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Original Research Paper

The selection of appropriate rootstock and training system towards sustainable production of stone fruits

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Abstract. In stone fruit species, such as peach, cherry, apricot and plum labour requirement is important ranging from 45% to 71% of the total cost of production. In this sense, combining size controlling rootstocks as Rootpac® series, Isthara® and others in peach and plum, or Gisela® and Corette® series in cherry, with intensive bidimensional training systems based on central axis or bi axis resulted in earlier and higher yields, compared with the traditional open vase associated with vigorous rootstocks. The association of these intensive orchards with bidimensional canopies and good accessibility to canopy by labour and machines, is essential to reduce the cost of production. These canopies allow an efficient use of labour and mechanization. Regarding peach, under Ebro Valley (Spain) conditions, the reduction on total cost of production ranged from 15% to 20% and the harvest rate increased by 41%, enhancing also fruit quality due to better light distribution within the tree canopy. In cherry the increase of harvest rate increased by 72% when UFO was compared with the traditional open center. Regarding what in Washington State (US). With European and Japanese varieties, intensification by using Rootpac®20 rootstock and super high density plantings (SHD), allowed to get more than 40 t ha^{-1} in the third year in Ebro Valley (Spain). With 'Agen' European plum, using the same rootstock, under Chilean conditions training trees in a small hedge (SHD) allowed the full mechanization of the harvest by using over-the-row harvester or pedestrian harvest for the needs of fresh market. In this case, manual harvest efficiency increased by 49% compared with the traditional open vase. In all species, the use of size controlling rootstocks offers different options to growers when selecting the training systems concerning skilled labour requirements to train the trees in the first years. Thus, an increase was recorded when the number of axes increased from central axis to bi-, tri- and multi-axes. Furthermore, all these planar canopies were better adapted to the application of precision technologies based on artificial vision (AV) for monitoring pest and diseases, neural network and AV for fruit counting, yield forecasting and robotic harvesting.

Keywords: peach, cherry, plum, size controlling, intensification, planar canopies, production cost, efficiency.

1. Introduction

Among *Prunus* species, stone fruits including peach, cherry, apricot and plum are important deciduous crops in countries such as China, USA, Spain, Poland, Chile and Australia, in terms of surface and production. Peach is the most important among stone fruit species. Spain ranks in the second place in the world concerning stone fruit production, with a surface area occupied of 185,527ha in 2021 and a production of 2,354,533t. Cherry world production was 2,665,313 t in 2021, leaded by China, Turkey, the USA, and Chile. Finaly world plum production recorded in 2021 reached 12,578,200t, led by China, Romania, United States and Serbia (FAOSTAT, 2022). Total world apricot production reached in 2021 2,860,100t ranking Turkey in the first place, followed by Uzbekistan and Iran.

Concerning rootstocks, in peach different interspecific hybrids and seedling rootstocks providing mid to high vigour ('GF-677', 'Garnem', 'Guardian', 'Nemaguard', 'Atlas', and 'Lowell', among others), are commonly used. In the last decade, the interest in size-controlling rootstocks has increased, with the aim of developing more intensive and efficient orchards (DeJong et al., 2005; Iglesias and Echeverría, 2022; Iglesias et al., 2023). Among others Rootpac® series, Isthara® and 'MP-29' (Beackman et al., 2012), are well known. In the last decade, new rootstock selections as 'Intensia' (Lordan et al., 2019) and 'Pilowred' (Bielsa et al., 2023), are in process of testing and development in different countries. In sweet cherry there a wide range of rootstocks are used. In the South of Europe, different selections of *P. mahaleb* and 'Adara' are commonly combined with MaxMa®14 (Iglesias et al., in press). In the USA, Chile and many other countries, 'Colt', 'Mazzard', 'Mahaleb' and 'Krymsk' are being used, and also different selections of GiSelA® (Long et al., 2019). In the last decade different trials are in progress to know the agronomical performance of size controlling rootstocks of Corette® series. la in US and Europe. In plum mid to high vigorous as 'Myrobolan 29C', 'Mariana 2624', 'Brompton', 'Nemaguard', among others are commonly used, associated with mid density orchards and open vase as the main training system.

Labour is one of the most critical production costs in deciduous fruit production, and particularly for stone fruit species associated with greater requirements of flower and/ or fruit thinning. An efficient way to gain competitivity by growers is replacing labour by efficient mechanization (pruning, thinning, harvest) developing planar canopies (Day et al., 2005; Neri et al., 2022). These bidimensional canopies are, in addition, more accessible to workers and machines (Long et al., 2019). Combining intensification with planar canopies results in early yields and in a reduction in the cost of production (Iglesias et al., 2023). Bidimensional canopies are better adapted to mechanization and thereby achieving greater efficiency in the use of inputs, particularly labour (Lugli et al., 2015; Musacchi et al., 2015; Iglesias et al., in press).

