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

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Rimini, 9th May 2024

International Rootstocks Symposium
Guidelines, breeding projects and new rootstocks

CONTENT

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1.- Prunus production in Spain

2.- Inputs and cost of production in Prunus species

3.- Combining rootstocks and training systems

4.- Benefits of 2D canopies + intensification

6.- Training systems mechanization & cost of production

7.- What's next? 4.0 precision fruit production

8.- Conclusions

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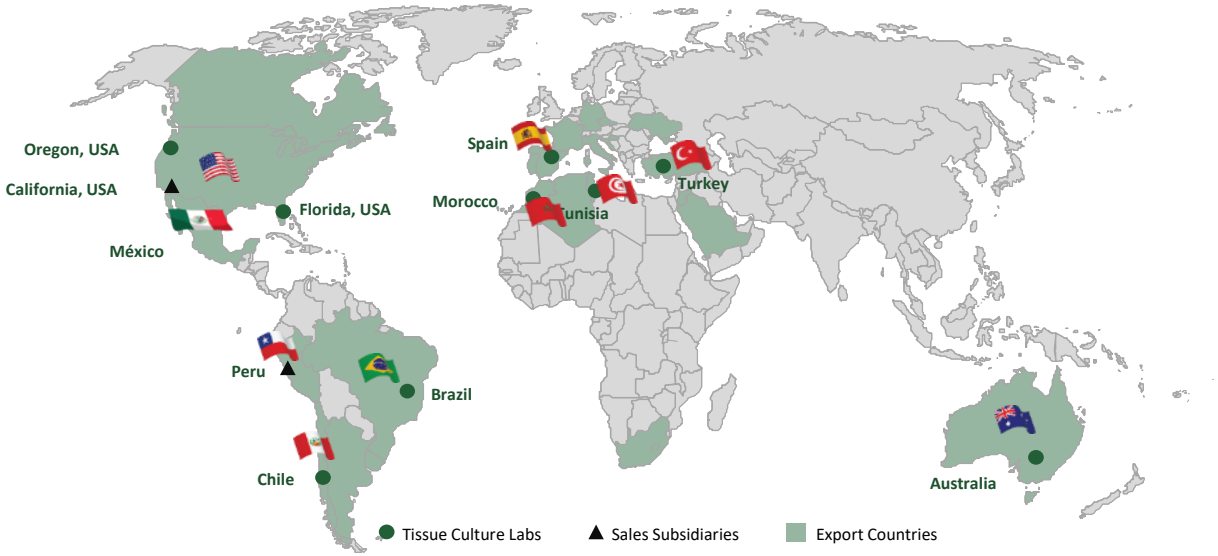
LEADING GLOBAL MARKET

GEOGRAPHIC LOCATION OF 11 SUBSIDARIES

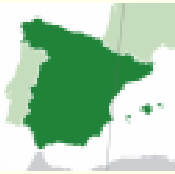


Benslimane, *Morocco*

- **5** continents
- **25** countries
- **10** Tissue culture labs
- **11** subsidiaries
- **>1,500** clients
- **c.80 million** of trees per year
- **+8** crops

390.0000 has

Surfaces and production of deciduous Fruit especies in SPAIN 2021-2023



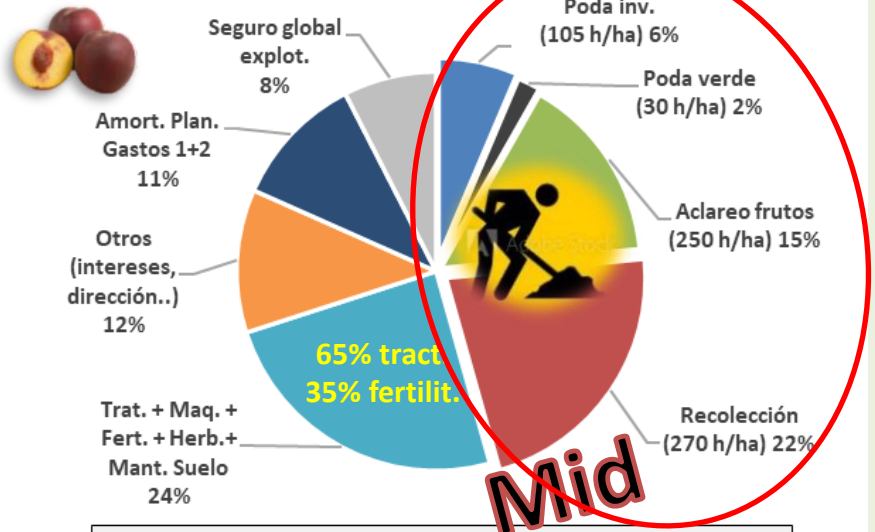
Especies	Surface 2022 (ha)	Production 2021-2023 (t)
Apple	29,246	472,667
Pear	19,113	286,500
Peach+300	**70,032**	**1,137,500**
Cherry	29,463	111,767
Apricot	18,428	108,033
Plum	13,245	178,067
TOTAL	179.527	2.294.533

131,168 ha

1,535,367 t.

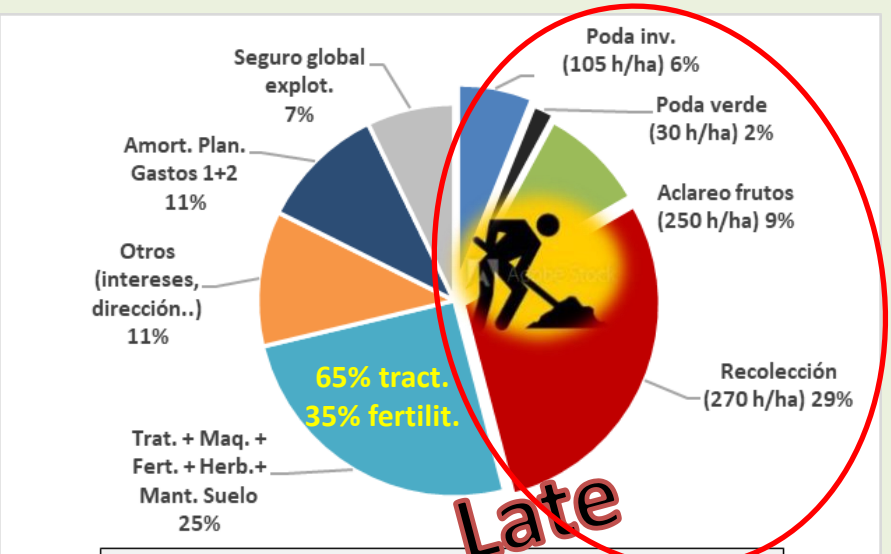
Labour and cost of production

Production costs peach & cherry 2022

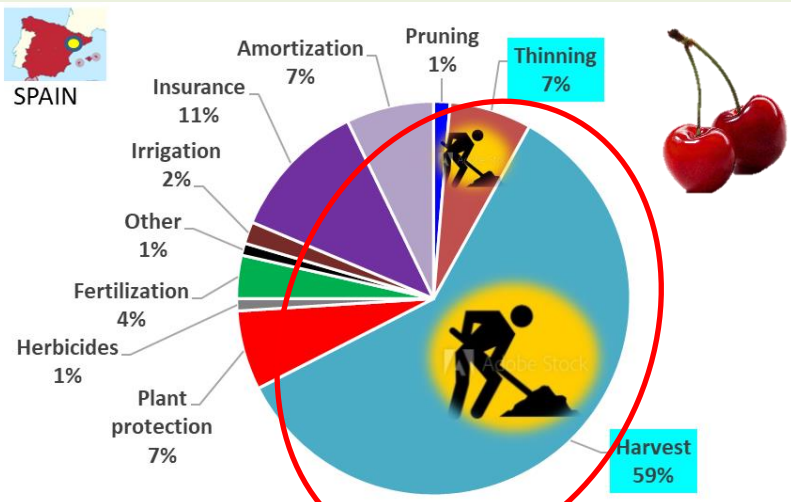


COSTE TOTAL PROD. MELOCOTÓN MEDIO 2022 = 0,43 €/kg
(17.200 €/ha-año y 40 t./ha)

