

‘Replantpac’ (Rootpac[®] R), a Plum–almond Hybrid Rootstock for Replant Situations

Jorge Pinochet

Agromillora Iberia, S.L., Research and Development, El Rebato s/n, 08739 Subirats, Barcelona, Spain

Additional index words. peach, apricot, nematode resistance, *Meloidogyne* spp., *Rosellinia necatrix*, tolerance, iron chlorosis, root asphyxia, clonal propagation

‘Replantpac’ is a new plum almond hybrid selected by Agromillora Iberia, S.L., Barcelona, Spain, for use mainly as a rootstock for Japanese plum (*Prunus salicina* Lindl.), peach, and nectarine [*P. persica* (L.) Batsch] cultivars, but it can also be used for almond [*P. dulcis* (Mill.) D. A. Webb, syn. *P. amygdalus* Batsch] and some apricot (*P. armeniaca* L.) cultivars. Trees are green leaf, with a vigor comparable to ‘Marianna 2624’ (*P. cerasifera* × *P. munsoniana* W. Wight & Herd.). Its high productivity, broad range of compatibility with several *Prunus* species, and outstanding adaptation to poor, heavy soils with high lime content (that cause iron chlorosis) offer a better production alternative for several *Prunus* species, especially in sites where soil limitations do not allow, for example, peach cultivation with traditional peach or peach–almond rootstocks (Felipe, 1989; Moreno, 2004). The high survival rate of ‘Replantpac’ as compared with peach, plum, and other peach–almond rootstocks makes this cultivar ideal for replant situations.

Origin

The rootstock originated from an open-pollinated hybrid of a Myrobalan plum (*Prunus cerasifera* Ehr.), likely the female parent, and almond, both of unknown origin. The new cultivar is probably a standard diploid genotype as both the *P. cerasifera* and *P. dulcis* parents. Several original and similar clones were found in a nursery in Zaragoza, Spain. They were observed and tested for root-knot and root-lesion nematodes, salinity tolerance, and ease of propagation by hardwood cuttings resulting in the selection of a single clone, PAC 941, which became the experimental designation of the selection and after-

ward the new cultivar. A selection process against biotic and abiotic stress factors was conducted in Barcelona and field-tested in several other geographical areas of Spain from 1997 to 2009.

Description

Unbudded trees of ‘Replantpac’ are vigorous with a slight weeping habit of growth, spreading in form. Its low propensity to generate root suckers offers significant savings in labor. Trunk bark is relatively thick forming lenticels ranging in size from 4 to 6 mm in length and 1.5 to 2.3 mm in height, moderate in number, and horizontally oriented. Branches are medium-sized, slightly smaller than that of the ‘Marianna 2624’ or ‘Myrobalan 29 C’ plums. Mature shoots are brown to olive drab [DC 15-C9; Dictionary of Color (DC); Maerz and Paul, 1950]. The current season’s shoot growth is reddish brown (DC 7-H9) with tones of purple (DC 7-4E). With maturity, shoots become grayish brown (DC 7-A8) late in the season. Internode length is variable fluctuating between 3.3 and 5.4 cm, larger than that of ‘Marianna 2624’ plum. Leaves are lanceolate (broad elliptic), larger than those of ‘Marianna’ plum and intermediate in morphology between almond and plum. Typical length from leaves on vigorous current-season’s growth is ≈11 to 14 cm, including the leaf petiole, and width is ≈3.5 to 5 cm. Leaf margins are serrate apically and along the midmargins turning crenate along the basal margins. The upper side surface is dark green (DC 23-H12) and semigloss in appearance. The lower side surface is a lighter green (DC 20-L9). The lower veins, especially the midvein, show a pale green tone (DC 20-L5). Petiole is short and grooved in the upper side ranging from 8 to 13 mm in length and ≈1 mm in thickness and pale green (DC 20-L4) with pubescence lacking along the top of the petiole. No glands are present on the petioles. Stipules are lacking. Flower buds are small, ovoid in form, and pointed. They are plump, oppressed to the bearing site, and ≈1 to 1.5 mm in length. There are commonly two floral buds per node. Flowers are of the rosaceous type (showy) and large in size. Fully expanded flower diameter is ≈25 to 32 mm, resembling those of almonds. Bloom is abundant throughout the

shoot. The petal shape is rounded ranging 12 to 17 mm in length to ≈9 to 13 mm in width. The petal number is five and color is white (DC 3-C1) to pale rose (DC 2-C1). Petal margins are smoothly undulated. Anthers are large in size and bright yellow in coloration (DC 10-K3). Stamens are long but variable in length between ≈7 and 12 mm. Coloration is white (DC 3-C1) evolving to pink (DC 3-E3). The pistil is absent. Occasionally some flowers present a small rudimentary pistil of ≈1-mm length. ‘Replantpac’ is a nonfruit-bearing tree because flowers are female-sterile (lacking female organs). Chilling requirements appear to be in the range of 500 to 600 chill units comparable to that of ‘Marianna 2624’ or ‘Myrobalan 29 C’.