In the main stone fruit species, the open vase or gobelet system, is the standard training system for most peach, cherry and plum orchards, system traditionally associated with mid to high-vigour rootstocks and important canopy volumes. In Spain, new, intensive peach orchards have been planted in the last decade, using size-controlling rootstocks from the Rootpac® series and other interspecific hybrids as Isthara® to avoid the need for bio-regulators, a common practice with the traditional Spanish gobelet system (Iglesias and Echeverría, 2022; Iglesias et al., 2023). Bi-dimensional planar canopies trained on single and bi-axes have been developed in all deciduous species with aiming to increase the efficiency of inputs, reducing production costs by providing better accessibility to the canopy for both workers and machines (Iglesias and Torrents, 2022; Iglesias et al., 2023) and increasing fruit quality.

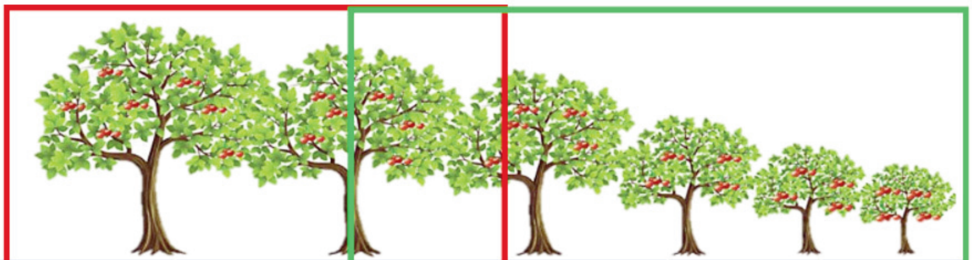
In this article we provide some examples showing how the combination of size controlling rootstocks with bidimensional training systems resulted in a more efficient production of peach, cherry and plum.

2. Examples and discussion

2.1. Size controlling rootstocks and training systems in Prunus *species*

In this section, we illustrate the effect of combining size-controlling rootstocks and intensive training systems on yield and fruit quality. The data were collected from either experimental or commercial orchards in different countries, such as the USA, Spain, and Italy. The aim was to show the benefits of an optimal combination of cultivar/ rootstock/training systems and how this could be used to achieve the best orchard performance. In the case of rootstocks, a wide range of vigour conferred to the cultivar is nowadays available for peach, cherry and plum. The main rootstocks available for peach, cherry, plum (European and Japanese) and apricot, grouped by tree vigour and training systems associated to them are illustrated in Figure 1. In Figure 2, only bi-dimensional training systems of potential use for stone fruit species are exposed: from central axis to planar cordon or multileader, this last one developed in apple (Tustin et al., 2022). Training systems with an increased number of axes are more adapted for more vigorous rootstocks (Lang et al., 2022; Tustin et al., 2022). An increase of labour for training trees during the first two years is required when the number of axes increased from central axis to bi-, tri- and multi-axes (Iglesias et al., in press).

Due to the lack of efficient size controlling rootstocks, until last decade, in stone fruit species compared with apple ('M.9' selections) or pear (quince), the intensification and consequently the use of planar training systems has been delayed. Intensive orchards and/or planar canopies in the main producing areas represents nowadays from 7 to 15% of the total surface. Thus, in peach different adaptations of open vase have been used in different countries as Spanish gobelet in Spain and Italy or Quad-V or Hex-V in the USA (Iglesias et al., 2023).



SPECIES	120-110% Very vigorous	110-100% Standard	100-80% Standard-mid	80-60% Mid	60-40% Semi-dwarf	<40% Dwarf
PEACH	Garnen (GN.15) Guardian® Nemaguard Atlas, Viking	GF.677, GF.305 Montclar® Cadaman® Krysmk®86	Tetra Penta Controller®7 Controller®8	Adesoto.101 Isthara® Controller®6 Rootpac®R	Rootpac®40 MP.29 Controller®5 Intensia®	Rootpac®20 Pilowred®
CHERRY	INRA®SL.64 Mazzard Mahaleb	Adara MaxMa®14 GiSelA®17	GiSelA®13 GiSelA®12 Piku®1	GiSelA®6 Weiroot.158 Krymsk.6	Weigi.2 GiSelA®5 Clinton	GiSelA®3 Lake, Cass Crawford, Clare
EUROP. PLUM JAPANE. PLUM	Mariana 26/24 Mariana GF 8/1 Nemaguard	Myrobolan 29C Adara	Rootpac®R Tetra Penta	Isthara® Adesoto®101	Miral 3278-AD	Rootpac®20
APRICOT	Marianna 2624 Marianna GF 8/1 Seedling	Aprimed® (AP-65) Montclar®, GF.305 Mirobolan 29-C Adara	Rootpac®R Tetra Penta	Isthara® Adesoto®101	Miral 3278-AD	Rootpac®20