Considering mid blooming intensity varieties



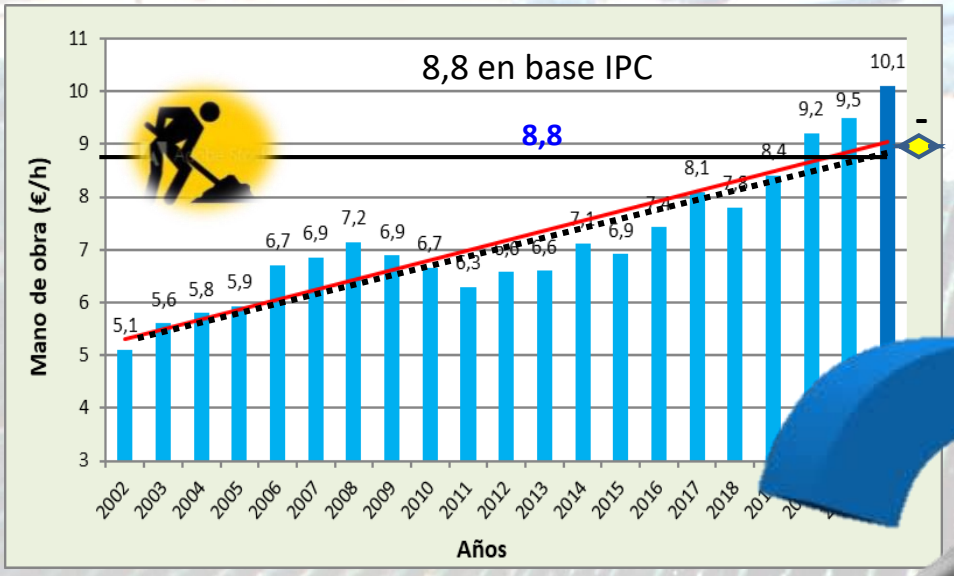
COSTE TOTAL PRODUCCIÓN 2022 = 0,34 €/kg
(55 tons/ha, 17.248 €/ha-año)

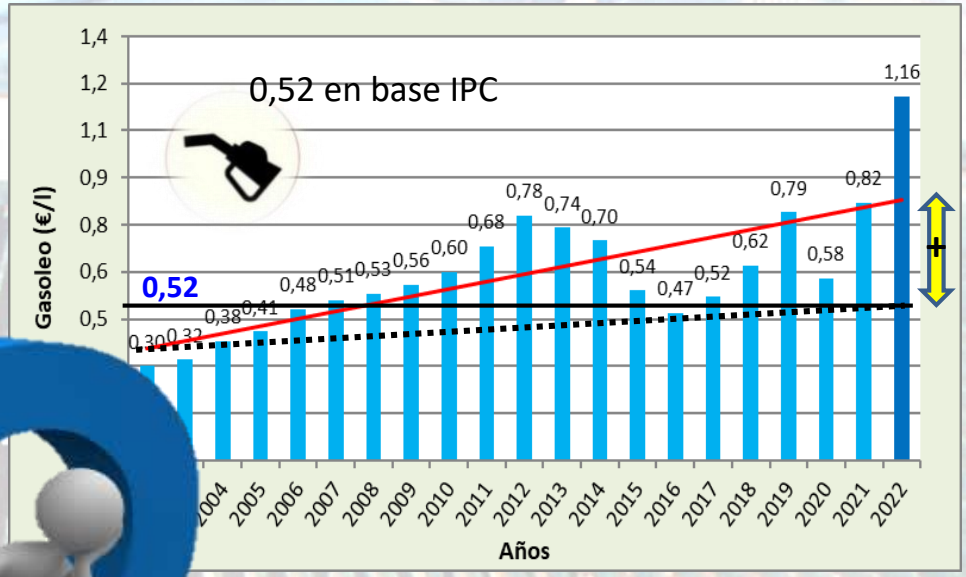


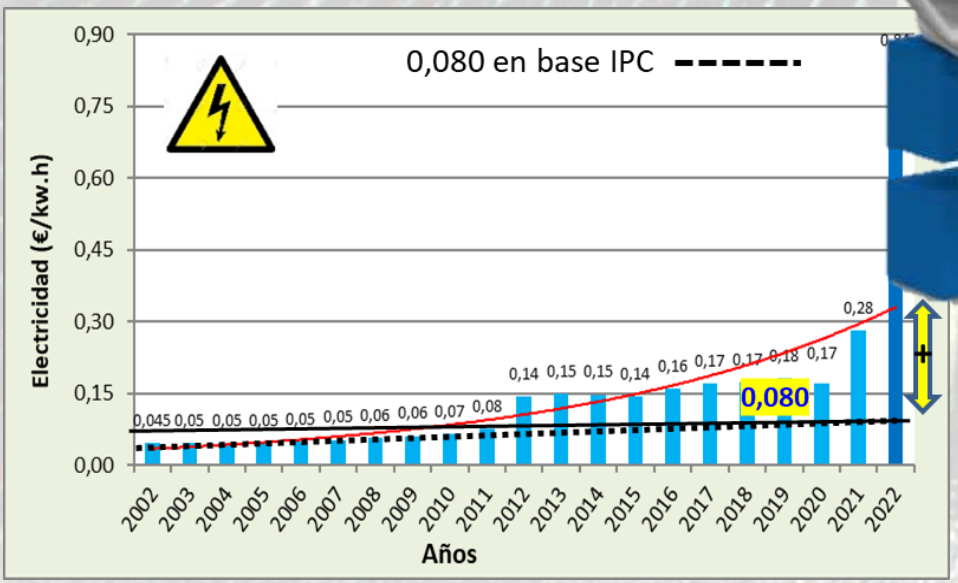
Mid season variety. Yield 15 t/ha.
Total cost of production 2022: 22.230 €/ha. Ebro Valley.

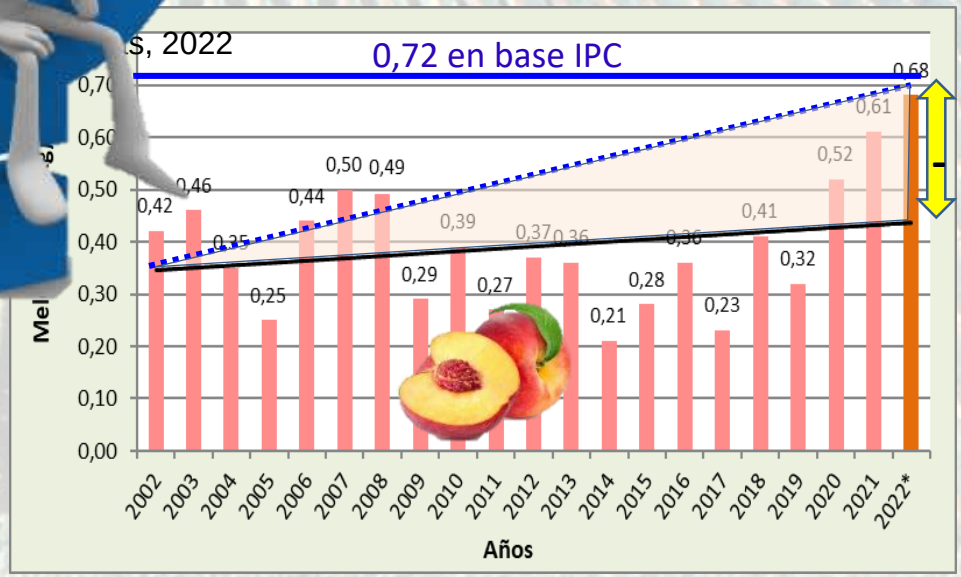
- **Total cost (2022): 1.48 €/kg**
- **Labor cost = 67% of total**
- **Price €/h = 10.1 €/h**
- **Harvests cost >55% of cost**
- **Labor availability decreasing**
- **Labor cost increasing**

Evolution of prices of inputs, outputs and CPI (IPC) in the period 2002-2022









Rootstocks and training systems

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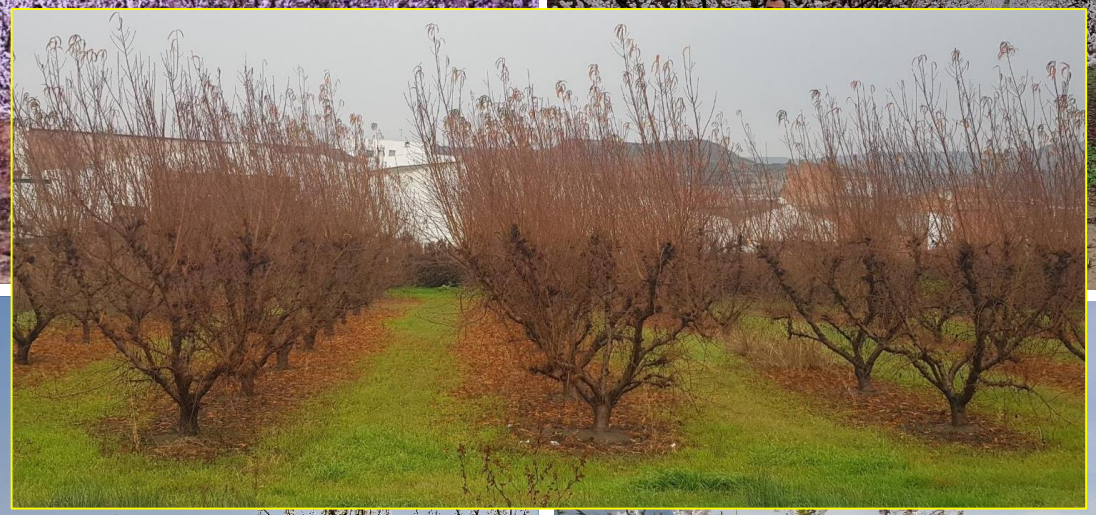
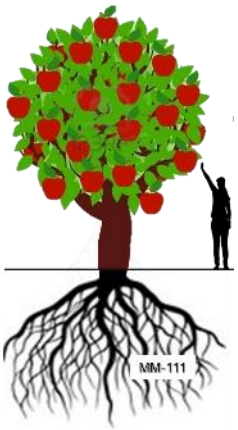
SPAIN



