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Tolerance of almond rootstocks to root-knot nematodes

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Background

The characteristics of a rootstock are often forgotten about or poorly taken into account as they are not as apparent – they are hidden under the ground. The scion on the other hand is well known due to its visible, above ground morphological characteristics such as flowering, growth habit, kernel quality, etc. Nevertheless, the rootstock is 50% of a fruit tree and must symbiotically and mutually interact with the scion to optimise fruit production and nut quality. It does this by providing a root system that when functioning correctly, will absorb water and nutrients and communicate important messages to the above ground components of the plant influencing stomatal conductance, shoot growth, fruit growth and ultimately fruit yield. When faced with limiting factors rootstock choice is critical as tree health and fruit yield will not be realised and the wrong choice will only be rectified by uprooting the orchard, so please make the decision carefully.

An increasing number of *Prunus* rootstock genotypes have been imported from around the world and now available in Australia for almond (and summerfruit) production. Each of these rootstocks are said to have certain beneficial characteristics (Table 1) that bring about numerous opportunities, but as there is still no perfect rootstock one should be mindful not to throw out the baby with the bath water, or in other words don't throw out the essential when ridding yourself of the bad. With this in mind, it's worth reviewing the characteristics of the industry's benchmark rootstock Nemaguard, which accounts for 92% (Figure 1) of the Australian almond acreage. The positive features of Nemaguard are: it has has good root-knot nematode tolerance; is available in plentiful supply; is easy to propagate; and has good graft compatibility. Whilst these are all admirable features, unfortunately

Table 1: Characteristics and traits of a selection of key rootstocks available for the Australian almond industry (based largely on overseas data).

Rootstock	Parentage	Pathogen Resistance					Soil Adaption			Effects on the Variety		
		Root knot Nematode	*Lesion Nematode*	*Ring Nematode/ Bacterial Canker*	*Crown Gall*	*Armillaria*	*Phytophthora*	*Anchorage*	*Chlorosis*	*Compatibility*	*Vigour*	*Propagation by cuttings*
Nemaguard	Wild Peach x Peach	H	M	M	M	S	M		S	G	M	NA
GF677	Peach x Almond	S	S	S	S		S		T	G	H	P
Atlas	Peach x Apricot x Almond x Plum	H	M	S	M	S	M		T	G	H	G
Viking	Peach x Apricot x Almond x Plum	H	M	H	M	S	M		T	G	H	G
Cadaman	Wild peach x Peach	H	S	U	S	S	U		M	G	H	P
Cornerstone	Peach x Almond	H	S	S	S	S	S		T	G	H	G
Krymsk (Kuban) 86	Peach x Plum	S	M	S	M	U	T	VG	M	G	M	G
Garnem	Peach x Almond	H	M/S	U	S	U	S		T	G	H	G
Hansen 536	Peach x Almond	H	More T than Nemaguard	S	S	S	S		T	G	H	P
Nickles	Peach x Almond	S	More T than Nemaguard	S	S	S	S		T	G	H	P
Bright's	Peach x Almond	H	More T than Nemaguard	S	S	S	S		T	G	H	P

Key: S - Susceptible, H - High, T - Tolerant, VG - Very Good, G - Good, M - Medium, P - Poor, U - Unknown, NA - Not available

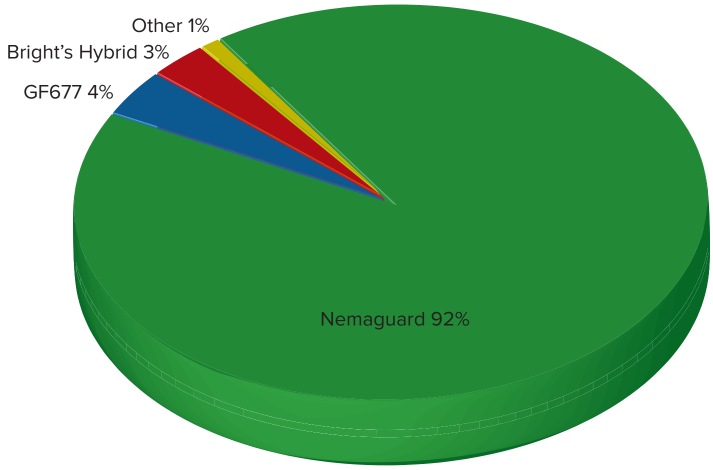

Figure 1: Almond rootstock genotypes planted in Australian almond orchards 2013 (Almond Board of Australia: survey response equating to 88% of planted hectares)