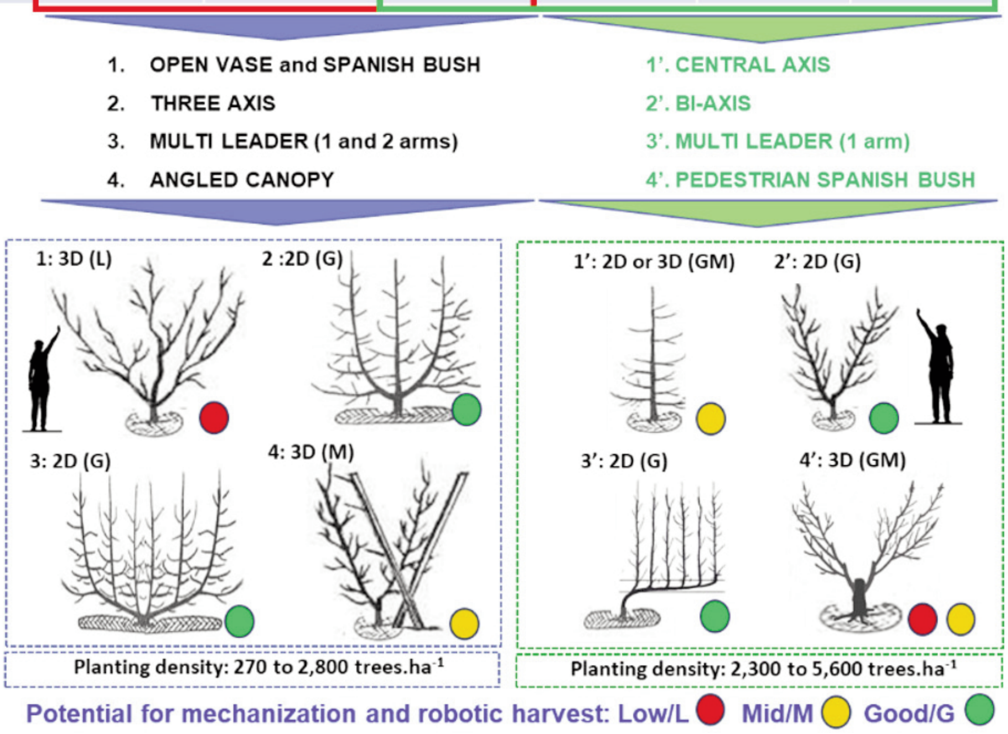


Figure 1. Comparative vigour conferred by different rootstocks used for peach, cherry, plum and apricot, and training systems associated (Source: adapted from Iglesias et al., 2023).

