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‘Intensia’, a New Dwarfing Almond × Peach Hybrid Rootstock for Almond and Peach

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‘Intensia’ is a dwarfing almond × peach hybrid rootstock obtained and released by the Institut de Recerca i Tecnologia Agroalimentàries (IRTA). This new rootstock is well-suited for modern intensive *Prunus* production models such as super high-density systems for almonds due to its ability to reduce vigor. Furthermore, ‘Intensia’ confronts certain challenges faced by *Prunus* crops in Mediterranean climates that are not currently addressed by existing rootstocks. The novel rootstock is characterized by conferring reduced vigor to the grafted cultivar, early bearing, adaptation to calcareous soils and other Mediterranean agroecological conditions, easy clonal propagation, reduced number of sylleptic shoots, and good graft compatibility with a wide range of peach and almond cultivars. ‘Intensia’ also exhibits outstanding agronomic performance in almond trials, including the promotion of early bearing, delayed flowering, early harvest induction, improved cropping efficiency, and drought tolerance by water use efficiency. This rootstock has also played a remarkable role in the recent development of *Prunus* genetics worldwide.

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Origin

The clone ‘Intensia’ (breeder reference ‘MB 1-37’) is an almond × peach hybrid, selected among a progeny raised from a cross made in 1979 by F. J. Vargas and M. A. Romero at IRTA Mas Bové, NE Spain (41°10′16″N, 1°11′30″E). The cross was made between two North American *Prunus* cultivars, the almond ‘Texas’ (syn. ‘Mission’ and ‘Texas Prolific’) as the female parent and the peach ‘Earlygold’ as the pollen donor. ‘Texas’ is a medium hard-shelled chance seedling that originated about 1891, and ‘Earlygold’ is a semifreestone of a complex parentage that was selected in 1952 by H. C. Swim from Armstrong Nurseries (Ontario, CA, USA) (Brooks and Olmo 1997).

Description

Unbudded trees of ‘Intensia’ showed reduced vigor coupled with upright and compact canopy. The leaves exhibit a green coloration with a morphology intermediate between almond and peach. The flowers are large (similar size to parentals), showy type, with five large pale-pink petals, reddish anthers, along with the uncommon traits of multiple pistils. The ‘Intensia’ rootstock blooms early, at the same time as the almond cultivar Nonpareil. The fruit is intermediate in size, between ‘Texas’ and ‘Earlygold’ mature fruits, resembling a peach in shape. Fruits are characterized to be nonjuicy, with red skin and flesh, and thick flesh.

Performance

Primary testing of ‘Intensia’ rootstock was conducted for 7 years at the IRTA Mas Bové research station, NE Spain (41°10′16″N, 1°11′30″E), in a plot under dryland conditions (450 mm, average annual rainfall) planted in 1986. In this initial trial, ‘Intensia’ was tested among 25 other almond × peach unbudded hybrids in an alkaline loamy-sandy soil, with low organic matter (1%), and low phosphorus and potassium content (Felipe et al. 1997). Later, ‘Intensia’ was evaluated in one rootstock trial planted in 2010 at the IRTA Les Borges Blanques research station, NE Spain (41°30′31″N, 0°51′10″E), using the almonds ‘Vairo’ and ‘Marinada’ as the scion cultivars (Lordan et al. 2019). This experimental orchard was characterized by loam clay soil, with a good water-retention capacity, and an organic matter content of ≈2%. The trees were planted in a randomized complete block design at a spacing of 5 × 4.5 m, drip-irrigated, with 6 to 12 trees per replicate trained to an open vase system. In addition, ‘Intensia’ was tested in another rootstock trail under loamy and calcareous soil conditions at the IRTA Gimenells research station, NE Spain (41°39′18″N, 0°23′31″E), using the peach ‘Big Top’ as the scion cultivar (Reig et al. 2022). The trees were planted in 2008, at a spacing of 5 × 2.6 m, in a randomized complete block design with three trees per scion-rootstock combination, trained to an open vase system. Finally, an assessment of different training systems of the almond ‘Vairo’ cultivar grafted onto ‘Intensia’ was evaluated. This trial was set in 2012 at the IRTA Mas Bové research station (NE Spain), drip-irrigated, in which productions of the ‘Vairo’ cultivar were scored under three training systems: open vase (6 × 3 m), central axis (5 × 1.5 m), and hedgerow (4 × 1 m).

