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OBSERVATIONS ON THE COMPATIBILITY, GROWTH, AND CROPPING OF CALAMONDIN, 'MEIWA' AND 'NAGAMI' KUMQUAT ON SEVERAL ROOTSTOCKS

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Abstract. **Calamondin, 'Meiwa' and 'Nagami' kumquat trees were grown for five years on several rootstocks in an unreplicated demonstration trial. Calamondin trees on all rootstocks except for Carrizo citrange and Swingle citrumelo grew well and had heavy yields. 'Meiwa' trees on Carrizo citrange, Swingle citrumelo, ridge pineapple and sour orange died but trees on other rootstocks generally grew and yielded well. 'Nagami' trees on all rootstocks also grew and yielded well with some limb breakage because of heavy crops. Further confirmation of these preliminary observations in replicated field trials could provide growth and yield information for calamondins and kumquats on a range of rootstocks for homeowner and speciality markets.**

Calamondins and kumquats are not major commercial citrus crops worldwide, but they are frequently used as ornamentals in the landscape and for other homeowner uses. Calamondins are usually grown from rooted cuttings in containers or in the landscape where as highly productive grafted trees they can reach 3 to 4 meters in height. Fruit are used to flavor drinks and in marmalades and jellies. Calamondins have also been used occasionally to study photosynthesis, fruit setting, fruit ripening and abscission in citrus species (Cooper and Horanic, 1972; Krezdorn and Powell, 1969). Kumquats are grown as grafted trees both in containers and in the landscape and field. Plant size may vary depending on rootstock but can reach 3 to 4 meters in height, with 'Nagami' being a more vigorous and larger tree than 'Meiwa' kumquat. Kumquat fruit, especially 'Meiwa' fruit, is eaten whole and is used for preserving in syrup, candying and making marmalade, and for decoration in gift packages of other citrus cultivars.

Both calamondins and kumquats are usually grown on trifoliate orange rootstocks. Calamondin is also often used as a rootstock for 'Nagami' kumquat (Hodgson, 1967). Since commercial acreage of calamondins and kumquats is relatively small and trees for the homeowner market are grown on traditionally used rootstocks, little information is available about their performance on other rootstocks. Calamondins and kumquats on selected rootstocks were therefore grown from 1994 to 1998 on the University of Florida campus in Gainesville to demonstrate the compatibility, growth and yield of these cold hardy species for master gardeners and homeowners.

Materials and Methods

Calamondin (*Citrus madurensis* Lour.), 'Meiwa' (*Fortunella margarita* [Lour.] Swing.) and 'Nagami' (*F. crassifolia* Swing.) kumquat trees, obtained from the Division of Plant Industry, Winter Haven, were planted on several rootstocks in Gainesville during April, 1994 with one to three scion/rootstock replications within rows of each scion cultivar and grown until May, 1998 Trees were planted 2.4×4.5 m on a site (Arredondo fine sand, loamy, siliceous, hyperthermic Gossarenic Paleudults; pH: 6.1 to 6.5) that sloped from north to south, with a clay hardpan within 20 cm of the surface on the southern end of the site.

The area was rototilled and deep plowed before planting to break up the hardpan. Black groundcover cloth was laid within the rows to suppress weed growth and trees planted in slits in the cloth. The ground cover cloth was initially laid down as part of a weed control experiment that was latter discontinued. Row middles were rototilled several times during the first year and herbicide applied the following four years.

Trees were irrigated with microsprinklers and fiberglass tree wraps were installed in December and removed in March of each year to prevent rootstock sprouting and for cold protection. Trees were fertilized in years one and two with 4.5 kg of processed chicken manure per tree (3N-1.7P-2.5K) spread beneath the canopy on the ground cover cloth three times per year and in years three and four with 1.4 kg of a granular, water soluble fertilizer (10N-4.4P-8.2K) applied three times per year. Systemic herbicides were applied two to three times per year to control weeds between tree rows and at the foot of each tree where weeds grew in the slits of the ground cover cloth. Other pests noted were fire ants, leaf miners, black scale and rust mites.

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Trees bloomed during April and May. Fruit was stripped from trees in years one and two but harvested in year three and four. Fruit was counted in year three but estimated in year four with data on fruit yield presented as an average estimate over two years. Trunk diameter of rootstock and scion were measured at planting and in April and December of each year thereafter. Tree condition was also rated at the end of the experiment. Growth and yield data, representing an average of one to three trees, are presented for general information and are only preliminary, inconclusive results.

Results and Discussion

Calamondin trees on all rootstocks except for those on Carrizo citrange and Swingle citrumelo were vigorous and had heavy yields (Table 1). A rootstock bench (overgrowth of the rootstock at the budunion) and rootstock constriction of the scion was especially noticeable in the one tree on Swingle citrumelo rootstock which was declining and had a relatively low yield and tree rating. The one tree on Carrizo citrange was also declining, had low yield and tree rating but no other obvious rootstock/ scion incompatibility. Trees on flying dragon rootstock were healthy and productive but not as tall as calamondin trees on other rootstocks. Two calamondin rooted cuttings planted in the same field plot were as tall (1.3m) as the calamondin tree on flying dragon rootstock (1.3 m) after 5 years, suggesting that budding trees on this rootstock may provide the option of having a small grafted tree with a normal tree growth habit rather than a rooted calamondin cutting which normally has a shrubby growth habit.

By the end of this 5-year trial, 'Meiwa' trees on Carrizo citrange, Swingle citrumelo, ridge pineapple and sour orange were dead and one of two trees on 80-18 was in severe decline. However, the other tree on 80-18 grew and yielded well (Table 2). The 'Meiwa' tree on sour orange rootstock died during the first year. Tree ratings were similar for all other trees still alive. 'Nagami' trees

Table 1. Growth, yield and tree rating of calamondin on several rootstocks after 5 years.