Performance

Field performance and tree survival of six plum rootstocks grafted with the Japanese plum cultivar 606 were compared in 9-year-old drip-irrigated field trial. The trial was carried out in a plum replant site near Los Palacios, Seville, on a heavy soil (clay loam texture), pH 8.4, and with 8.3% active lime. Trees were planted at 6 × 3 m. The orchard was managed following the usual local procedures. The trial was established in a randomized block design with nine replications for each scion–stock combination. Guard rows were used to preclude edge effects. ‘Replantpac’ was more productive with a higher yield efficiency than most plum rootstocks. The clone also showed the best survival rate (Table 1).

‘Replantpac’ propagates with some difficulty by hardwood cuttings. In contrast, it propagates well in vitro. Initial stages of growth in the greenhouse present low to moderate feathering and an even rate of growth. Nongrafted plants are vigorous and in the nursery they exhibit a vigorous growth. The percentage of budding success for plum, peach, nectarine, and almond cultivars is good, but it is more difficult with apricot.

Root-knot nematodes (*Meloidogyne* spp.) are common in replant sites in Spain, especially where highly susceptible peach–almond hybrids such as ‘GF-677’ were previously established (Calvet et al., 2000). In a root-knot nematode trial conducted in 2008 with *M. javanica* (Treub) Chitwood, ‘Replantpac’ was found to be resistant. No galling was observed nor any life stage of the nematode recovered at the end of the trial after initial inoculation with 20,000 eggs per plant (Pinochet, 2009).

The clone has shown to be resistant to the root fungus *Rosellinia necatrix* Prill. (ana. *Dematophora necatrix* Hartig) under field conditions. This pathogen known as the white root rot fungus (Sztejnberg and Madar, 1980) is common in Spain (López Herrera, 2000). It is associated with a high mortality rate in young trees in the initial years of establishment in replant sites where peach and peach–almond hybrids are commonly used as rootstocks. A 1-ha peach orchard near Barcelona heavily infested with *R. necatrix* was pulled out after 2 years after suffering an 18%

Received for publication 13 Oct. 2009. Accepted for publication 19 Nov. 2009.

I gratefully acknowledge the advice of Dr. Antonio Felipe. I thank colleagues within Agromillora and outside collaborators for their help that made possible the development of this rootstock. Appreciation is extended to Joan Torrents, Marisa Cunill, Salvador Durán, Luis Angel Pérez, María Angeles Moreno, Vicent Albert, Belén Tamargo, Cinta Calvet, and Antonio Sánchez.
e-mail jpinochet@agromillora.com.

mortality rate (87 dead trees). Peaches were grafted on 'GF-677'. The site was replaced entirely with 'Replantpac' (480 trees). Two years after establishment, no trees had died or showed any symptoms of decline. Trees exhibited uniform growth (J. Torrents, personal communication).

'Replantpac' has also shown to be tolerant to iron chlorosis in several field trials with standing high active lime content ranging between 8% and 15% without expressing any visual symptoms of iron deficiency. In an 8-year-old field trial conducted in Zaragoza, Spain, 'Replantpac' grafted with the nectarine cultivar Big Top[®] performed well on a heavy and calcareous soil with high pH (8.4), reaching the second highest SPAD value (chlorophyll content) among 14 rootstocks in 2002 and the highest in 2003 (Table 2).

The clone adapts well to heavy-textured soils where peach-based rootstocks grow poorly. Like many plum and plum hybrids, 'Replantpac' exhibits a high tolerance to root asphyxia caused by water-logging (Moreno et al., 2008; Okic, 1987). In an asphyxia trial, death of young trees occurred between the 12th and the 16th day (Table 3). In this trial, six replicates of each of nine *Prunus* rootstocks were established in Jan. 2009 in a 9 m × 1.5 m × 0.8-m concrete pool filled with a sandy loam soil, pH 7.1, and 0.8 organic matter content. Trees were grown for 6 months before flooding in July 2009. Mean monthly temperature for July was 24.6 °C. Mortality of young trees was recorded in relation to the number of days flooded. The peach-almond hybrid 'GF-677' was used as the sensitive reference rootstock and the plum 'Myrobalan 29 C' as the tolerant rootstock to root asphyxia.

