Fukumoto Navel *Citrus sinensis* (L. Osbeck) Incompatibility

**PRELIMINARY SURVEY**

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**Introduction** The Fukumoto navel originates from Japan. It was first grown by S. Fukumoto and became fairly popular in the warmer south western navel growing regions of Japan. It was released in California in 1990. It is an earlier maturing navel with good internal quality and is best known for its excellent external colour, which is substantially better than other navels, and closer to that of mandarins with its deep orange to red rind colour. One aspect of the Fukumoto navel that is not very well understood is a serious, but variable incompatibility issue experienced with certain rootstocks. Information regarding the incompatibility issues appears to be conflicting and therefore reports to date have been inconclusive. At present there is no definite answer to this problem. Additionally, the compatibility issue usually only manifests itself after 7 to 8 years, although problems have been observed earlier than this. Reports from California indicate that the incompatibility with Fukumoto happens on trifoliate hybrids, although to date no disease has been linked to this disorder. The incompatibility problem has however not been observed in all trifoliate rootstocks in South Africa. C35 citrange has shown a dwarving effect on Fukumoto of up to 50%, but with no incompatibility line at the bud union. In case problems do start to develop on an extensive scale, as in California, a new Fukumoto selection has been imported for evaluation under our conditions. Existing plantings in South Africa are being kept under observation and examined annually. Commercial Fukumoto orchards in South Africa are still young (oldest planted in 2003), and as a result, the extent of incompatibility may well still appear in the next few years. It is important to note that the findings in this report are not yet considered conclusive and investigations are ongoing.

**Incompatibility symptoms** The symptoms associated with incompatibility between scion and rootstock can range from trees that are severely stunted to total tree mortality. One of the first symptoms associated with incompatibility is a yellowing of the tree canopy and an abnormal bud-union condition. This usually includes, but is not limited to, the proliferation of small shoots on the scion in the vicinity of the bud union (Fig.1). This proliferation of shoots can also be below the bud union. Upon the removal of bark around the bud union incompatibility is confirmed by the presence of a dark line around the stem (Fig.2). Once this dark line has formed, it is expected that the tree will begin to decline fairly quickly and will eventually have to be removed.

**Surveys** In order to determine which rootstocks posed the most problems relating to incompatibility, a survey was conducted during 2008 in the Eastern and Western Cape over a range of rootstocks. There are only a limited number of plantings of Fukumoto navel on rootstocks other than Carrizo citrange. Previously a survey was performed in the Western Cape in 2004. These trees were revisited during 2009 for a more recent assessment. Another survey is planned for the northern regions of the country during 2010. Results of the survey have been interesting. One of the areas visited in the Western Cape is a trial site that had been rebudded in 2002 with over 100 Fukumoto navel scions on a range of rootstocks, namely Rough lemon, Swingle citrumelo, Benton citrange and Koethen citrange. Fukumoto had only been budded onto C35 citrange in 2004 so the trees are younger than the others. Most of the Fukumoto navels on Rough lemon appeared healthy. There were instances where lesions and swellings below the bud-union had formed, but other than that the trees themselves appeared healthy with no dark rings forming at the bud union. The same was noted for the only stunted tree on the Rough lemon rootstock. On Swingle citrumelo, one of the Fukumoto navel trees had died back completely and one of the trees was found to be smaller than the rest. The remaining trees all appeared fairly healthy; however, several yellowed leaves
were found amongst the foliage and upon closer inspection the stem revealed dense clusters of tiny green shoots above the bud union on all the trees. Removal of bark from around the bud-union revealed the presence of a dark line, indicative of bud union incompatibility. It is important to note that in the earlier survey the dark line on the bud union was not yet present on the trees, which were 2 years old at that stage. From this it is reasonable to conclude that the incompatibility only manifests itself once trees become older; these trees are now 7 years old. From these observations it would appear that the use of Swingle citrumelo as a rootstock for Fukumoto may not be advisable. 

Benton citrange has not shown any incompatibility with the Fukumoto scion at this stage. Of the eight Fukumoto trees that had been budded onto Koethen citrange, only one survived. The tree appeared healthy apart from a few yellow leaves amongst the foliage. Closer inspection of the stem again revealed many tiny green outgrowths above the scion. Once bark was removed from the bud union a clearly defined incompatibility ring was observed. It is assumed that the other trees died as a result of incompatibility from rapid decline in the early years. The previous survey revealed no such incompatibility at the bud union apart from the green outgrowths on the scion and the trees appeared healthy. Like Swingle, the incompatibility on Koethen appears only to show after a few years and the use of Koethen citrange as a rootstock for Fukumoto is therefore not advisable. Most of the Fukumoto on C35 have died back and the few that remain are severely stunted. Stems remain narrow with minor lesions and swellings but with no dark line at the bud-union. The trees are much younger than the other trees and the incompatibility may yet manifest itself in the future.