Initial assessment of 7-year-old unbudded ‘Intensia’ trees showed a significantly smaller trunk diameter (18.4 cm) compared with some *Prunus* references rootstocks of the same age (‘GF-677’: 42.3 cm; and ‘Garrigues’: 28.7 cm) (Felipe et al. 1997). Subsequent assessments involving grafted ‘Intensia’ trees with almond and peach cultivars revealed a decrease in vigor transmitted to the cultivar (Lordan et al. 2019; Reig et al. 2022). This reduction in vigor was 40% to 50% less than that observed in trees grafted onto ‘GF-677’, and similar to the reduction reported in low-vigor rootstocks such as ‘Rootpac® 20’ (Table 1). Thus, tree volume induced by ‘Intensia’ to the almond scions makes this semidwarfing rootstock suitable for the new medium- and high-density almond plantings with spacing ranging from 5 × 1.5 to 4 × 1 m (1250 to 2500 trees/ha, respectively) (Casanova-Gascón et al. 2019).

In terms of flowering time, differences were observed within the same almond cultivar when grafted onto various rootstocks (Table 1). Evaluations indicate that, on average, ‘Intensia’ delays the blooming time of the cultivar by 1 d compared with ‘GF-677’ while advancing the flowering by 2 d compared with other low-vigor rootstocks such as ‘Rootpac® 20’. Similarly, regarding harvest

Table 1. Summary of agronomic and productivity assessment of almond (Vairo and Marinada) and peach (Big Top) cultivar trees grafted onto Intensia, Rootpac® 20, and GF-677 rootstocks. Data sourced from Lordan et al. (2019) (averaged over 5 years on trees 4 to 8 years old) and Reig et al. (2022) (data from the 10th crop year).

		Rootpac® 20	Intensia	GF-677
Trunk cross-sectional area (cm^2)	Vairo	204.7	200.0	317.9
	Marinada	135.9	144.0	248.5
	Big Top	142.7	153.5	169.1
Bloom time (Julyian days)	Vairo	73.0	72.8	72.0
	Marinada	81.5	80.5	79.5
Nut ripening date (Julyian days)	Vairo	242.2	247.8	251.8
	Marinada	255.4	267.2	269.8
Yield (kg/ha)[i]	Vairo	1345	2134	3638
	Marinada	717	1203	2344
	Big Top	32938	27780	24146
Yield efficiency (Yield kg/TCSA cm^2)	Vairo	0.09	0.14	0.15
	Marinada	0.07	0.13	0.13
	Big Top	0.30	0.23	0.19
Kernel or fruit weight (g)[ii]	Vairo	1.00	1.15	1.18
	Marinada	1.15	1.25	1.29
	Big Top	159.7	154.8	174.5

[i] Yield was assessed in terms of kernel dry weight for the almond cultivars (Vairo and Marinada), and fruit weight for the peach cultivar (Big Top).

[ii] Kernel dry weight for the almond cultivars (Vairo and Marinada), and fruit weight for the peach cultivar (Big Top).

time (in the case of almond cultivars evaluated when more than 75% of the fruits had completely dried hulls), it was observed that almond cultivars grafted onto 'Intensia' were harvested by 2 to 3 d earlier than those grafted onto 'GF-677'. Compared with other low-vigor rootstocks like 'Rootpac® 20' or 'Rootpac® R', 'Intensia' delays the harvest time of almonds by ≈1 week (Lordan et al. 2019).

Yield observations from trials with almond and peach cultivars grafted onto various rootstocks revealed that 'Intensia' demonstrated production levels similar to those seen in other rootstocks like 'Rootpac® 40' and surpassed those of another group of rootstocks including 'Ishtara®', 'Adesoto', or 'Rootpac® 20' (Lordan et al. 2019). These differences were attributed to the vigor induced by the rootstock. However, the yield efficiency observed with 'Intensia' was significantly improved relative to that reported for other rootstocks of comparable vigor, as measured by trunk cross-sectional area (Table 1). Furthermore, in a separate trial initiated in 2012 at the IRTA Mas Bové research station, using 'Intensia' as the rootstock, an assessment was conducted to evaluate the productivity of the almond cultivar (Vairo) under three distinct training systems. In this trial, the average annual production over 7 years (2014 to 2020) ranged from 1453 (open vase; 596 trees/ha) to 2384 kg of kernel/ha (hedgerow; 2500 trees/ha) (Fig. 1). In addition, early bearing cropping was observed on the central axis and hedgerow training systems. This trial revealed the potential of 'Intensia' rootstock in medium- and high-density almond plantations.