Nemaguard isn't tolerant to calcareous soils, and is not thought to be as efficient in its use of water and fertiliser. In addition, Nemaguard isn't clonally (uniformly) propagated. Fortunately though, the key trait of root-knot nematode resistance is a dominant trait and thought to be present across all progeny.

With the industry entering a period of replanting older orchards and a possible expansion through the conversion of unprofitable horticultural crops to almonds, the almond industry thought it pertinent to understand the variance in the resistance/susceptibility of the available rootstocks to root-knot nematode species and isolates. The industry engaged the services of CSIRO Plant Industry to fast track this knowledge using glasshouse based screening methods, a faster alternative to long-term field trials. The glasshouse screening approach for root-knot nematode resistance was adapted from methods developed for grapevines which have been shown to be a robust means for selection of genotypes with field resistance, as well as a rapid way of identification of susceptible plant species.

Root-knot nematodes are plant-parasitic nematodes from the genus Meloidogyne. Their symptoms on plant roots can be extreme. Nematodes feed on the roots causing large galls, with female nematodes laying egg masses under the skin (epidermis) of the root. The root system of severely infected root systems exhibit short stunted roots with a significant reduction in fine fibrous root hairs (Figure 2). These symptoms cause a limited ability to absorb water and nutrients for the plant, often resulting in stresses, particularly in periods of high demand (e.g. large yields and high temperatures). The consequence of these stresses cause a reduction in crop yields.

Table 2: Mean total root-knot nematode galls of 18 *Prunus* rootstocks for each of the 7 nematode sources. Colours are used to denote low infection (blue) and high infection (red) and rootstocks are grouped into low susceptibility, low to medium susceptibility, and medium to high susceptibility based on these results.

	Rootstock	**Nematode Species/ Source**						
		M. incognita	***M. arenaria***	***M. javanica***				
		Lettuce, S.A	Winegrapes, B. Valley	Winegrapes, M. Vale-1103	Winegrapes, Riverland	Almonds, Riverland - L	Almonds, Riverland - W	Almonds, Angle Vale
Low susceptibility	Cadaman	0	0	0	0	0	0	0
	Hansen 536	0	0	0	0	0	0	0
Low to medium susceptibility	Adafuel	1.5	0	0	0	4.5	0	0
	Bright's Hybrid	8.5	0	0	0	0	0	0
	Cornerstone	0.3	0	0	0	1.0	0	0
	Felinem	0	0	0	2.5	0	0	0
	Garnem	6.0	0	0	0	5.5	0	0
	Nemaguard	4.5	0.5	0	0	16.5	0	0
	Penta	5.0	0	0	0	0.5	0	0
	Tetra	0	0	0.5	0	0	0	0
	Viking*	0	ND	9.5	ND	ND	0	ND
Medium to high susceptibility	Atlas	0	0	0	0.5	15.0	15.0	0
	GF557	19.7	0	9.0	0	29.0	60.0	0
	GF749	32.5	2.5	35.0	0	33.5	12.5	12.5
	GF677	17.0	3.5	129.0	8.5	0.5	22.5	0
	Krymsk 86	3.0	3.0	211.0	12.5	10.5	43.0	1.0
	Monegro	35.0	0	51.0	0	6.5	7.5	0
	Nickels	64.5	6.0	3.5	0	13.5	50.5	0

ND = No data
*Not enough Viking material was available to test against all isolates and would need further testing to gain further confidence in its susceptibility.