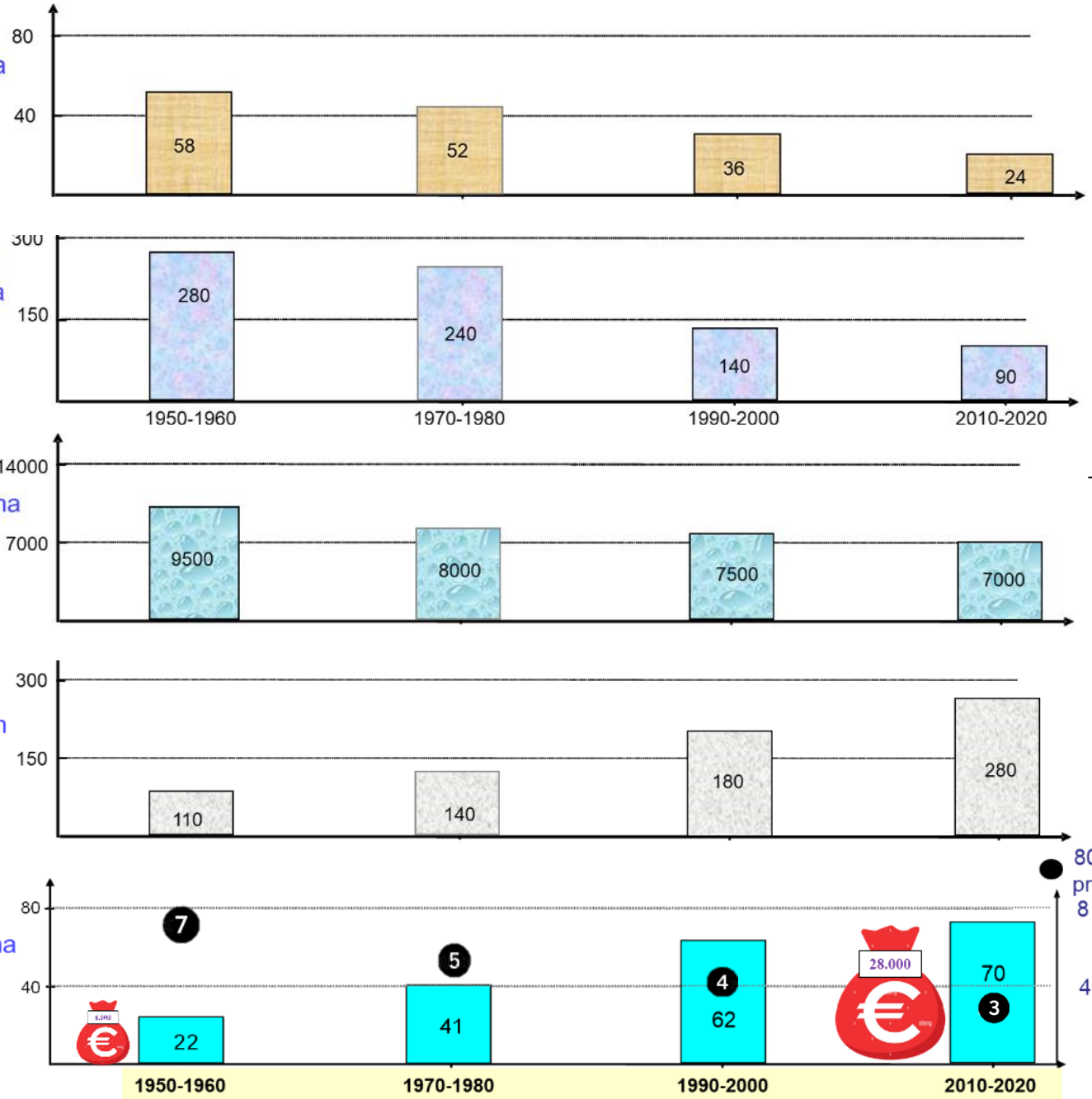
TANY NATURE

SUSTAINABLE INTENSIFICATION IN APPLE

Transition to small trees = sustainable intensification



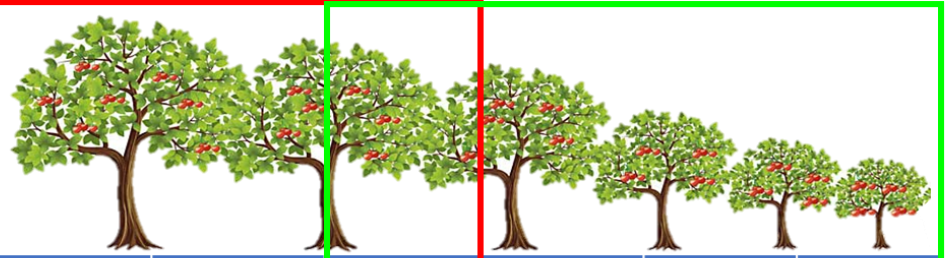
333 tre./ha



2,857 tre./ha

Iglesias, 2022

Rootstocks



SPECIES	120-110%	110-100%	100-80%	80-60%	60-40%	<40%
	Very vigorous	Standard	Standard-mid	Mid	Semi-dwarf	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

Iglesias et al., 2023

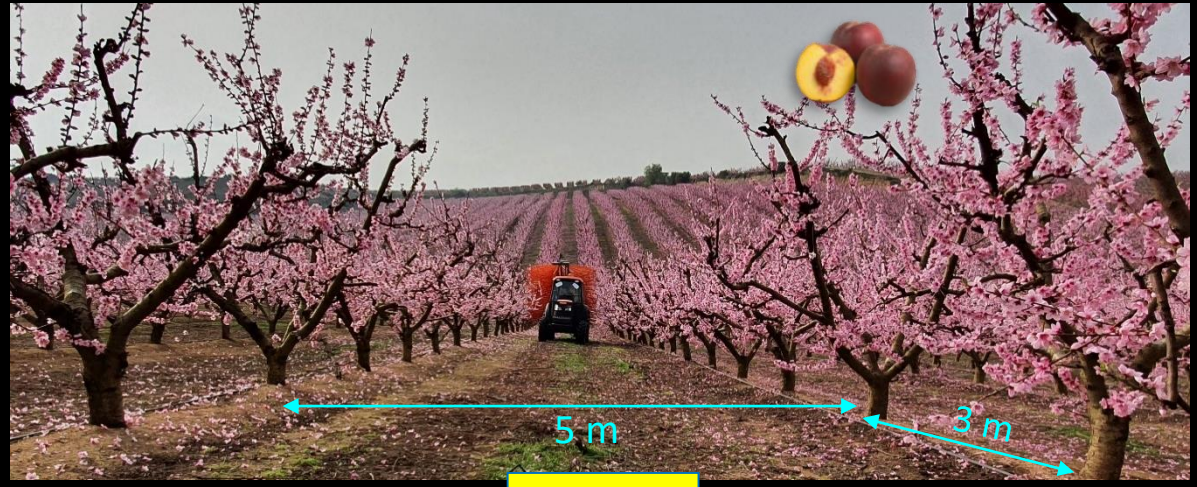
APPLE

PEACH

ROAD MAP:
Planar canopies
+ intensification

5 x 3 m

GF-677
(667 t/ha)



3D 1

4 x 2 m

GF-677
(1,250 t/ha)

2D 2

3,5 x 1,0 m

Rootpac-40
(2,857 t/ha)