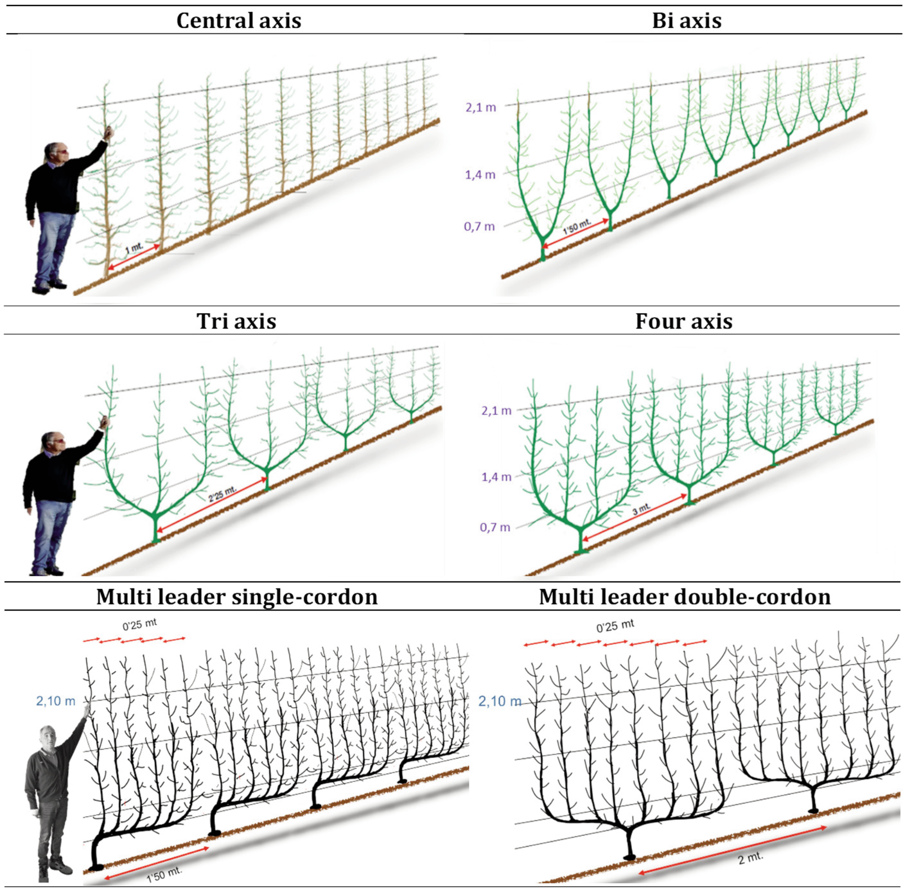


Figure 2. Different options of training systems for steno fruits: from central axis to multi-leader. (Drawing by A. Monturiol and I. Iglesias).

The most common planar system in the past was palmette or the tri-axis associated with either, semi vigorous or vigorous rootstocks (Iglesias and Echeverría, 2022). Over the last decades the availability of mid to low vigour rootstocks and also in some countries of paclobutrazol made if possible, the intensification and the use of training systems, as the central axis or bi axis, requiring less labour for train during the first two or three years. In cherry, mid-vigour rootstocks are commonly used combining different modifications of open vase, KGB, central axis system and UFO in some cases. Rootstocks as 'Mazard', 'Mahaleb', Maxma®14, 'Colt', 'Adara' and different GiSelA® selections are commonly used. With Japanese and European plums, mid to high vigorous rootstocks as 'Myrobolan 29C', 'Mariana 2624', 'Nemaguard' and other interspecific hybrids, are the most used in all countries. The schema of different options available today for stone fruits to train trees in bidimensional 2D canopies are illustrated in Figure 2, from less to more number of axis. The increase in the number of axis/tree is required to reach a natural balance yield/vigour when more vigorous rootstocks are used. But increasing this number, the requirements of labour to train trees during the first 2-3 years also increased. In this sense, central axis is the easy way to train the trees during the first two years and planar cordon the most demandant in labour.

2.2. Cost of production and training systems in Peach

After cherry, peach is the crop with the greatest demand for labour, with this representing around 50% of the total cost of production, based on 0.45 € kg^{-1} in the Ebro Valley (Spain), for a mid-season cultivar in 2022 (Figure 3). The main components of labour costs are harvest, fruit thinning (no options for chemical thinning) and pruning. In the same Figure 3, the different trends of labour cost and prices perceived by growers over 2002-2022 period are represented. The cumulative increase of labour has been much higher than the price increase perceived by growers (Figure 3).

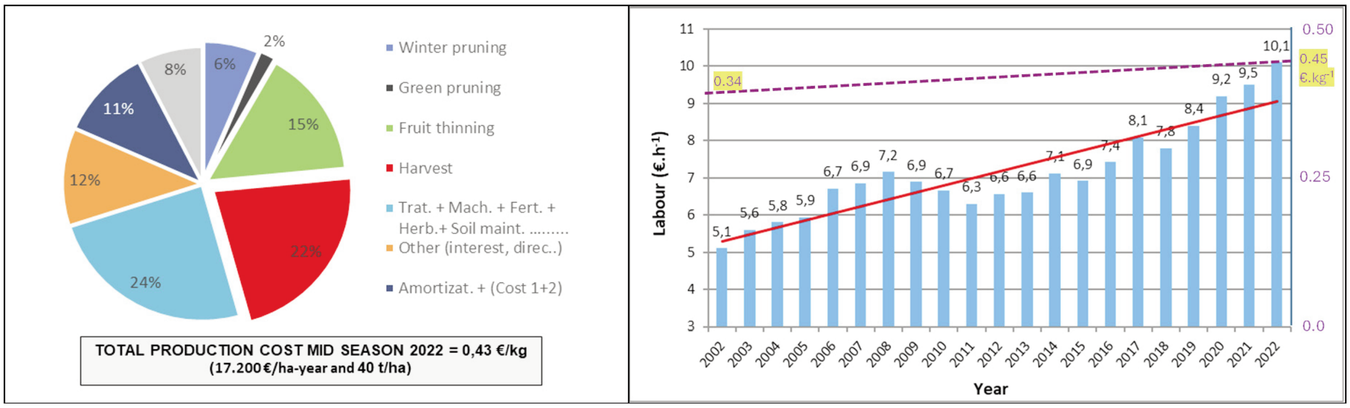


Figure 3. The 2022 cost of production by concepts for a mid-season nectarine cultivar with a 40 t.ha^{-1} yield trained in Spanish gobelet, spacing 5 × 3 m and expected lifespan of 14 years in Ebro Valley, Spain (left). Trends of labour cost and prices perceived by growers (discontinuous line) over 2002-2022 period (right).