Rootstock	Stem diameter increase (%)	Plant height increase (%)	Scion/rootstock diameter difference (mm)	Yield[z] estimate (fruit no)	Tree[y] rating (1-10)
Trifoliate orange	980	160	25	3000	9
Flying dragon	400	200	17	1200	7
Carrizo citrange	327	70	10	700	6
Swingle citrumelo	314	187	27	800	5
Cleopatra mandarin	492	220	13	2500	9
80-18	361	225	28	2000	8
80-18	510	233	31	1800	8
X639	278	350	36	2700	9, limb breakage
X639	428	322	30	2900	8
K × R	371	160	18	1500	9
Benton citrange	566	183	24	3000	9
Benton citrange	622	277	25	3000	9
Benton citrange	478	325	16	2700	9

[z]Average yield from third and fourth years.
[y]Tree rating from 1 (low) to 10 (high).

Table 2. Growth increase, yield and tree rating of 'Meiwa' kumquat on several rootstocks after 5 years.

Rootstock	Stem diameter increase (%)	Plant height increase (%)	Scion/rootstock diameter difference (mm)	Yield[z] estimate (fruit no)	Tree[y] rating (1-10)
Trifoliate orange	571	150	36	1500	7
Trifoliate orange	616	77	26	1050	7
Carrizo citrange	dead	dead	dead	dead	dead
Swingle citrumelo	dead	dead	dead	dead	dead
Swingle citrumelo	dead	dead	dead	dead	dead
Ridge pineapple	dead	dead	dead	dead	dead
Sour orange	dead	dead	dead	dead	dead
80-18	783	128	20	100	3, declining
80-18	1150	144	19	1500	7
K × R	733	88	16	1800	8
K × R	657	128	22	1700	8
K × R	683	150	22	2000	9

Table 2. Growth increase, yield and tree rating of ‘Meiwa’ kumquat on several rootstocks after 5 years.

Rootstock	Stem diameter increase (%)	Plant height increase (%)	Scion/rootstock diameter difference (mm)	Yield[z] estimate (fruit no)	Tree[y] rating (1-10)
Benton citrange	454	1.2	14	1100	9

[z]Average yield from third and fourth years.
[y]Tree rating from 1 (low) to 10 (high).

Table 3. Growth increase, yield and tree rating of ‘Nagami’ kumquat on several rootstocks over 5 years.

Rootstock	Stem diameter increase (%)	Plant height increase (%)	Scion/rootstock diameter difference (mm)	Yield[z] estimate (fruit no)	Tree[y] rating (1-10)
Trifoliate orange	766	88	19	1500	7
Trifoliate orange	687	122	24	1500	7
Carrizo citrange	391	175	12	1900	9
Carrizo citrange	433	155	11	1500	8, limb breakage
Swingle citrumelo	555	150	33	1400	8, limb breakage
Swingle citrumelo	558	187	31	900	8
Sun Chu Sha	771	200	9	1050	7
Milam	1600	125	17	725	8
80-18	588	162	12	1300	8
X639	440	144	8	760	9
K × R	728	144	22	1300	8, limb breakage
K × R	1275	157	9	400	7, limb breakage
Benton citrange	644	250	11	1310	8

[z]Average yield from third and fourth years.
[y]Tree rating from 1 (low) to 10 (high).

on all rootstocks generally grew well and had heavy yields (Table 3). Trees on trifoliate orange, Carrizo citrange and Benton citrange had the greatest yields. A 20-year study in Argentina also reported excellent yield efficiencies of ‘Nagami’ kumquat on trifoliate orange and Troyer citrange, which has trifoliate orange in its parentage (Anderson and Benatena, 1992). Trees on Swingle citrumelo, 80-18, X639, and K × R had excessive limb breakage in year 5 because of heavy crop load, suggesting some thinning may be necessary. Tree rating of all ‘Nagami’ kumquat trees were generally similar.

Rootstock/scion incompatibility may become evident earlier for some rootstock/scion combinations (‘Meiwa’ trees on sour orange after 1 year) than for others (calamondin on Carrizo citrange and Swingle citrumelo; ‘Meiwa’ on Carrizo citrange, Swingle citrumeo, and ridge pineapple after 3 to 4 years). Anatomical analysis of bud union tissue could lead to early diagnosis of such incompatibility for scion cultivars on new and experimental rootstocks, thereby abbreviating extensive field testing. No attempt was made to monitor water and fertilization movement through the ground cover which remained intact after 5 years. Although initially expensive, ground cover may offer some benefits for weed control in small plantings but may also harbor fire ants. Further confirmation of these initial observations is also needed and could potentially benefit both nurserymen producing trees for the homeowner market and growers producing calamondin and kumquat fruit for niche markets.

Literature Cited

Anderson, C. M. and H. N. Benatena. 1992. Performance of ‘Nagami’ kumquat on six rootstocks in Argentina. Proc. Int. Soc. Citriculture:244-245.

Cooper, W. C. and G. E. Horanic. 1972. The requirement for ethylene in cycloheximide-induced fruit abscission. Plant Physiol. 49 (Suppl):17

Hodgson, R. W. 1967. Horticultural varieties of citrus.pp. 431-591. In W. Reuther, H. J. Webber and L. D. Batchelor. (eds.), The Citrus Industry, Vol.1. Univ. Ca. Press.

Krezdorn, A. H. and A. A. Powell. 1969. *Citrus madurensis* Lour cv. Calamondin as a plant for fruit set research. Proc. Am. Soc. Hort. Sci. Trop. Reg. 13:149-156.