2D 3

23 marzo.- 2021

SIZE CONTROLLING ROOTSTOCKS FOR *PRUNUS*

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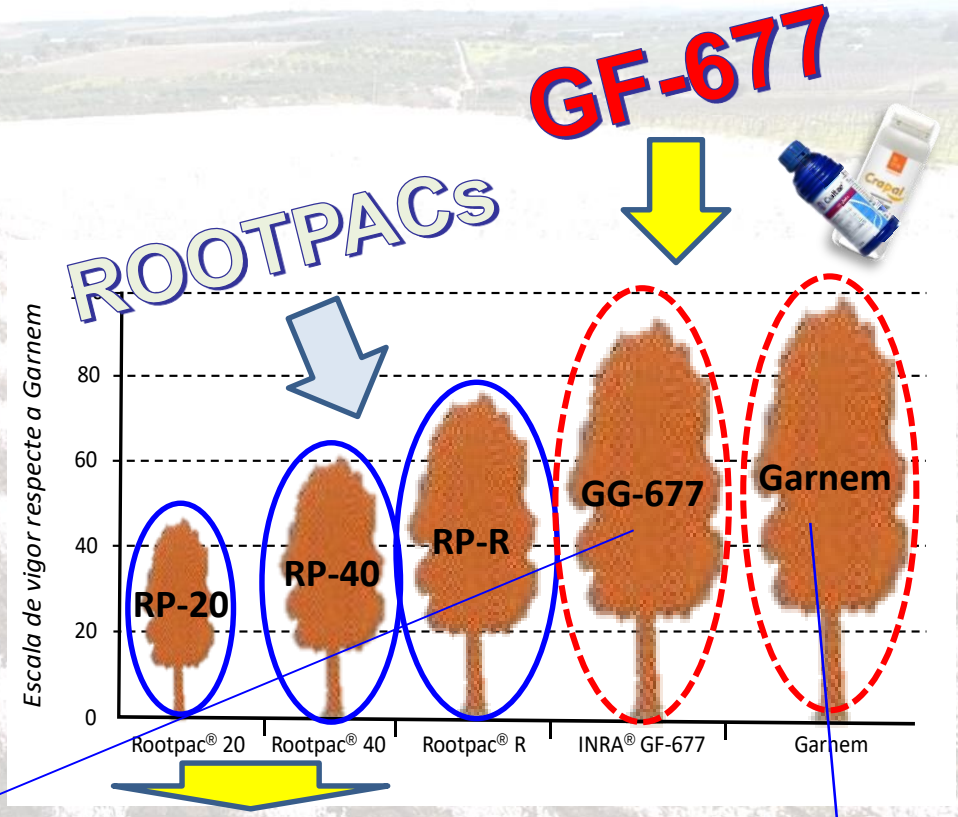
PRUNUS ROOTSTOCKS

ROOTPAC®

ROOTPAC 20

ROOTPAC 40

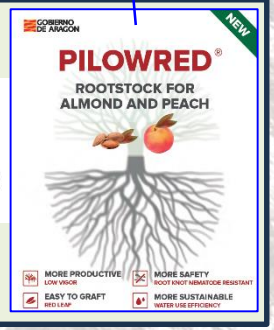
ROOTPAC R



INTENSIA

IRTA
Institut de Recerca i Tecnologia Agroalimentàries

cita
CENTRO DE INVESTIGACIÓN Y TECNOLOGÍA AGROALIMENTARIA DE ARAGÓN



Benefits of planar canopies + intensification

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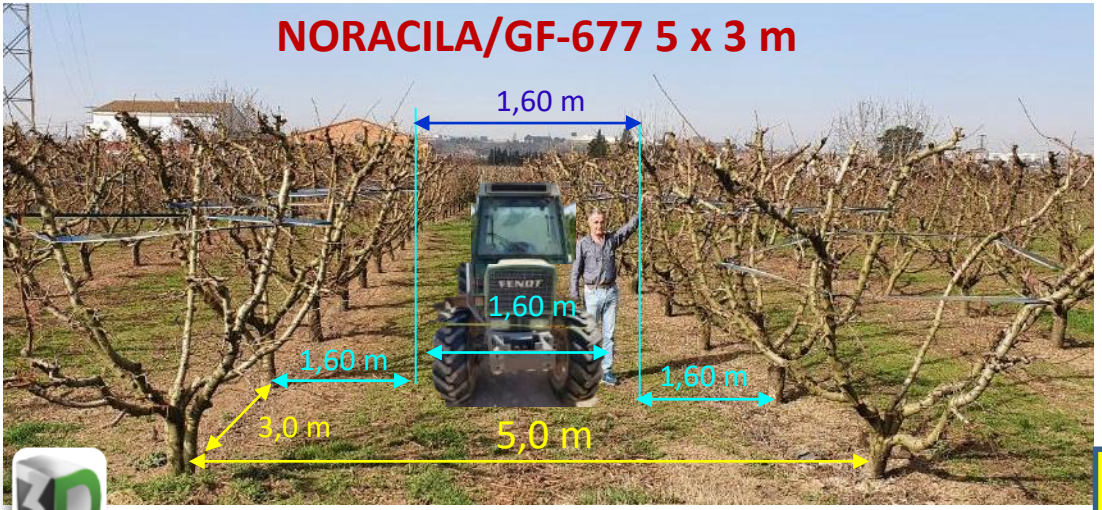
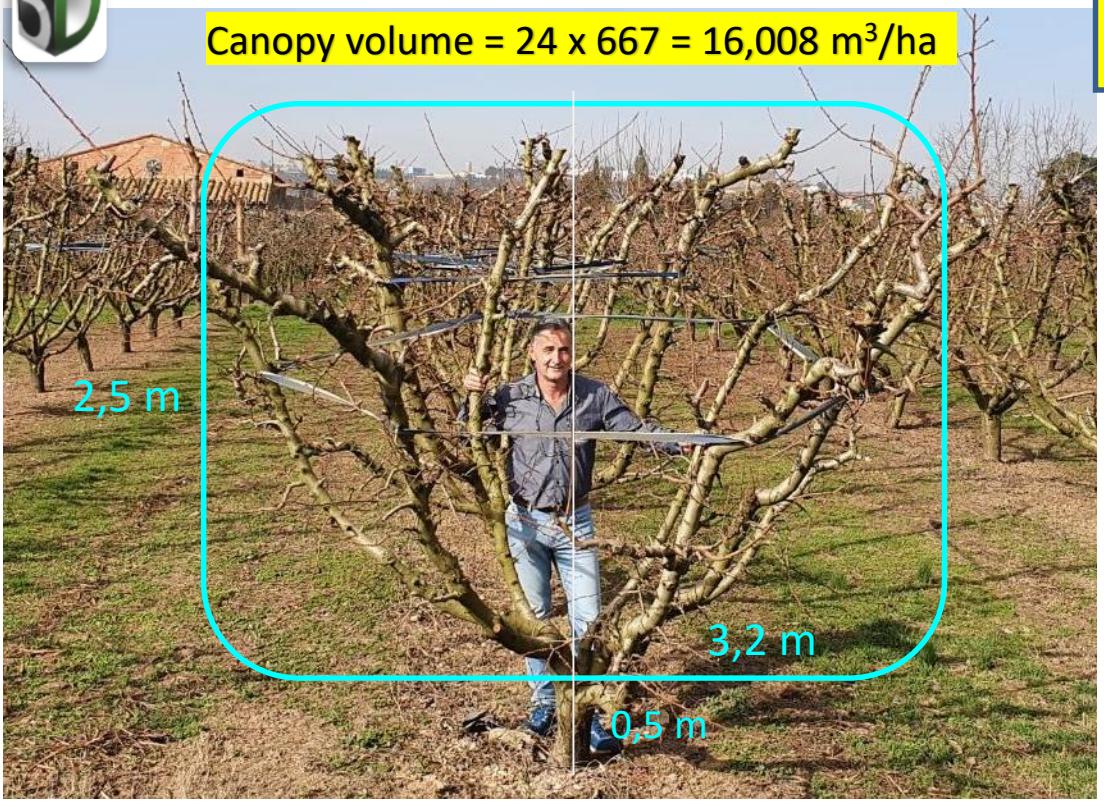
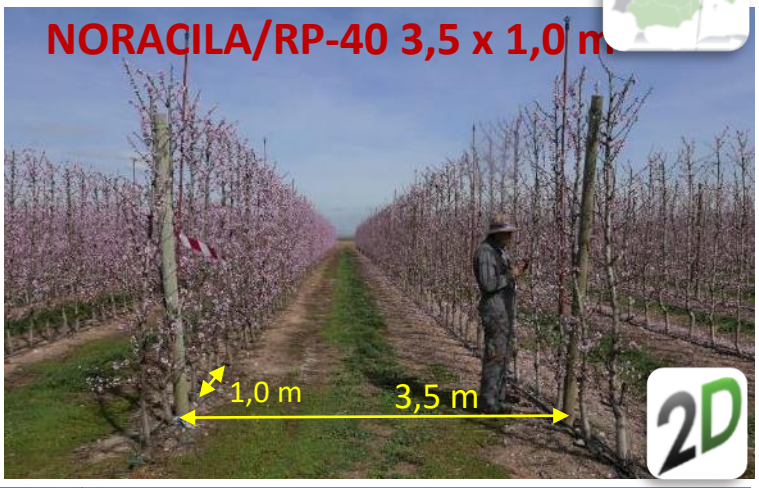
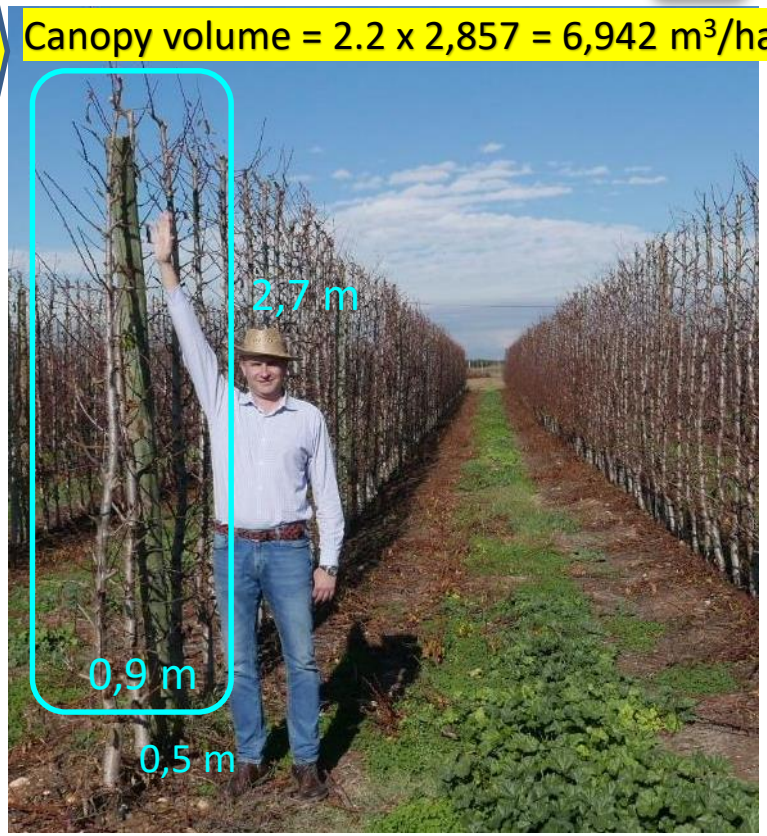
TREE ARCHITECTURE AND CANOPY ACCESIBILITY