Partition of costs by components (Figure 3) evidence that the reduction of cost should be based on the reduction of labour, and plant protection and fertilization in a second place. A full set of data reported by Iglesias and Echeverría (2022; Iglesias et al., 2023), showed the benefits for growers of combining intensification, planar canopies (axis and bi-axis) and mechanization. These data are updated to 2022 in Table 1 and show that by developing planar canopies with size-controlling rootstocks as Rootpac®40 and using mechanization for pruning, thinning and harvest, including more efficient spraying, the total cost of production was reduced by 2503 € ha^{-1} or 1646 € ha^{-1} considering the annual amortization cost of 857 € ha^{-1} (Table 1).

Table 1. Training system and rootstock effect on yield, production cost and labour efficiency for 10-year-old trees of cultivar 'Luciana' in Lleida (Ebro Valley, NE Spain) in 2020. Updated to 2022 from Iglesias and Echeverria, 2022).

Traing syste. Rootstock Spacing	Yield (kg ha^{-1})	Total cost (€ ha^{-1})$^{+}$	Total cost (€ kg^{-1})	Pesticides + fertilizers (€ ha^{-1})*	Winter pruning (€ ha^{-1})*	Flo. + Fru. thinning (€ ha^{-1})*	Harvest (€ ha^{-1})*	Total vari. Cost *(S) (€ ha^{-1})	Other (€ ha^{-1})$^{+}$	Labour efficiency (h t^{-1})
Spanish Gob. GF-677 5 × 3 m	**40**	**17.64**	**0.44**	**4,233.6** (2,751.8 pest.) (1,431.7 fert.)	**1,104.0**	**2,142.0**	**3,399.6**	**10,879.2**	**6,760.8**	**(651 h ha^{-1})** **16.0 h t^{-1}**
Central Axis RootPAC®40 3.5 × 1.1 m	**50**	**15.137**	**0.30**	**3,372.0** (2,192 pest.) (1,180 fert.)	**900.0**	**1,003.2**	**2,427.6**	**7,702.8**	**7,434.0**	**(398 h ha^{-1})** **7.6 h t^{-1}**
DIF. CL-SG	**10**	**-2.503**	**-0.14**	**-861.6**	**-204.0**	**1,138.8**	**-972.0**	**3,176.4**	**673.2**	**39%**

Labour cost considered: 10.1 € h^{-1} (2022).
$^{+}$ including annual amortization = 857 € year^{-1} (14 years lifespan). Cost of establishment 9,600 € ha^{-1} SG and 21,600 € ha^{-1} CA
SG = Spanish Gobelet CA = Central leader.

The total labour requirements per season were reduced from 651 to 398 h ha^{-1} when intensive planting orchards and planar canopies were used. This represents a 39% decrease in required labour due to its greater efficiency. Despite this advantage, for intensive orchards the cost of planting is more than twice as high compared with the standard Spanish gobelet system. To calculate the current annual cost, we considered a total planting cost of 9,600 € ha^{-1} for the Spanish gobelet and 21,600 € ha^{-1} for the central leader system and a lifespan of 14 years, which resulted in an increased annual cost of amortization of 857 € ha^{-1}, including interest costs, for the intensive system (Table 1). In addition, bidimensional canopies in peach are more efficient in the use of pesticides and fungicides (Table 1), reducing total volume of pesticide applied and drift in around 20% and consequently the environmental impact and the cost of production (Grau and Iglesias, 2023; Iglesias, 2021).

2.3. Production costs and rootstocks in Sweet Cherry

Cherry is the most labour-demanding deciduous fruit crop. In Spain, considering a mid-season variety, only harvest represents 59% of the total cost of production (Figure 4). Changing the current Spanish bush for more intensive/planar canopies is an interesting option to improve the accessibility of labour and machines and, consequently, reduce the cost of production as reported in peach by Iglesias and Echeverría (2022) and in cherry by Whiting (2018).

