# Genetic diversity of almond rootstocks. The INRA Prunus rootstock breeding program

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# Genetic diversity of almond rootstocks. The INRA *Prunus* rootstock breeding program

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**Abstract.** Almond and peach seedlings and peach*almond hybrids are still the most grown almond rootstocks in the Mediterranean countries. However a lot of new almond rootstocks were released in the last years, with different vigour, disease and nematode resistance, tolerance to abiotic stress. The almond rootstock choose is become more important, but there are opportunities for new rootstocks adapted to certain soil types like heavy soils or adapted to new high density systems. It could be possible to create them by interspecific crosses between several Prunus species, checking first the graft-compatibility with almond varieties. The main objective of the Breeding rootstock program is to pyramide three root-knot nematode resistance genes by interspecific crosses almond*peach*myrobalan.

**Keywords.** Almond rootstock – Root-knot nematodes – Resistance gene – *Prunus* species.

***Diversité génétique des porte-greffes de l'amandier. Le programme d'amélioration des porte-greffes Prunus à l'INRA***

***Résumé.*** *Les semis d'amandier et pêcher, ainsi que les hybrides pêcher*amandier sont toujours les porte-greffes les plus utilisés dans les pays méditerranéens. Cependant beaucoup de nouveaux porte-greffes ont été inscrits dans les dernières années avec différentes vigueurs, avec des résistances aux maladies et aux nématodes, tolérants aux stress abiotiques comme l'asphyxie racinaire ou des porte-greffes adaptés à des systèmes haute-densité. Il est possible de créer de nouveaux porte-greffes par croisements interspécifiques entre les différentes espèces Prunus, mais en vérifiant l'incompatibilité au greffage avec les variétés d'amandier. Le principal objectif du programme porte-greffe INRA est de pyramider 3 gènes de résistance aux nématodes à galles par croisement interspécifique amandier x pêcher x myrobolan.*

***Mots-clés.*** *Intensité de floraison – Persistance – Germoplasme* – Prunus.

## I – The place of the of almond rootstocks in the Redher *Prunus* classification

Rootstock allows a good adaptation of the almond trees to the soil and can be prevent the tree decline against biotic and abiotic stress. Many *Prunus* species are used as rootstocks for apricot, peach or almond crops. The wide genetic variability within the *Prunus* genus allows to breed a high diversity of rootstocks for acumulating the characteristics by intraspecific or interspecific crosses. In the Redher *Prunus* classification, Fruit Prunus species are grouped in the three sections *Cerasus*, *Prunophora* and *Amygdalus* (Figure 1). For almond rootstocks. most of them belong to the section *Amygdalus* because the species of this section have good graft-compatibility with almond varieties. For calcareous soils, peach*almond hybrids are preferred to peach seedlings because they have better tolerance and a higher vigour. 'GF677' is still widely used, but the peach*almond hybrids like 'Hansen' and 'Garnem', resistant to root-knot nematodes replace 'GF677' in the infected soils. In the heavy soils, plum rootstock or amygdalus*prunophora hybrids are the best good alternative. They are more tolerant to root diseases such as *Armillaria* than peach and almond. In California, the prunus Marianna clone 'M2624' is the most planted, but now there are new Amygdalus*Prunophora

hybrids clones like 'Krymsk, 'Atlas','Viking' that would be replaced 'M2624'. The INRA hybrids 'Myran' and 'Ishtara' are not very planted, but have shown good results in heavy soils, like also for some slow growing plums from domestica and insititia species that are graft-compatible with almond.

Microcerasus species like *Prunus besseyi* are interesting genitors to obtain dwarfing rootstocks. The new rootstock Rootpac®20 is well adapted for the super high density orchards. The horticultural characteristics of the main commercial almond rootstocks are summarized in the Table 1.

## II – The INRA *Prunus* Rootstock breeding program

A lot of *Prunus* rootstock are available to cover all soil types (cf Table 1) and several of them are resistant to RKN nematodes (Reighard and Loretti 2008), however in prevision of the climatic changes, in all rootstock breeding programs, the RKN resistance is a required trait to introduce and face the risk of breaking resistance, it is important to build temperature-stable resistances. Three RKN resistance genes have been identified in three *Prunus* species, *Ma* in the myrobalan plum (*Prunus cerasifera,* clone P2980 and P2175), *RMia* in the peach rootstock 'Nemared' and *RMja* in the almond 'Alnem' variety. So pyramiding these three genes by interspecific crosses almond* peach*myrobalan is the main objective of the breeding rootstock program.