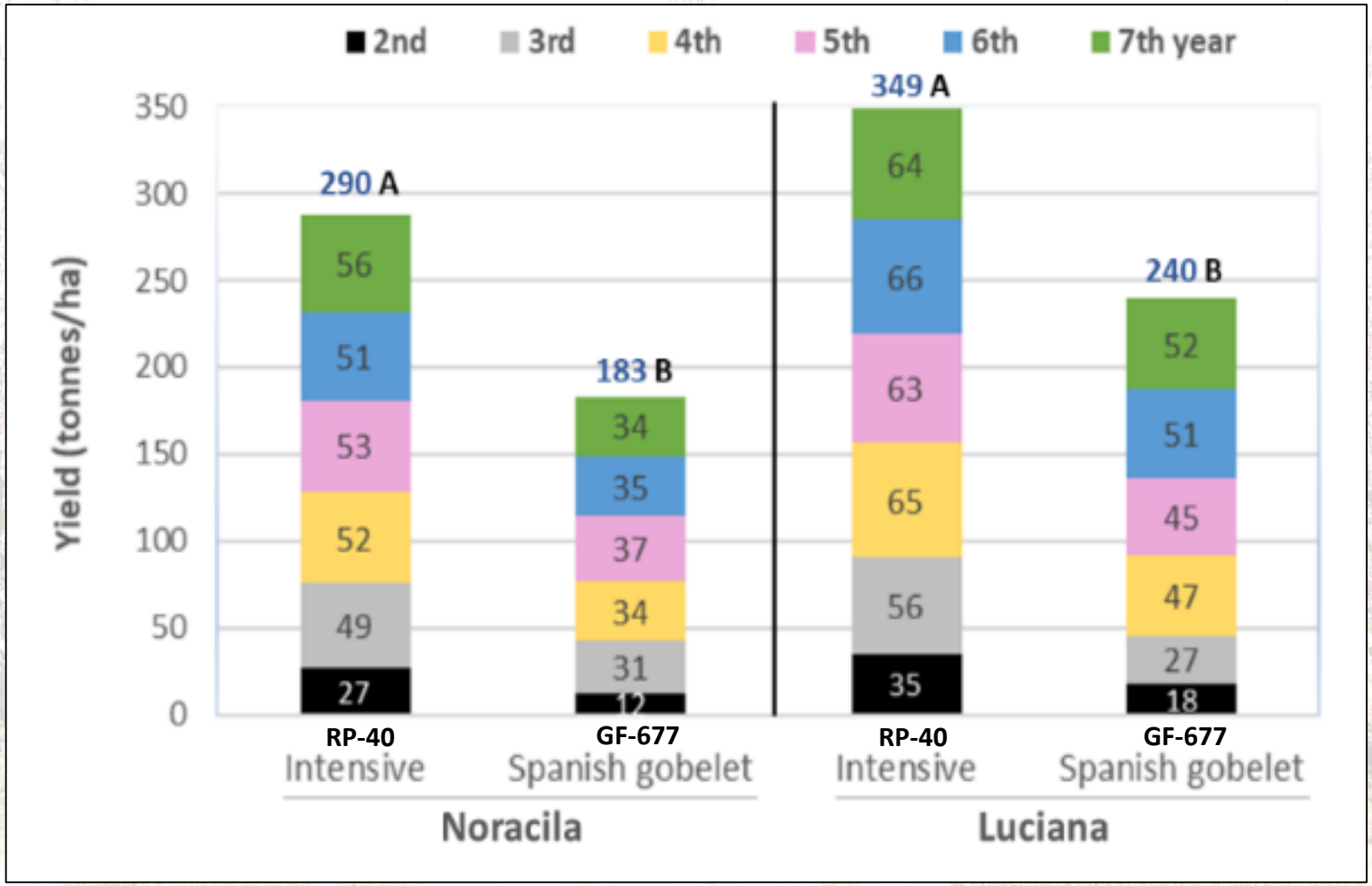








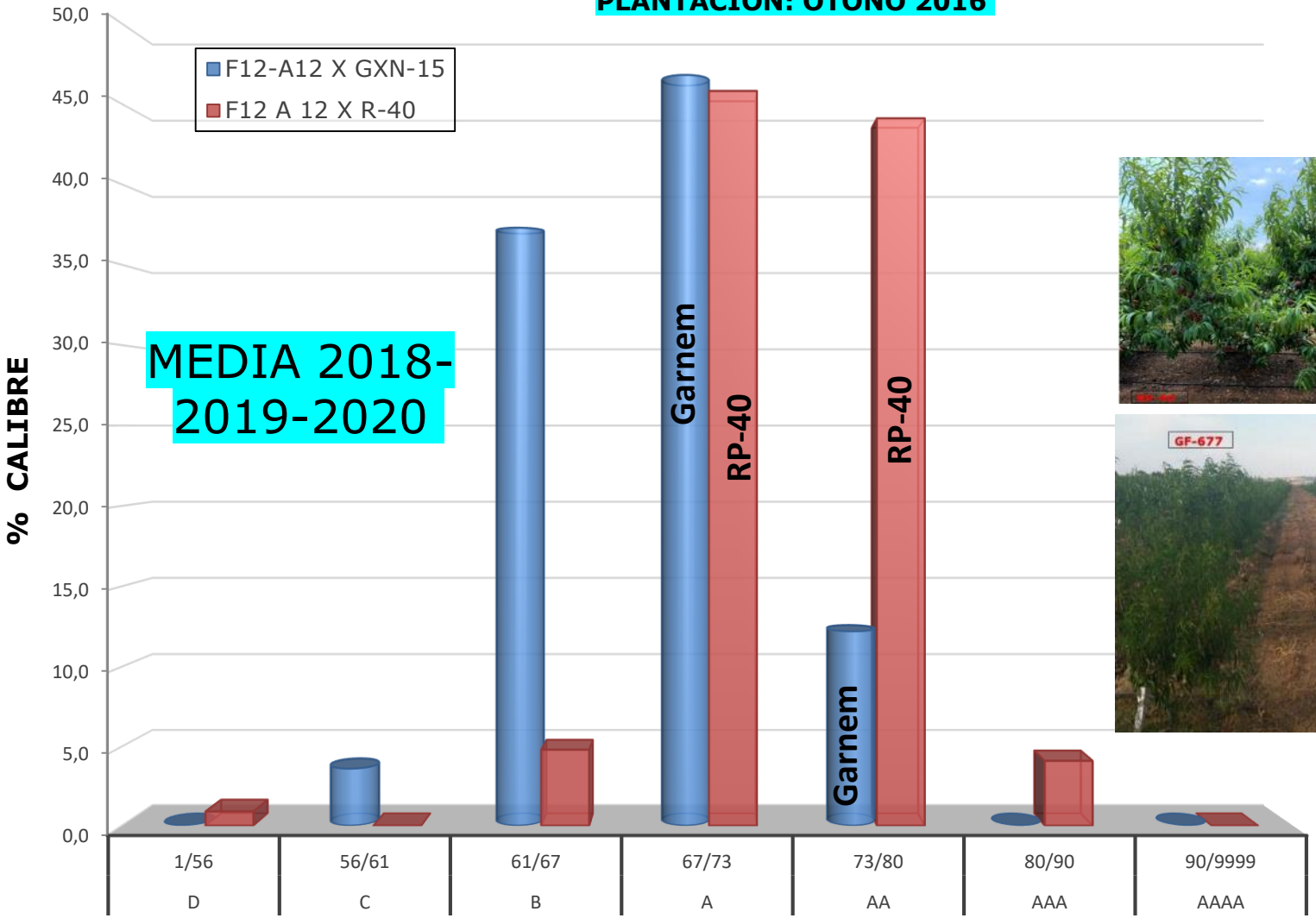
The effect of training system and rootstock (RP-40 and GF-677) on anual and cumulative yield of two nectarine cultivars