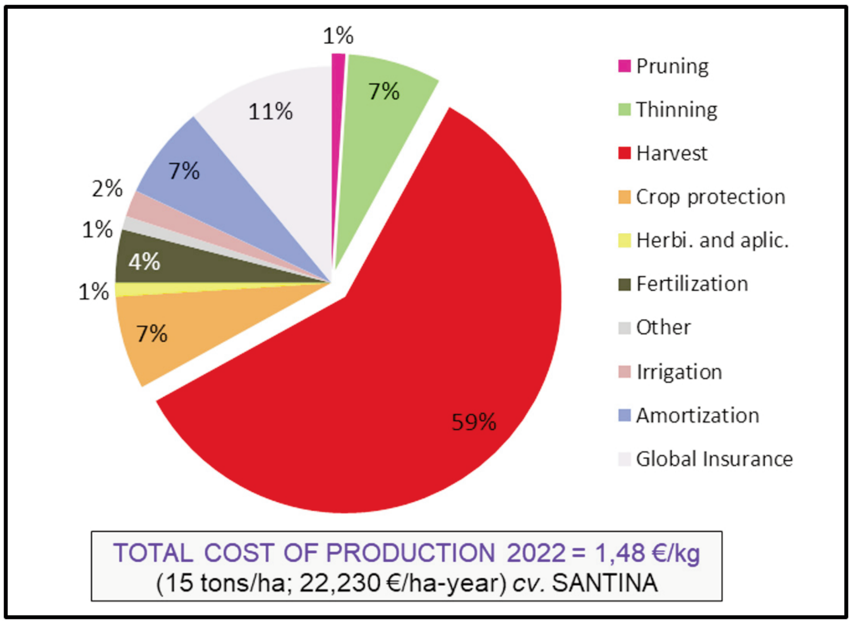


Figure 4. The 2022 cost of production by concepts for a mid-season cherry cultivar with 15 t.ha^{-1} yield, trained in Spanish gobelet, spacing 5 × 3 m and expected lifespan of 14 years in Ebro Valley, Spain.

The potential of intensive orchards for a specific variety compared to the standard open vase is due to the combination of controlling rootstocks with a specific training system. As in apple, the intensification results in early yields from shorter branches compared to low density orchards, reducing the cost of bending the branches towards the fruiting position (Long et al., 2015). Additionally, planar canopies in cherry resulted in a better access to labor and machines, improving light distribution in the whole canopy and fruit quality (Ghelfi et al., 2015). Data from Whiting (2018) illustrated the clear effect of canopy accessibility on harvest efficiency, reporting an increase of 72% and 52%, respectively, when UFO and KGB systems were compared with the open center. The process of selection of different control sizing rootstocks around the world over the last decades has provided new opportunities to develop more intensive, efficient and sustainable cherry training systems (Lang, 2000). Especially important has been the GiSelA® series developed in Germany by the Consortium Deutscher Baumschulen GmbH Ltd. company (CDB). Some rootstocks such as GiSelA®5 or GiSelA®6 were introduced years ago by the fruit industry in several countries such as Germany, Italy and Chile. The results obtained by applying this concept in commercial orchards of Emilia Romagna Region (Italy), combining different 'Sweet series' varieties with dwarfing rootstocks as the dwarfing GiSelA®5 is shown in Table 2. Their efficiency in increasing precocity, yield and fruit quality, in particular fruit size, is clear. Similar results were obtained by Dallabetta et al (2019) in the Northern Trentino region where trees grafted on GiSelA®5 obtained a higher cumulative yield, yield efficiency and fruit quality (data not shown) compared to trees on the stronger Piku®1(S). In this trial, the innovative 2-D planar trees produced a higher yield than the traditional and most common 3-D spindle training system without detrimentally affecting fruit size.

Table 2. Annual and cumulative yields (C.Y.), mean fruit size and fruit weight of 7-year-old trees of Sweet Valina®, Sweet Saretta® and 'Kordia', grafted on GiSelA®5 in Ferrara (Emilia Romagna, Italy). Source: Giori M., personal com. (2020).

Variety	Space distances (m)	Yield (t ha^{-1})						Fruit size		Fruit Weight (g)
		2nd year	3rd year	4th year	5th year	6th year	C.Y. (t.)	% (Ø mm)	mm	
S. Valina®	3.50 × 0.50	3.3	6.5	15.1	18.4	16.3*	59.6	100% (28+)	28-30	7.7
S. Saretta®	3.50 × 0.50	3.8	7.7	18.3	22.8	20.7*	73.3	100% (30+)	30-32	8.2
'Kordia'	3.50 × 0.50	3.0	6.5	12.6	13.1	5.2*	40.4	90% (28+)	28-30	7.4

* Affected by spring frost in blooming time, 9 days at 0ºC and 2 days at - 4,5°C.