In relation to its susceptibilities, 'Replantpac' has proved to be a poor host to the root lesion nematode *Pratylenchus vulnus* Allen and Jensen in Spain (unpublished data). When challenged with two different *P. vulnus* isolates in California, the clone has shown a poor host response in one case and a good host response in the other and is likely susceptible (M.V. McKenry, personal communication). Differences in pathogenicity among populations of this pest in *Prunus* hosts tend to be common (Pinochet et al., 2000).

'Replantpac' has shown good graft compatibility with Japanese plum and with numerous peach and nectarine cultivars such as Alexandra, Ambra[®], Britney Lane, Big Top[®], Catherine, Magique, May Crest, Romea[®], Subirana[®], Summergrand, Sweet Dream, and Ufo-4[®] when tested in nursery (3 years) and orchard trials (more than 4 years). It is also graft-compatible with the Spanish almond cultivars Desmayo Langueta and Moncayo as well as with Nonpareil, Monterey, and Butte in California. The clone has shown to be compatible with some apricot cultivars, although the range of tested cultivars is not extensive.

Availability

Registration of 'Replantpac' is in progress at the Community Plant Variety Office,

Table 1. Field performance and tree survival of six rootstocks grafted with the Japanese plum cultivar 606 in a 9-year-old drip-irrigated field trial established on a heavy soil with 11% active lime content in Los Palacios, Seville, Spain.

Rootstock	TCSA [†] (cm ²)	Cumulative production (kg/tree)	Yield efficiency (kg·cm ⁻²)	Mean fruit wt (g)	Number of dead trees [‡] (total established)
Replantpac	329 a	154 a	0.47 a	47.2 a	0 (9)
Cirpac-2	181 b	59 c	0.32 c	44.5 a	5 (9)
Redglow	158 b	41 c	0.25 c	47.1 a	6 (7)
Marianna 4001	385 a	145 ab	0.38 b	46.4 a	2 (9)
Bruce	328 a	115 b	0.35 bc	45.1 a	3 (10)
Marianna 2624	386 a	153 a	0.40 ab	45.8 a	1 (10)

[†]TCSA = trunk cross-sectional area.

[‡]Trial established in a plum replant site with a history of low tree survival.

[§]Data are means of seven to 10 replications. Means within a column followed by the same letter are not significantly different (least significant difference, $P \leq 0.05$).

Table 2. Influence of 14 rootstocks on SPAD leaf values (chlorophyll content) on the nectarine cultivar Big Top[®] in a flood-irrigated trial established in a replant site with 9% active lime and pH 8.4 in Zaragoza, Spain.[†]

Rootstock	SPAD value, Aug. 2002	SPAD value, Aug. 2003	Iron chlorosis tolerance rating [‡]
Lucero	32.6 a [§]	25.6 a	Se
Rebato	34.7 ab	26.7 a	Se
Garnem	35.9 abc	40.6 bc	T
Tetra	36.6 abc	35.3 bc	MT
Monegro	37.0 abc	39.1 bc	T
Felinem	37.0 abc	32.8 ab	MT
Adafuel	37.7 abc	39.0 bc	T
Cadaman [®]	38.3 abc	42.4 c	T
Barrier [®] 1	38.4 abc	41.4 bc	T
Mayor	38.7 abc	42.8 c	T
Adesoto 101	39.4 bc	37.3 bc	T
Adarcias	39.2 bc	41.3 bc	T
Replantpac	40.3 bc	44.6 c	T
GF 677	41.9 d	41.7 bc	T

[†]SPAD values were taken the third and fourth year after grafting.

[‡]Tolerance rating: Se = sensitive to iron chlorosis with visual symptoms; MT = moderately tolerant; T = tolerant.

[§]Means in the same column followed by the same letter do not differ significantly according to least significant difference ($P \leq 0.05$). SPAD measurements were made from 10 fully expanded leaves from different areas of each tree. Five replicates were taken per rootstock established in a completely randomized block design.