Iglesias & Echeverría, 2022

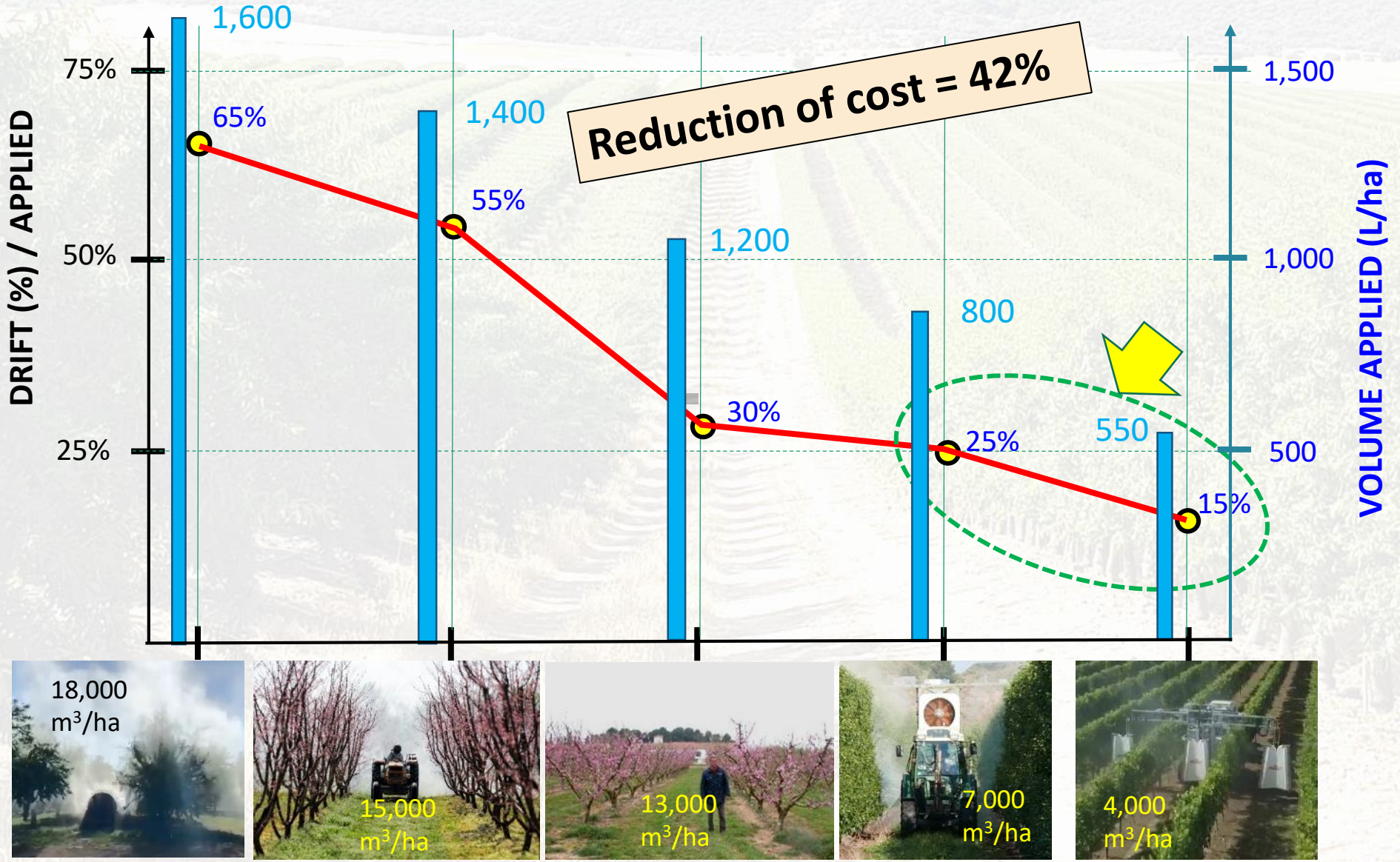
COMPARATIVA CALIBRES PAMELA RP-40/GARNEM

PLANTACIÓN: OTOÑO 2016



Datos COOP. Carlet

DRIFT (%) AND VOLUME APPLID (l(ha) AFFECTED BY TRAINING SYSTEM AND SPRAYING EQUIPMENT



Iglesias, 2021

EFFECT OF NUMBER OF LEADERS ON TCSA, LH, LCSA, LATERAL SHOTS/LEADER AND CANOPY DENSITY

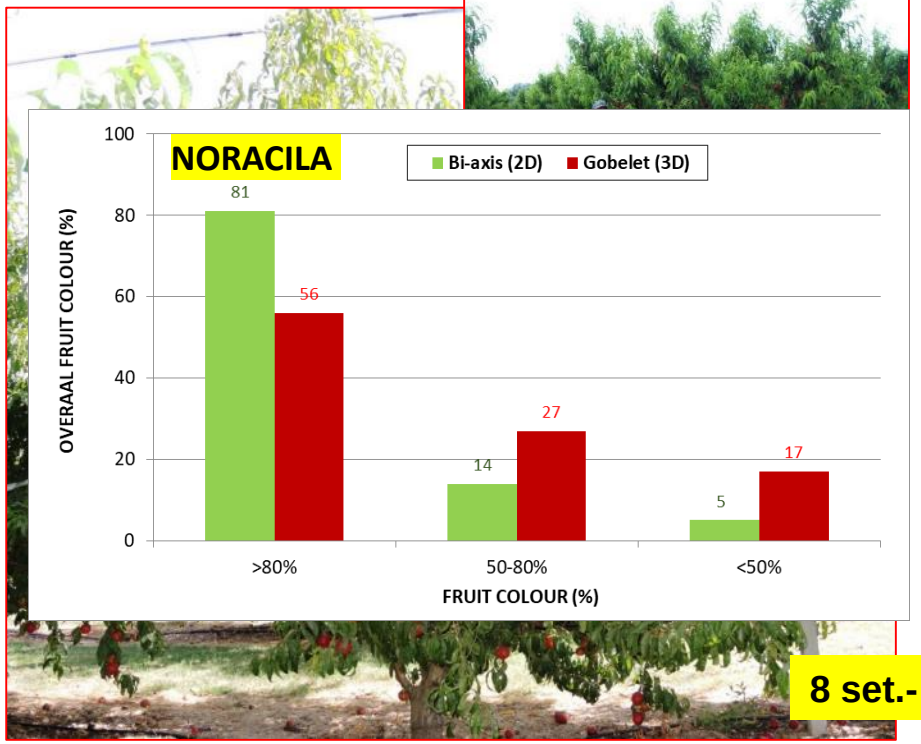
Multi-leader Vigor Diffusion: As the number of leaders (Upright Fruiting Offshoots) increases (and tree spacing increases), *tree* vigor increases but *leader* vigor decreases

