed using the physical balance. Juice was extracted and soluble solids content in the juice was estimated using Automatic Temperature Correction Refractometer (Atago PR-1). The titratable acidity of juice was determined by acid-base titration method using 0.1 NaOH.

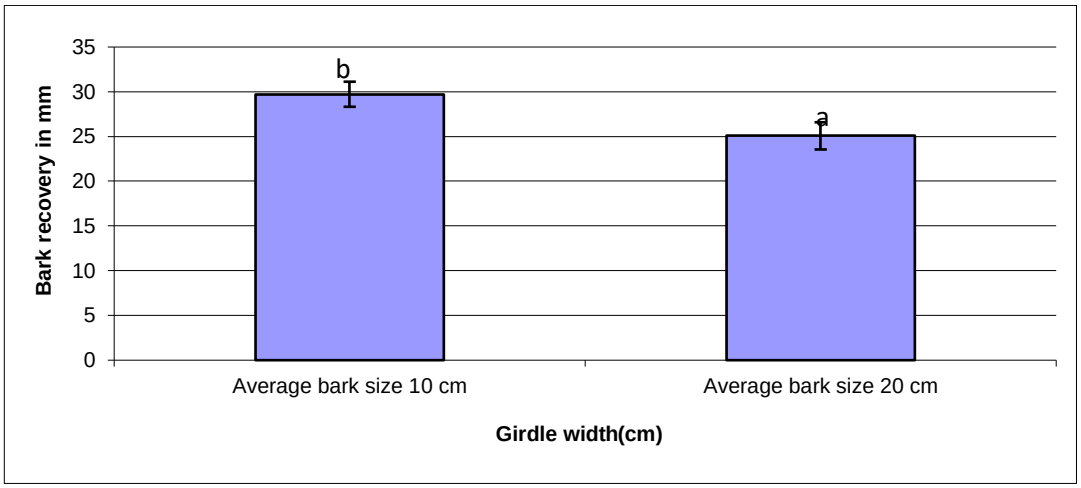
The data were analyzed using ANOVA test and separated by multiple range tests. Bark recovery was determined by measuring regenerated bark at girdled branches and presented as percentage of the total branch circumference.

## RESULTS

### Bark recovery

There was continuous and gradual recovery of the bark on the girdled portion of the branches of Satsuma mandarin tree. The healing was faster in the branches that received 10 cm girdling than in the branches receiving 20 cm girdling (Figure 1). After three years of girdling operation, 10 cm girdled branches had recovered 31% of the bark while 20 cm-girdled branches had recovered 23% of the bark. Onguso et al. (2004) also reported recovery of bark on girdled peach stem.

**Figure 1:** Influence of girdle width on bark recovery in Satsuma mandarin.




The bars are mean of recovered barks± standard errors. The means followed by same letter do not differ significantly by paired student t test (n=4, p=0.01)

### Fruit Quality

After three years of girdling operation, it was observed that the size of fruit, acidity of fruit juice and TSS were not significant among the treatments (Table 1). Yamane and Shibayama (2006) working on 'Aki Queen' grapevine, Peng and Rabe (1996) on 'Mihowase' satsuma and Onguso et al. (2005) on peach made similar observation.

**Table 1:** Residual effect of 10 cm and 20 cm partial girdling on quality of Satsuma mandarin fruit

| Treatment | Fruit weight (g) | Acidity (%) | TSS (% ) |
|---|---|---|---|
| Control | 98.4±3.52 | 1.1±0.05 | 10.0 ± 0.12 |
| 10 cm girdle | 97.4±2.33 | 1.1±0.04 | 10.5 ± 0.25 |

| | | | |
|---|---|---|---|
| 20 cm girdle | 93.0±4.18 | 1.1±0.10 | 10.4 ± 0.25 |

Values are means ± standard error. Means do not differ significantly from one another (p=0.05) by use of ANOVA test and multiple range test, n=4

There was no difference in total soluble solid content of fruit between 10 cm and 20 cm girdling treatment indicating that wider girdles do not enhance the effect of girdling over the longer duration after the imposition of treatment. It may be due to the fact that the influence of girdling on quality improvement diminishes gradually over time as the bark healing process occurs.

## DISCUSSION

Although 10 cm and 20 cm girdling treatments resulted in significant increase in soluble solid concentration along with the decrease in acidity of fruit in the girdling year, its effect seems to reduce as the bark healing process takes place and speed up over time. The effect is not significant in the third year even though the bark has not fully regenerated. Brix and acidity of 10 cm girdling were not different from those of 20 cm girdle indicating that there is no advantage of larger girdle to fruit trees. Since large girdle will take a longer time to heal and causes more injury to the tree, if girdling is to be used for fruit improvement, a smaller girdle that heals within the same year is preferable to enable the tree to regain its vigor within shorter duration of time.

From this experiment, it has been observed that the girdles reduced fruit size slightly, with 20 cm girdle reducing the size more than 10 cm girdle. This may be due to increased fruit set in the ungirdled and 10 cm girdled branches than in the 20 cm girdled branches although we did not count the fruits to determine yield per treatment branch. In addition it may also be due to the reduced vigor of the branch resulting from wider girdling / wounding in those branches. The fruits, however, were all of medium size and hence of good market value. Yamane and Shibayama (2006), Wright (2000) and Rabe and Peng (1996) have also made similar observations in their experiment related to girdling.

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