However, to ensure the presence of the three genes in a same rootstock, it has been necessary to develop molecular markers to detect genes in the 3 way-hybrids. The identification of intra-gene markers for the two nematodes resistance genes *Ma* and *RMia* has allowed to apply marker assisted selection for these two genes (Claverie *et al.*, 2011, Duval *et al.*, 2014). A new F2 almond population of Lauranne x Alnem, with more 1000 hybrids has been created in order to clone the *RMja* resistance gene of 'Alnem' and to find intragenic molecular markers for this gene. The *RMja* gene is localized in the linkage group 7 of the *Prunus* genome in the same region than the *Ma* gene (Van Ghelder *et al.*, 2010). After that, it will be possible to select in the hybrid population' (Alnem*Nemared)*myrobalan', the pyramided hybrids with the three nematode resistance genes.

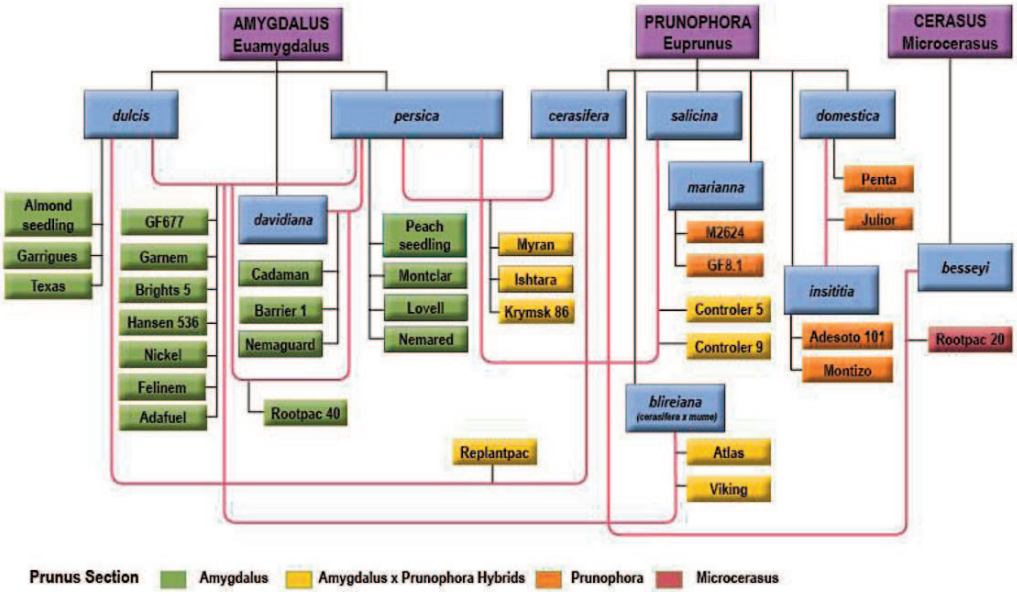


**Fig. 1. Main almond rootstocks positioned in the Redher *Prunus* classification.**

**Table 1. Horticultural characteristics of commercial almond**

| Name Rootstock | Vigor | Heavy soil | Chlorosis | Nematode | | | | Armillaria |
|---|---|---|---|---|---|---|---|---|
| | | | | RKN -Mi | RKN -Ma | RKN -Mj | Lesion | |
| Almond seedling | standard | poor | high | S | S | S | S | S |
| Lovell | standard | fair | poor | S | S | S | S | S |
| Nemared | standard | poor | poor | R | R | MS | S | S |
| GF677 | high | fair | high | S | S | S | MR | S |
| Hansen 536 | high | fair | high | R | R | MR | MR | S |
| Brights 5 | standard | fair | high | R | R | MR | MR | S |
| Garnem (GN15) | high | fair | high | R | R | MS | MR | S |
| Nemaguard | standard | fair | poor | R | R | MR | S | S |
| Cadaman®avimag | high | fair | fair | R | R | MR | S | MS |
| Barrier I | standard | fair | fair | R | R | MR | S | S |
| Krymsk 86 | semi-dwarf | good | poor | S | S | S | S | S |
| Rootpac® R | standard | good | good | MR | MR | MR | S | |
| Ishtara®Ferciana | semi-dwarf | good | good | R | R | R | MS | MR |
| Myran®Yumir | semi-dwarf | good | poor | R | R | R | | MR |
| Atlas | standard | poor | fair | R | R | R | S | |
| Viking | high | fair | fair | R | R | R | S | |
| Marianna 2624 | semi-dwarf | good | good | R | R | R | S | R |
| Penta | semi-dwarf | good | good | R | R | MR | S | |
| Julior® | semi-dwarf | good | fair | R | R | R | S | |
| Rootpac®20 | dwarf | good | fair | R | R | R | R | |

RKN : Root-Knot Nematode (Mi: Meloidogyne incognita, Ma: M arenaria, Mj: M javanica).

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