Table 3. Death of peach and plum hybrid rootstocks in relation to the number of days under total flooding conditions in a root asphyxia trial conducted in July 2009 with a mean monthly temperature of 24.6 °C.

Rootstock	Plant species	Days under flooding to attain 100% death [†]
Barrier [®] 1	<i>P. persica</i> × <i>P. davidiana</i>	5
GF-677	<i>P. dulcis</i> × <i>P. persica</i>	6
PAC 0608-05	<i>P. persica</i>	6
PAC 0608-04	<i>P. persica</i>	8
ROOTPAC [®] 70	(<i>P. dulcis</i> × <i>P. persica</i>) × (<i>P. persica</i> × <i>P. davidiana</i>)	9
PAC 0529-03	<i>P. salicina</i> × <i>P. cerasifera</i>	12
PAC 9921 07	(<i>P. besseyi</i> × <i>P. salicina</i>) × <i>P. armeniaca</i>	14
Replantpac	<i>P. cerasifera</i> × <i>P. dulcis</i>	16
Myrobalan 29 C	<i>P. cerasifera</i>	17

[†]Data are means of six replications.

49101 Angers, Cedex 02, France, with the reference of requesting authority N° 2009/0230. Virus-free material is available from Agromillora Iberia, El Rebato s/n. 08739 Subirats Barcelona, Spain. 'Replantpac' is currently marketed in Spain and Europe by several nurseries under the commercial Trademark name Rootpac[®]. In the United States, the clone was filed on 14 Oct. 2008 at the U.S. Patent and Trademark Office as 'PAC 941' maintaining the same commercial trademark name as in Europe. Inquiries regarding the availability

of Rootpac[®] R should be directed to North American Plants LLC, 9375 NE Warmington Road, McMinnville, OR 97128 and Nurstech, Inc., 612 East Gridley Road, Gridley, CA 95948.

Literature Cited

Calvet, C., V. Estaún, A. Camprubi, and J. Pinochet. 2000. Enfermedades de replantación en los frutales. Parte VI, p. 107-109. In: Montesinos, E., P. Melgarejo, M.A. Cambra, and J. Pinochet (eds.). Enfermedades de los frutales de pepita y

- hueso. Monografía de la Sociedad Española de Fitopatología N° 3. Ediciones Mundi-Prensa, Madrid, Barcelona, Spain.
- Felipe, A.J. 1989. Patrones para frutales de pepita y hueso. Técnicas Europeas, S.A. Barcelona, Spain.
- López-Herrera, C. 2000. La podredumbre blanca de la raíz causada por *Rosellinia necatrix*. Parte IV, p. 79–81. In: Montesinos, E., P. Melgarejo, M.A. Cambra and J. Pinochet (eds.). Enfermedades de los frutales de pepita y hueso. Monografía de la Sociedad Española de Fitopatología N° 3. Ediciones Mundi-Prensa, Madrid, Barcelona, Spain.
- Maerz, A. and M.R. Paul. 1950. Dictionary of color. 2nd Ed. McGraw Hill Book Company, Inc., New York, NY.
- Moreno, M.A. 2004. Breeding and selection of *Prunus* rootstocks at Aula Dei Experimental Station, Zaragoza, Spain. *Acta Hort.* 658:519–528.
- Moreno, M.A., Y. Gogorcena, and J. Pinochet. 2008. Mejora y selección de patrones *Prunus* tolerantes a estreses abióticos, p. 449–475. In: Avila, C.M., S. Atienza, M.T. Moreno and J.I. Cubero (eds.). La adaptación al ambiente y los estreses abióticos en la mejora vegetal. Consejería de Agricultura y Pesca, Junta de Andalucía, Spain.
- Okie, W.R. 1987. Plum rootstocks, p. 321–360. In: Rom, R.C. and R.F. Carlson (eds.). Rootstocks for fruit crops. Wiley, New York, NY.
- Pinochet, J. 2009. 'Greenpac' a new peach hybrid rootstock adapted to Mediterranean conditions. *HortScience* 44:1456–1457.
- Pinochet, J., C. Fernández, C. Calvet, A. Hernández-Dorrego, and A. Felipe. 2000. Selection against *Pratylenchus vulnus* populations attacking *Prunus* rootstocks. *HortScience* 35:1333–1337.
- Sztejnberg, A. and Z. Madar. 1980. Host range of *Dematophora necatrix*, the cause of white root rot in fruit trees. *Plant Dis.* 64:662–664.