

'Felinem', 'Garnem', and 'Monegro' Almond × Peach Hybrid Rootstocks

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Additional index words. stone fruits, nematode resistance, *Meloidogyne*, *Prunus*, clonal propagation

Abstract. 'Felinem', 'Garnem', and 'Monegro' are three almond × peach hybrid rootstocks released to address the problems of *Prunus* growing in Mediterranean conditions not solved by the presently available rootstocks. These new rootstocks are characterized by red leaves, good vigor, easy clonal propagation, resistance to root-knot nematodes, adaptation to calcareous soils and other Mediterranean agroecological conditions, and graft compatibility with the whole range of peach and almond cultivars as well as some plum and apricot cultivars.

Stone fruit growing has limitations in the Mediterranean area as a result of the prevalence of calcareous soils, where most rootstocks show lime-induced chlorosis. In addition, the presence of root-knot nematodes (*Meloidogyne* spp.) in many irrigated orchards renders fruit growing extremely difficult, especially after the ban on the use of methyl bromide for soil fumigation. Thus, the need for rootstocks to overcome these shortcomings has become essential for growing stone fruit in many regions, not just the Mediterranean area (Felipe, 1989). 'Felinem', 'Garnem', and 'Monegro' had been released as potential rootstocks for several stone fruit species that are grown in soils having these limitations.

Origin

These three clones were selected among the progeny obtained in the cross between the Spanish almond 'Garfi' [*Prunus amygdalus* Batsch, syn. *P. dulcis* (Mill.) D.A. Webb] as the female parent and the North American peach 'Nemared' [*P. persica* (L.) Batsch] as the pollen donor. 'Garfi' is an open-pollinated seedling of 'Garrigues' almond previously selected because of its good morphological characteristics and ease of clonal propagation (Felipe, 1992; Felipe et al., 1995). 'Nemared'

was chosen mainly as a source for root-knot nematode resistance (Ramming and Tanner, 1983). Selection of this progeny was carried out at the then Servicio de Investigación Agraria de la Diputación General de Aragón, now Centro de Investigación y Tecnología Agroalimentaria de Aragón (CITA).

Description

Unbudded trees of 'Garnem', 'Felinem', and 'Monegro' are vigorous and no differences in size are noticeable between them. The vigor induced in grafted cultivars is comparable to that induced by 'GF-677' or 'Hansen 536' with a similar productivity. Nongrafted plants are vigorous and in the nursery exhibit an erect growth with little or no feathering during the first season (Felipe, 1989). Leaves are red, big, lanceolate, and intermediate in morphology between almond and peach. Active growing shoots exhibit an intense red–purplish color similar to its male parent, 'Nemared'. Because the leaves mature during the growing season, they turn brownish green to green. The first-year shoots are straight with little or no lateral branching. Shoots are green with red areas from which stem color turns to an intense and continuous red–purplish during winter dormancy. Internode length is medium to long (5 to 7 cm).

The three rootstocks bloom early, at the same time as 'Nemared' peach and 'Nonpareil' almond, exhibiting similar low chilling requirements. Flowers are large (3.5 to 4 cm), of the rosaceous type, with large pale pink petals. The flowers have between 30 and 45 stamens and one pistil. Fruits are small (4 to 5 cm in width) and rounded with a pubescent epidermis. Fruits are green with reddish overtones. The mesocarp is thin, nonedible, and has a free stone or endocarp.

Despite their similar morphology and performance, the three clones may be distinguished by molecular markers (Serrano et al., 2002).

Evaluation was conducted in Zaragoza and under other Mediterranean conditions such in the hotter climate of southern Spain and the mild climate of eastern Spain both in heavy and sandy soils. The three clones were selected because of an important soil chemical limitation that is inherent in Mediterranean environments, which is tolerance to iron chlorosis (De la Guardia et al., 1995; Said et al., 1993) as a result of alkaline soils (pH = 8.0 to 8.5) that contain high levels of active lime (10% to 12%). Their level of tolerance to iron chlorosis is similar to that of 'GF-677' and 'Adafuel' (Felipe, 1989) with 'Felinem' showing the highest tolerance. They also tolerate drought conditions well with a higher resistance to water stress in 'Monegro', mainly selected for almond in nonirrigated conditions. 'Felinem' and 'Garnem' are mostly adapted to irrigated conditions. Adaptation to poor soils is good if the soils are well drained.