One of the oldest known Fukumoto navel plantings in the Western Cape was also visited, of which only seven trees remain. All of the trees appeared healthy and in some instances it was difficult to distinguish where the bud-union was situated. It is of interest that this was probably due to the presence of an interstock between the rootstock and scion. Bark had been removed from both unions and there were no signs of incompatibility. Due to the age of the trees, which was older than the age at which incompatibility is known to occur, it is possible that the presence of the interstock negates any incompatibility issues. This may be worth further investigation.

Another trial site, planted in 2001, consisting of a series of navel varieties was also included in the survey. All varieties included in this block are early varieties and have been budded onto C35 citrange. Although trees are the same age (8 years), the Fukumoto navel trees were noticeably smaller than the rest but lacked the dark line at the bud-union. Since it appears that C35 citrange does have a fairly severe dwarfing effect on Fukumoto with trees being at least half the size of the rest, but lacking the dark ring, it may signify a type of incompatibility relationship unique to C35 and Fukumoto in South Africa as this is not similar to the results of Fukumoto on C35 reported from California. Due to this dwarfing effect it is not advisable to plant Fukumoto on C35 at this stage.

In the Eastern Cape, most of the Fukumoto orchards are on Carrizo citrange and Rough lemon, but there are cases where Swingle citrumelo has been used, although most orchards are still young. Fukumoto trees on Rough lemon rootstock of various ages yielded the same results as were found in the Western Cape with no problems associated with incompatibility, and it can therefore safely be said that no problems will be associated with Rough lemon rootstock. However, an orchard of Fukumoto on Swingle of three-year-old trees began showing proliferations of shoots along the scion with foliage displaying hints of yellow. Upon removal of the bark, a clearly defined dark ring was beginning to develop. From this it appears that the incompatibility begins to show earlier in Swingle citrumelo. The older Carrizo trees in the same orchard did not show any problems apart from the minor development of shoots along the scion at the bud-union. A younger orchard of Fukumoto on Carrizo in a different region in the Eastern Cape had also displayed the presence of shoots along the scion at the bud-union but no incompatibility line. In an extensive commercial Fukumoto orchard of trees on Carrizo ranging from four to six years of age, stems were smooth and uniform. Trees displayed good crops. The majority of the trees appeared healthy, although there were signs of iron deficiency with some twig dieback on heavy, calcareous soil sections of the orchard. Removing bark from the bud union of these trees did not reveal any incompatibility problems and it was therefore concluded that this dieback was not indicative of any incompatibility issues. Further random observations made throughout this large orchard showed a high standard of tree health and uniformity where other factors such as iron deficiency were not involved.

**Comments from California** Recent comments received from California have confirmed that while Fukumoto on all trifoliate rootstocks is problematic, C35 is usually the worst. There have been problems in numerous orchards, but where good quality trees are under good management practices, the orchards are economically viable.

**Conclusions** • Except for Carrizo and Benton citrange, surveys
Ongoing surveys have shown that all trifoliate rootstocks used for Fukumoto have been affected by incompatibility problems to varying degrees. Some examples include:

- Swingle citrumelo has developed incompatibility problems as early as 3 years after planting, which included a darkened line at the bud union.
- C35 has been one of the worst rootstocks affected due to severe dwarfing although incompatibility lines at the bud union have not been observed on trees in South Africa.
- Rough lemon has not shown any incompatibility symptoms with Fukumoto, but benton citrange should be included as a small percentage of these plantings could become a problem after 7 years.
- In California Volckameriana has not shown incompatibility symptoms with Fukumoto, but benton citrange is not suggested as an alternative rootstock due to its detrimental effects on fruit quality.

**Recommendations**

- Any planned Fukumoto developments should be on Carizzo citrange and higher planting densities should be considered so that early returns could offset losses if incompatibility becomes a problem after 7 years.
- Although Rough lemon has not shown any incompatibility with Fukumoto, it is not suggested as an alternate rootstock because it affects fruit quality.

**Aanbevelings**

- Enige toekomstige Fukumoto aanplantings moet op Carizzo citrange wees. Oorweg verseker hoor aanplantingstigthed wat vinniger inkomste gaan genereer as die onenervigbaarheidsprobleem na 7 jaar opduik.
- Een breed scala van die Carizzo blokke moet gebruik word, om die langtermyn uitwerking in kombinasie met Fukumoto te bepaal.
- Alhoewel Growwekel suurleemoen goed onenervigbaarheid wys nie, word dit nie as ‘n alternatiewe onderslag aanbeveel nie, a.g.v. die swakker interne kwaliteit van die vrugte wat geproduseer word.