Method

The resistance to root-knot nematode reproduction of 18 *Prunus* rootstocks, currently used or with potential for use in almond orchards, was assessed in the glasshouse screening studies. The study included 3 species of root-knot nematodes (*M. incognita, M. arenaria and M. javanica*) including 5 isolates of *M. javanica* sourced from almond orchards (3 isolates) and vineyards (2 isolates). Root-knot nematodes were extracted from soil samples collected from almond orchards and vineyards.

The *Prunus* rootstocks were inoculated with approximately 1000 juveniles and after 3 months were assessed for egg masses of reproductive females. Galls containing egg masses were counted.

Results

There was a wide variation in the resistance/susceptibility of the *Prunus* rootstocks to the root-knot nematode species and isolates used in the screening studies (Table 2).

Cadaman and Hansen 536 showed resistance to the three root-knot nematode species, an indication they could be useful rootstocks for adoption in almond orchards, provided their production and influence on nut quality characteristics are adequate.

Tolerant rootstocks with very low levels of reproduction included Adafuel, Cornerstone, Felinem, Garnem, Nemaguard, Tetra and Viking, which may also be useful rootstocks for consideration for testing and use.

Atlas, GF557, GF749, GF677, Krymsk 86, Monegro, and Nickels were susceptible to one or more species and isolates of root-knot nematodes, and should be avoided where high nematode pressures are to be expected.

Bright's Hybrid and Penta were found to be susceptible to *M. incognita* but resistant to *M. javanica* or *M. arenaria.*

Implications

The results of the study have significant implications for selection and adoption of *Prunus* rootstocks by the almond (and summerfruit) industry, particularly when current orchards are redeveloped or new plantings occur in land previously used for other horticultural pursuits (e.g. vines and vegetables).

Whilst it will be important to confirm resistance/susceptibility of the rootstocks to root-knot nematodes under field conditions, similar tests by the grapevine industry indicate the results are transferable to field conditions. Field assessment could be quickly achieved using ungrafted trees in high density plantings established in sites with known root-knot nematode issues (e.g. sites from which the *M. javanica* Almond Riverland-L and Almond Riverland-W pathotypes were isolated).

To facilitate decisions regarding the choice of rootstock it would also be useful to conduct a broader survey of existing almond orchards to determine the distribution of root-knot nematode species and virulence of the root-knot nematode isolates across the industry. Furthermore, it would be prudent for orchardists to implement soil sampling strategies to identify root-knot nematode species and numbers prior to development of plantings.

The diversity of results within the one rootstock also suggests growers should avoid redevelopment of orchards with the same rootstock used in original plantings. This is illustrated by Nemaguard's high infection with the *M. javanica* Almond Riverland-L isolate, suggesting it should not be planted back at that site. At this site, Nemaguard has effectively lost its resistance to this isolate and selected for it.

It is also important the almond industry consider root-knot nematode as a biosecurity risk and implement strategies to minimise the risk of spread of species and isolates with varying virulence. The strategies could involve heat treatment of all field nursery grown material, propagation in soil free medium (potted nurseries) and attention to cleaning machinery and equipment when moving between orchards.

Hence, in the longer term it will be important to develop an understanding of the inheritance of resistance to Australian root-knot nematodes in *Prunus* rootstocks. The industry would also benefit from the development of a rapid screen using molecular markers, to identify virulent root-knot nematode pathotypes of *Meloidogyne* spp., particularly *M. javanica.*

Field Trials

The Australian industry has a field evaluation trial on a replant almond orchard that will also be a very useful resource in investigating various rootstock traits; in particular, the effect on yield. The trial is a four hectare statistical design consisting of fifteen rootstocks and was planted in August 2013. Information will come to hand in later years as the trees mature and begin cropping.

Conclusion

In conclusion, root-knot nematode resistance should be considered an important trait in the selection and development of rootstocks for the Australian almond industry. It's not the only trait to be considered, but be careful of losing it when changing to alternatives.

Figure 2: GF677 (left) root system with root-knot nematodes causing stunting and galls, in comparison to a Nemaguard (right) root system with a more expansive network or fine fibrous roots. Samples from a 3 year old almond replant orchard.

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