Other rootstocks have been released by Michigan State University (MSU) in the U.S., named Corette® with the following numbers: Corette®1 Cass, Corette®2 Clare, Corette®3 Clinton, Corette®4 Crawford, and Corette®5 Lake. Three of the MSU rootstocks, 'Cass', 'Clare' and 'Lake', produce particularly small trees, equivalent or smaller than trees on GiSelA®3. They have been tested in different locations in the U.S. providing interesting results (Iezoni, 2013). For example, Corette® selections with 'Bing' provided a significant reduction of tree canopy with high yield efficiency and similar fruit size to GiSelA® selections. Yield efficiency and fruit weight of the 'Bing' cultivar was shown to be improved by the rootstocks 'Cass' and 'Clare', but the trial was limited, and more testing is required (Long et al., 2019). For 'Regina' at The Dalles (OR), trained to a steep leader, 'Cass' and 'Clare' followed by 'Clinton' in 2019, resulted in significantly increased annual projected per hectare yields when compared with Krymsk®6 (K6) and GiSelA®6 (Gi6) (Table 3).

Table 3. Tree yields, projected per hectare yields and fruit size for 'Regina' on four Corette® rootstock selections (Root. Selec.), 'Gi5', 'Gi6' and 'K6' for trees planted in 2015 in The Dalles, OR. The tree numbers/hectare and spacings (m) used for the projected yields were 1,282 (1.8×4.3) for 'K6' and 'Gi6'; 1,537 (1.5×4.3) for 'Gi5', 'Clinton' and 'Lake'; and 1,922 (1.2×4.3) for 'Clare' and 'Cass'. Data for three years are presented with yield efficiencies (Y.E.) for 2019.

Root. selection	Tree Yield (kg)			Y.E. (kg.cm^{-2})	Yield/hectare (tons.ha^{-1})			Fruit size (mm)		
	2017	2018	2019	2019	2017	2018	2019	2017	2018	2019
'Gi5'	2.9 a[1]	10.8 ab	5.9 bc	0.13 bc	0.8 a	3.0 ab	1.6 bc	28 a	28 ab	29 a
'Gi6'	2.4 a	13.7 a	7.5 abc	0.23 ab	0.5 a	3.2 ab	1.7 c	28 a	27 ab	28 ab
'K6'	1.4 a	10.1 ab	2.9 c	0.06 c	0.3 a	2.3 b	0.7 d	28 a	28 ab	28 ab
'Cass'	1.8 a	10.7 ab	12.5 a	0.39 abc	0.6 a	3.7 a	4.3 a	28 a	28 ab	28 ab
'Clare'	6.1 a	6.2 b	7.8 ab	0.33 a	1.0 a	2.1 b	2.7 b	28 a	29 a	29 a
'Clinton'	2.0 a	10.3 ab	8.8 ab	0.39 a	0.5 a	2.8 ab	2.5 ab	28 a	27 b	27 b
'Lake'	1.4 a	6.8 b	4.5 bc	0.14 b	0.4 a	1.9 b	1.3 c	28 a	28 a	28 ab

[1]Significantly different means ($P < 0.05$) are denoted by different letters.

In addition, 'Clinton' and 'Clare' had a significant higher yield efficiency compared to 'Lake', GiSelA®5 (Gi5) and 'K6'. In terms of fruit quality, fruit size on 'Clinton' was significantly smaller than that on 'Gi5' and 'Clare' in 2019 and 'Clare' and 'Lake' in 2018.

2.4. Rootstocks and high-density plantings in European plum and Japanese plum

Cultivation of plums is important in most of European countries, in particular Japanese varieties in the South Europe, South Africa and United States. European varieties are cultivated mainly for fresh market in different European countries as France or Germany, United States and Chile, among other. In the case of 'Agen' and related cultivars, the situation in different because they are produced in European and American countries, either for fresh market or drying. Traditional training system for plums in all countries is the traditional gobelet combined with vigorous rootstocks as Myrobolan 29C or Mariana 2624 and low-density plantings, ranging from 300 to 600 trees ha^{-1}. As in other *Prunus* species, the trend over the last two decades is towards intensification to reduce the harvest costs in particular when the destination is for fresh market.