Incorporation of root-knot nematode resistance was the primary breeding objective to replace several widespread nematode susceptible almond × peach hybrid rootstocks used for peach production in Spain, especially in replant situations (Pinochet, 1997). All three rootstocks have a high level of resistance to the main root-knot nematode species attacking *Prunus*, including *Meloidogyne arenaria* (Neal) Chitwood, *M. hapla* Chitwood, *M. hispanica* Hirschmann, *M. incognita* (Kofoid and White) Chitwood, and *M. javanica* (Treub) Chitwood (Marull et al., 1991; Pinochet et al., 1996a, 1999). The three rootstocks were evaluated over several years with up to 13 root-knot nematode populations from different geographical areas of the world, showing all rootstocks a broad spectrum of resistance (Esmenjaud et al., 1997; Marull et al., 1994). In addition, 'Felinem' shows a moderate resistance to the root-lesion nematode *Pratylenchus vulnus* (Pinochet et al., 2000). Resistance mechanisms to nematode are determined by hypersensitive reactions (Marull et al., 1994). Partial resistance breaking may occur under extreme heat conditions of mean soil temperature over 35 °C (Esmenjaud et al., 1996; Fernández et al., 1993).

Like most almonds and almond × peach hybrids, they exhibit a low tolerance to root asphyxia caused by waterlogging and are susceptible to crown gall caused by *Agrobacterium tumefaciens* (unpublished data). 'Monegro' and 'Garnem' are also susceptible to the root-lesion nematode *Pratylenchus vulnus* (Pinochet et al., 1996b).

Propagation and Compatibility

'Garnem', 'Felinem', and 'Monegro' propagate well by hardwood and herbaceous cuttings in aerated and well-drained soils (Gómez Aparisi et al., 2002). Best results for hardwood cuttings are obtained in the fall. Cuttings are easily obtained thanks to the low

Received for publication 29 July 2008. Accepted for publication 23 Sept. 2008.

The development of these rootstocks has involved many research projects from INIA as well as the collaboration of department colleagues, the late Dr. M. Carrera, Dr. J. Gómez Aparisi, and Dr. R. Socías i Company, the nematode resistance evaluation of Dr. J. Pinochet (IRTA, Cabrils), and the technical assistance of J.M. Ansón. I acknowledge the help and comments from Drs. R. Socías i Company, J. Pinochet, M.J. Rubio-Cabetas, and P. Errea.

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level of shoot branching. They also propagate very well in vitro.

Nursery operations are facilitated by the low presence of feathers and the red leaves as well as by the long vegetative period of the plants, allowing the production of nursery plants in a shorter period. The percentage of bud take is high for all known peach, nectarine, and almond cultivars (personal communication by different nurserymen).

These rootstocks have been selected primarily for almond and peach and have exhibited total graft compatibility with numerous almond, peach, and nectarine cultivars as shown in the almond and peach germplasm collections of the CITA, which maintain the most important Spanish and foreign cultivars (Carrera et al., 2002; Espiau et al., 2002). They are also compatible with some diploid plums (*P. salicina* Lindl. and related plums) such as 'Santa Rosa' and 'Golden Japan'. Compatibility has also been observed with some apricot cultivars belonging to the more compatible apricot group such as 'Paviot' but not with the apricot cultivars of the more exigent group such as 'Moniquí'.

Availability

'Felinem', 'Garnem', and 'Monegro' have been granted European Community Plant Variety Rights numbers 16366, 16363, and 16362, respectively. They are available to nurseries through commercial licenses by Geslive, A.I.E. (C. Juan de Mena 19-3°-D, 28014, Madrid, Spain).