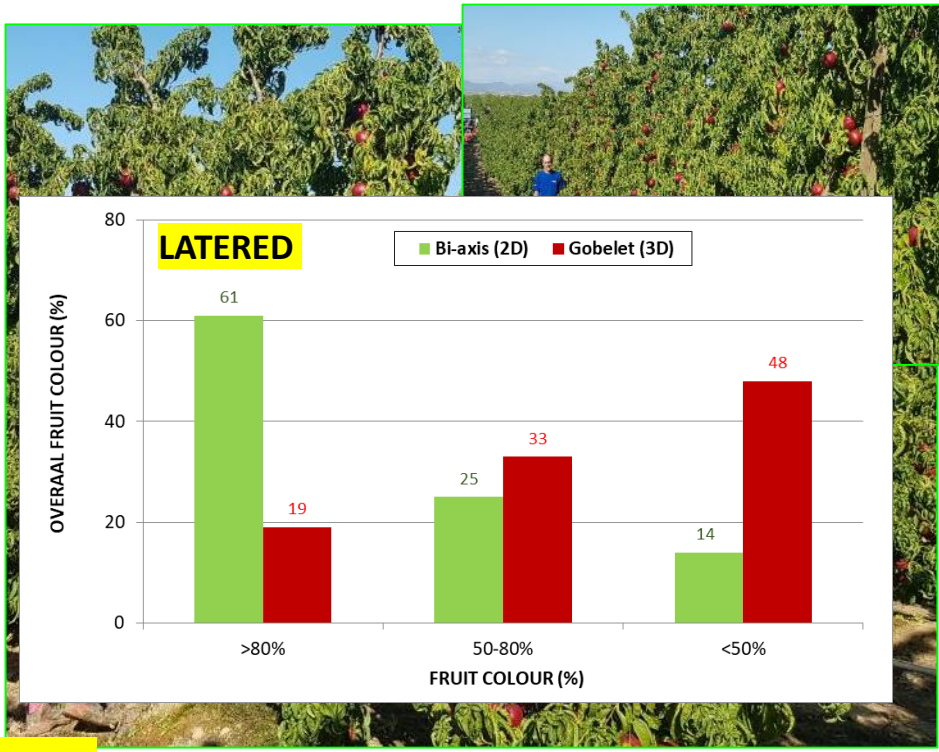
	Trunk cross-sectional area (TCSA)		Tree (leader) height		Leader cross-sectional area (LCSA at 1.5 m)		Lateral shoots per leader and canopy density	
Number of Leaders	cm^2	% single leader	m	% single leader	cm^2	% single leader	no.	no. / m of leader
1	40.8	100	3.88	100	14.7	100	72.7	18.7
2	48.4	119	3.66	94	9.8	67	71.3	19.4
4	54.4	133	3.60	93	7.7	52	60.1	16.7
6	60.4	148	2.98	77	5.1	35	50.4	16.9
8	74.4	182	2.86	74	4.4	30	45.2	15.8
		+82%		-26%		-70%		Lower density, better light

MSU Stone Fruit Research

G. Lang (MSU)

2 Effect of tree achitecture on fruit colour: LATERED 3D< >2D





8 set.- 2020

Increasing pack-out 26%

Iglesias, 2023

DIFFERENT OPTIONS FOR VERTICAL CANOPIES

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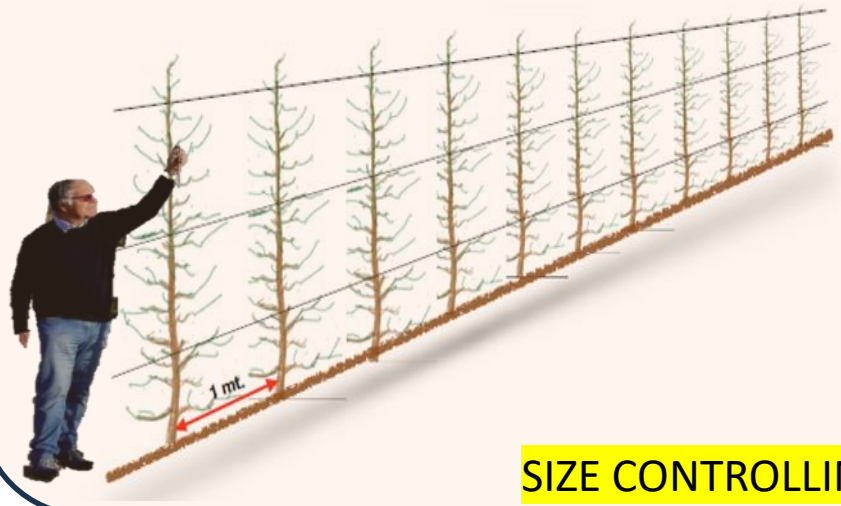
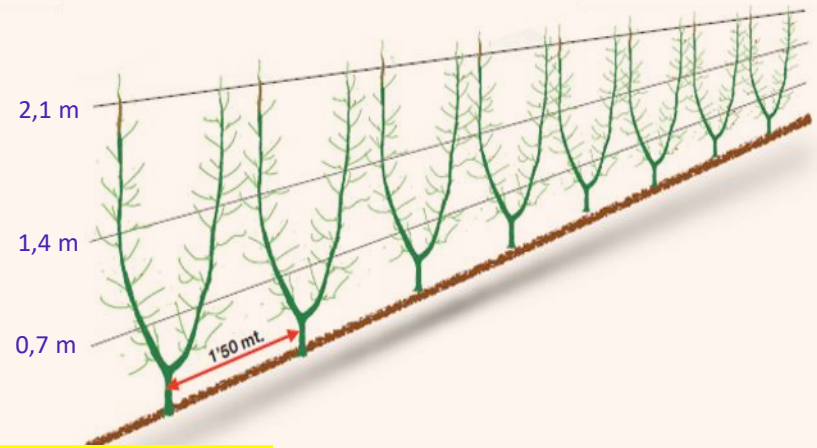
Central Axis