A new proposal from Agromillora initiated in 2015 in Chile and Spain is by using the size-controlling rootstock Rootpac®20 trained in hedge system (SHD) as an alternative to the traditional open-vase. It allows to get early yields and easy crop management with an almost complete mechanization of pruning and harvesting by using over-the-row harvesters when the destination is for drying (Figure 5). In addition, this particular training system allows growers to pick the fruits efficiently from the ground when the destination is for fresh market. Depending on the current prices growers can decide, either harvest manually, mechanically or combining both systems (Iglesias and Fuentes, 2021). First results with this system were obtained from a commercial orchard located in Peralillo, O'Higgins (Chile), planted in 2016 and spaced 3.5 × 1.5 m. Yield obtained were 30 t ha^{-1} in the five year. It can be improved in further orchards narrowing the planting distances to 3.0-3.2 × 1.0-1.2 m, obtaining potential yields around 40 t ha^{-1}, as illustrated in Figure 5. Also in Spain several trials were carried out in a long term collaboration INTIA-Agromillora. In this case the cultivar was 'Claudia Verde' grafted on Rootpac®20 trained in hedge system (SHD) for industrial destination. Harvest was carried out mechanically by using a over-the-row harvester. Data obtained were reported by Iglesias et al. (2021) and evidenced the efficiency of harvest and also the early ang good yields obtained.

The intensification in plum, in addition for mechanical harvest previously exposed, is also interesting when the destination is for fresh market. Different commercial orchards were planted years ago in Italy and Serbia with different European and Japanese varieties grated on Rootpac®20. Location of the

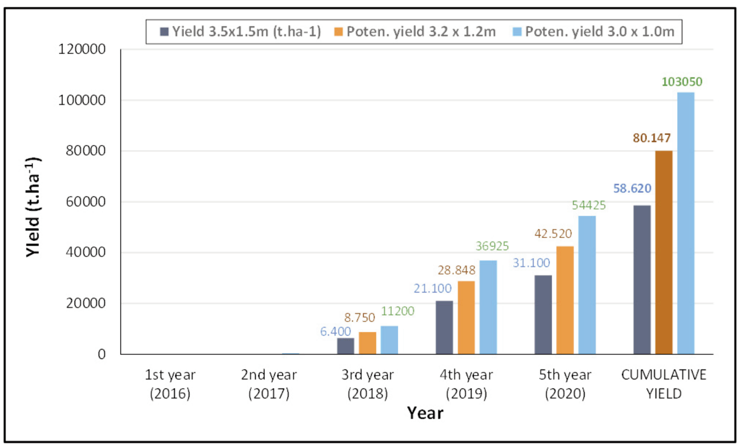


Figure 5. Annual and cumulative yields (black bars) of a SHD planting of 'Agen' plum grated on Rooppac®20 rootstock, planted in 2016 at Peralillo, O'Higgins (Chile). Brown and blue bars indicated the potential yields in two different narow spacings. (Source: Iglesias and Fuentes, 2021).

orchards, cultivars planted, spacing used (planting densities from 3,570 to 6,666 trees ha^{-1}) and yields obtained until 6th year, are illustrated in Table 4. The most important achievements were the early and high yields obtained, optimum fruit size, easy management of pruning and harvest and mechanization of flower thinning and summer pruning.

Table 4. Planting distances, yields and fruit quality of different Japanese and European plum in Italy and Serbia. Training system central axis and rootstock Rootpac®20.

Variety	Spacing (m)	Yield (t ha^{-1})						F. size (ø mm)
		2º	3º	4º	5º	6º	Acum.	
				EMILIA ROMAGNA – Ferrara (Italy)				
Stanley	3.0 × 0.5	20	45	65	48	54	230	40
				VENETO - Verona (Italy)				
Agust Delight®	3.5 × 0.8	16	52	*	*	*	68	55
Blue Moon®	3.5 × 0.8	13	48	*	*	*	61	55
Owen T®	3.5 × 0.8	11	45	*	*	*	56	60
Crimson Gloo®	3.5 × 0.8	14	49	*	*	*	63	60
				BANAT (Serbia)				
Stanley	3.0 × 0.5	35	45	55	52	58	80	40
Angeleno®	3.0 × 0.5	15	30	40	19	25	45	55

* yields affected by spring frost.

3. Conclusions

Rootstock plays a crucial role in modern fruit production. Size controlling rootstocks resulted in smaller and more efficient canopies providing in the meantime early yields and better fruit quality compared to traditional ones. Selecting the best combination cultivar/rootstock is crucial to define the right training system, adapted to each specific situation. Size controlling rootstocks, combined with bidimensional canopies, allow an efficient accessibility to canopy of labour and machines. Due to increasing costs of labour and its impact on the cost of production, mechanization and intensive orchards are required for present and future orchards. Mechanization of flower thinning, results in a significant decrease of cost. Green pruning reduces the cost of winter pruning and combined with flower thinning allows the increase of fruit colour and size. In addition, small trees associated with planar canopies resulted in a better efficiency of inputs as labour, pesticides, or irrigation water, among other and furthermore a more sustainable production, either environmentally or grower's profit. Any sustainability can be reached without profit. These smaller planar canopies open the door to precision fruit production in key labours as flower/fruit thinning, robotic harvest and pest and disease monitoring, among other.

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