Regarding almond kernel quality parameters, it was noted that trees grafted onto 'Intensia' showed kernel weights comparable to those reported for 'GF-677' in various evaluated almond cultivars (Table 1). Moreover, these weights were ∼15% higher than those reported for cultivars grafted onto rootstocks such as 'Rootpac® 20' or 'Ishtara®' (Lordan et al. 2019; Reig et al. 2022). As for other parameters like shelling percentage, 'Intensia' demonstrated values similar to those of 'GF-677', with minimal differences observed between rootstocks. For the peach fruit weight, no significant differences between fruits of the same variety grafted onto 'Intensia' and 'GF-677' rootstocks were observed (Reig et al. 2022).

In addition, 'Intensia' displayed lower evapotranspiration and showed better water use efficiency than rootstocks with similar canopy vigor (Bellvert et al. 2021). Furthermore, 'Intensia' shows moderate susceptibility to iron chlorosis and tolerance to calcareous soil (Felipe et al. 1997; Reig et al. 2020). 'Intensia' was also tested for root-knot nematode resistance and classified as susceptible (Fernández et al. 1994 and J. Pinochet, personal communication).

An ease of propagation of 'Intensia' by hardwood cuttings was observed with rooting percentages ranging from 34% to 38% obtained in three different assays. These tests involved treating the cuttings with 4000 ppm of indole butyric acid by dipping the cutting bases and then placing them in a perlite-vermiculite medium with bottom heating set to 25 °C.

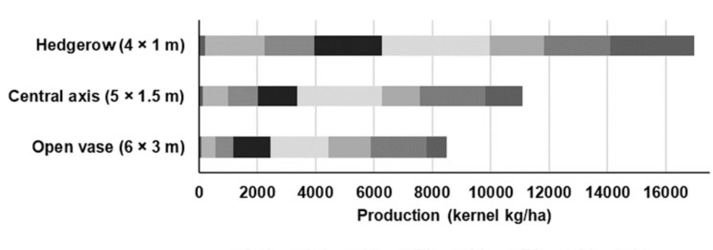

Fig. 1. Accumulated yields of 'Vairo' (kg of kernel per hectare) from the trial including three training systems (hedgerow, central axis, and open vase) at IRTA Mas Bové (Tarragona, Spain) using 'Intensia' as the rootstock. Data cover annual yields from the second to the ninth year of observation.

Prunus Genetic Development

The origin of 'Intensia' is closely related to the remarkable developments of *Prunus* genetics achieved over the past few decades. Its selfed progeny (T × E) was used to construct the first saturated linkage map in a *Prunus* species (Joobeur et al. 1998) using transferable markers (mainly restriction fragment length polymorphisms) and was later adopted by the scientific community as the reference map for the genus (Dirlewanger et al. 2004). In addition, it set the foundation for chromosome number and orientation used later in the assembly of the first peach genome "*de novo*" sequence (Verde et al. 2013) and most of the other *Prunus* sequences generated afterward, including the 'Texas' almond genome (Alioto et al. 2020). Furthermore, the genetic analysis of the T × E F_2 population and the backcross of 'Intensia' to 'Earlygold' (T1E population), resulted in the discovery of a cytoplasmic male sterility conferred by the almond cytoplasm (Donoso et al. 2015). In addition, numerous major genes and quantitative trait loci responsible for the interspecific variability across various agronomic traits in these species were discovered (Donoso et al. 2016). Moreover, backcrossing 'Intensia' with 'Earlygold' as a recurrent parent allowed the proof-of-concept of a method (marker-assisted introgression) to introgress single DNA fragments from almond into the peach genome in only two backcross generations (Serra et al. 2016), which finally led to the creation of a full collection of introgression lines of single almond fragments into the peach genetic background (Kalluri et al. 2022).

Availability

'Intensia' was sent to examination in 2021 to the European Community Plant Variety Office with application number 20213277.

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