Literature Cited

- Carrera, M., R. Socías i Company, and M.T. Espiau. 2002. The Spanish germplasm bank of almond, peach and pear. XXVI Int. Hort. Congr, Toronto, Canada.
- De la Guardia, M.D., A.J. Felipe, E. Alcántara, J.M. Fournier, and F.J. Romera. 1995. Evaluation of experimental peach rootstocks grown in nutrient solutions for tolerance to iron stress, p. 201–205. In: Abadía, J. (ed.). Iron nutrition in soils and plants. Kluwer Acad. Publ., Dordrecht, The Netherlands.
- Esmenjaud, D., J.C. Minot, and D. Voisin. 1996. Effect of durable inoculum pressure and high temperature on root galling, nematode numbers and survival of Myrobalan plum genotypes (*Prunus cerasifera* Ehr.) highly resistant to *Meloidogyne* spp. Fundam. Appl. Nematol. 19: 85–90.
- Esmenjaud, D., J.C. Minot, R. Voisin, J. Pinochet, M.H. Simard, and G. Salesses. 1997. Differential response to root-knot nematodes in *Prunus* species and correlative genetic implications. J. Nematol. 29:370–380.
- Espiau, M.T., J.M. Ansón, and R. Socías i Company. 2002. The almond germplasm bank of Zaragoza. Acta Hort. 591:275–278.
- Felipe, A.J. 1989. Patrones para frutales de pepita y hueso. Ed. Técnicas Europeas, S.A. Barcelona, Spain.
- Felipe, A.J. 1992. Aptitude pour la propagation chez l'amandier 'Garrigues' et sa descendance. Rap. EUR 14081:73–79.
- Felipe, A.J., J. Gómez-Aparisi, and R. Socías i Company. 1995. 'Garfi': Una nueva variedad de almendro (*P. amygdalus* Batsch) seleccionada por su aptitud al enraizamiento. VI Congr. Nac. SECH, 102.
- Fernández, C., J. Pinochet, and A. Felipe. 1993. Influence of temperature on the expression of resistance in six *Prunus* rootstocks infected with *Meloidogyne incognita*. Nematropica 24:185–202.
- Gómez Aparisi, J., M. Carrera, A.J. Felipe, and R. Socías i Company. 2002. 'Garnem', 'Monegro' y 'Felinem': Nuevos patrones híbridos almendro × melocotonero resistentes a nematodos y de hoja roja para frutales de hueso. Inf. Téc. Econ. Agrar. 97V:282–288.
- Marull, J., J. Pinochet, A.J. Felipe, and J.L. Cenis. 1994. Resistance verification in *Prunus* selections to a mixture of 13 *Meloidogyne* isolates and resistance mechanisms of a peach–almond hybrid to *M. javanica*. Fundam. Appl. Nematol. 16:85–92.
- Marull, J., J. Pinochet, S. Verdejo, and A. Soler. 1991. Reaction of *Prunus* rootstocks to *Meloidogyne incognita* and *M. arenaria* in Spain. J. Nematol. 23:564–569.
- Pinochet, J. 1997. Breeding and selection for resistance to root-knot and lesion nematodes in *Prunus* rootstocks adapted to Mediterranean conditions. Phytoparasitica 25:271–274.
- Pinochet, J., M. Anglés, E. Dalmau, C. Fernández, and A. Felipe. 1996a. *Prunus* rootstock evaluation to root-knot and lesion nematodes in Spain. J. Nematol. 28:616–623.
- Pinochet, J., C. Fernández, E. Alcañiz, and A. Felipe. 1996b. Damage by a lesion nematode, *Pratylenchus vulnus*, to *Prunus* rootstocks. Plant Dis. 80:754–757.
- Pinochet, J., C. Calvet, A. Hernández Dorrego, A. Bonet, A. Felipe, and M. Moreno. 1999. Resistance of peach and plum rootstocks from Spain, France and Italy to root-knot nematode *Meloidogyne javanica*. HortScience 34:1259–1262.
- Pinochet, J., C. Fernández, C. Calvet, A. Hernández Dorrego, and A.J. Felipe. 2000. Selection against *Pratylenchus vulnus* populations attacking *Prunus* rootstocks. HortScience 35:1333–1337.
- Ramming, D.W. and O. Tanner. 1983. 'Nemared' peach rootstock. HortScience 18:376.
- Said, A., A.J. Felipe, and J. Gómez-Aparisi. 1993. Patrones híbridos de almendro y melocotonero: Comportamiento en condiciones clorósantes. Actas Hort. 9:254–261.
- Serrano, B., J. Gómez-Aparisi, and J.I. Hormaza. 2002. Molecular fingerprinting of *Prunus* rootstocks using SSRs. J. Hort. Sci. Biotechnol. 77:368–372.