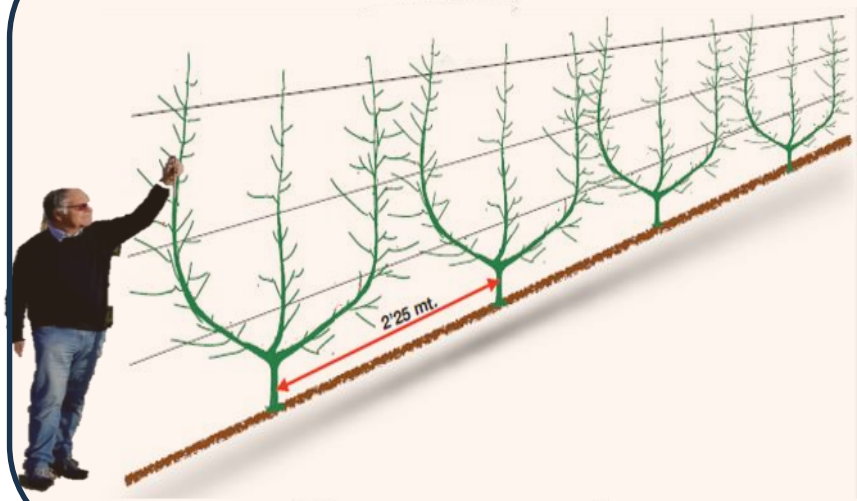


Bi-Axis

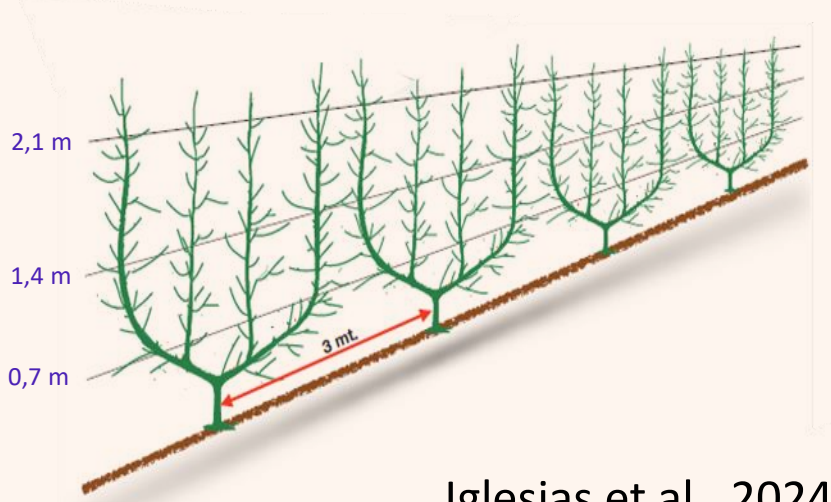


SIZE CONTROLLING ROOTSTOCKS

Tri-Axis



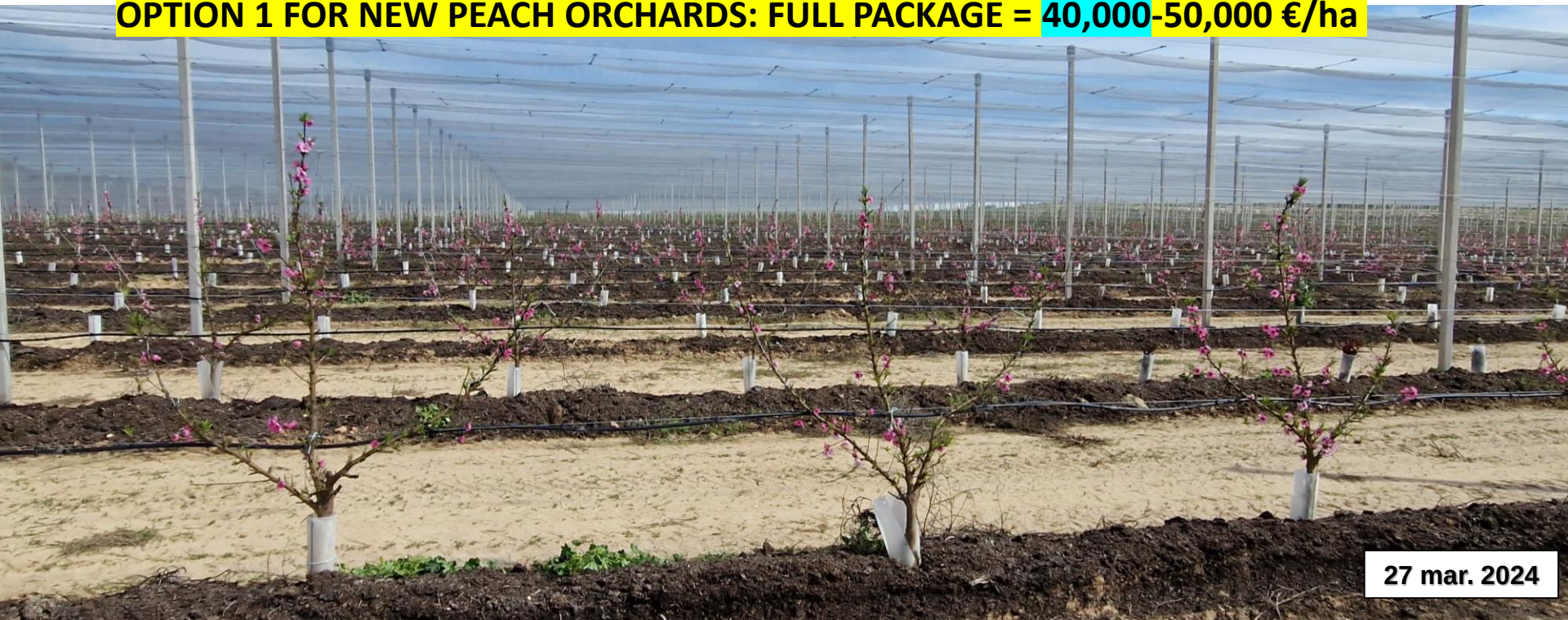
Four Axis



Iglesias et al., 2024

Planar canopies

OPTION 1 FOR NEW PEACH ORCHARDS: FULL PACKAGE = 40,000-50,000 €/ha



OPTION 1 FOR NEW PEACH ORCHARDS: FULL PACKAGE = 50,000 €/ha

SUPP0RT STRUCTURE + HAILNET V5= 19,000 €/ha

FILOÉ / RP-R 3,5 x 1,2 m Bi-eje

60,5 t/ha

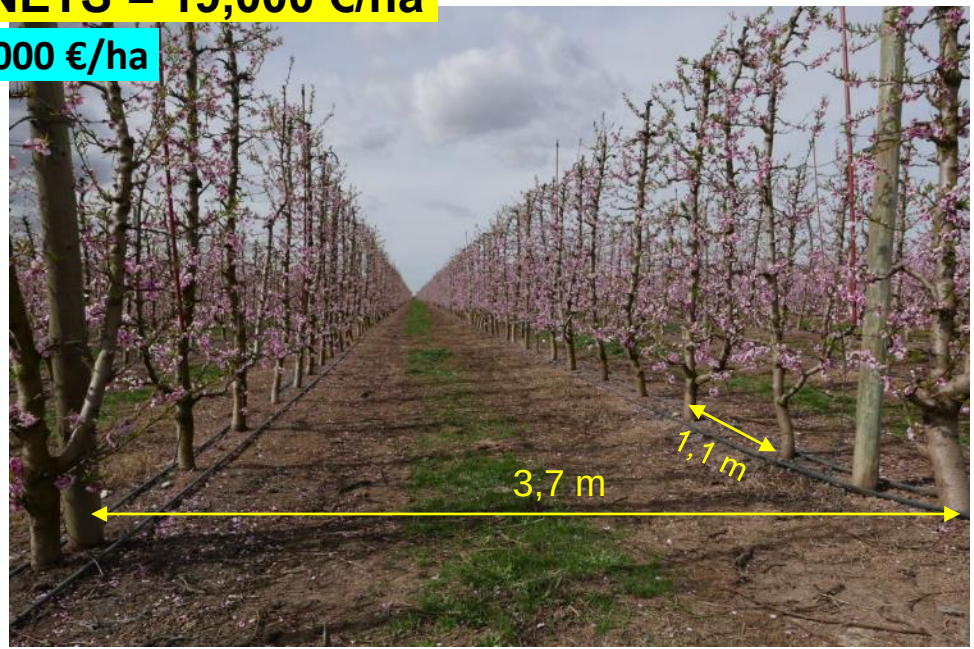
2-agos.-2022

2 years GF-677 4 x 2,2 m
Photo: V. Dimitrios

4 mar. 2019

OPTION 2: NO HAILNETS = 19,000 €/ha

SUPPORT STRUCTURE = 7,000 €/ha



2b.- AXIAL SYSTEM: EARLY/RP-40 3,8 x 1 m: 30-32 t/ha

OPTION 3: SINGLE STRUCTURE = 12,800 €/ha

SUPPORT STRUCTURE = 1,000 €/ha

VIVERSA

Carla / RP-20 7è (ud), 3,4 x 0,6 m (Algerri)

Pedestrian

SUPP0RT STRUCTURE = 0 €/ha

Flower thinning: different options

SINCE 1920

Rinieri

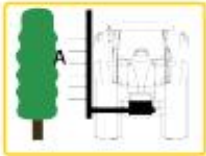
FLORIX

AGROXX
smart farming

FLORIX PLUS BY AGROXX - ACLAREADOR DE FLORES

Equipamiento estandar:

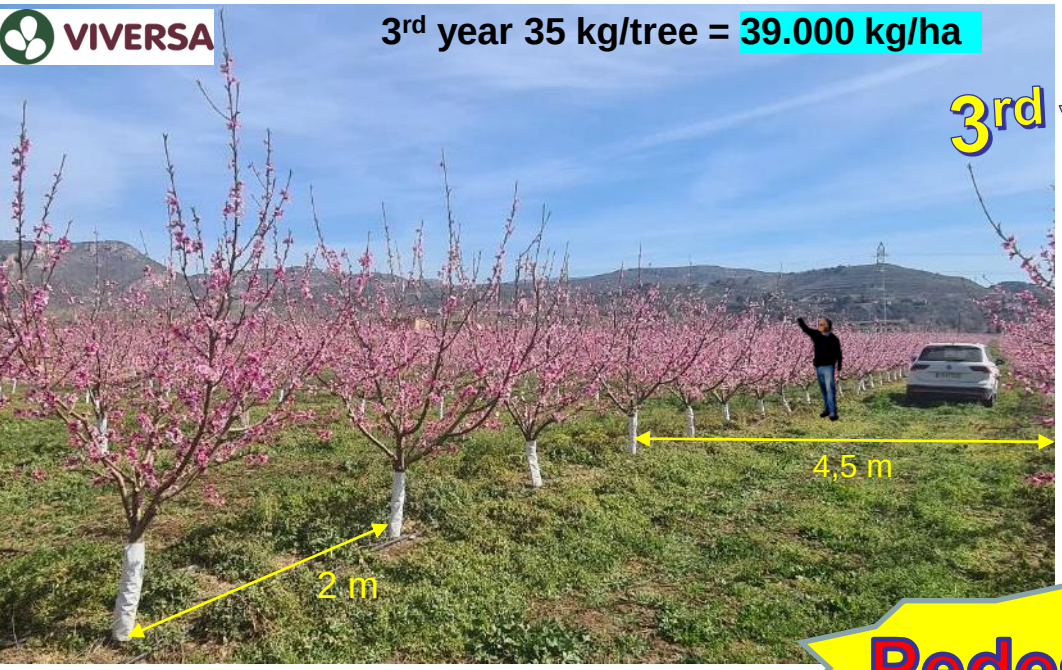
CHASIS	SEGURIDAD	AL TRACTOR
- Distribuidor electrohidráulico con joystick 4+1 - Levantada hidráulica 40cm - Balanceo hidráulico columna +/-5° - Desplazamiento lateral hidráulico 40cm - Enganche de 3 puntos incluido en el bastidor - Máximo ahorro de espacio para el transporte por carretera	- Válvula manual para el ajuste de la velocidad de rotación - Válvula de máx presión para motores - Caballete de almacenamiento incluido en el bastidor	- N.1 Distribuidor hidráulico de doble efecto - N.1 Escape libre - 25-30 Litros/min - Toma 12V



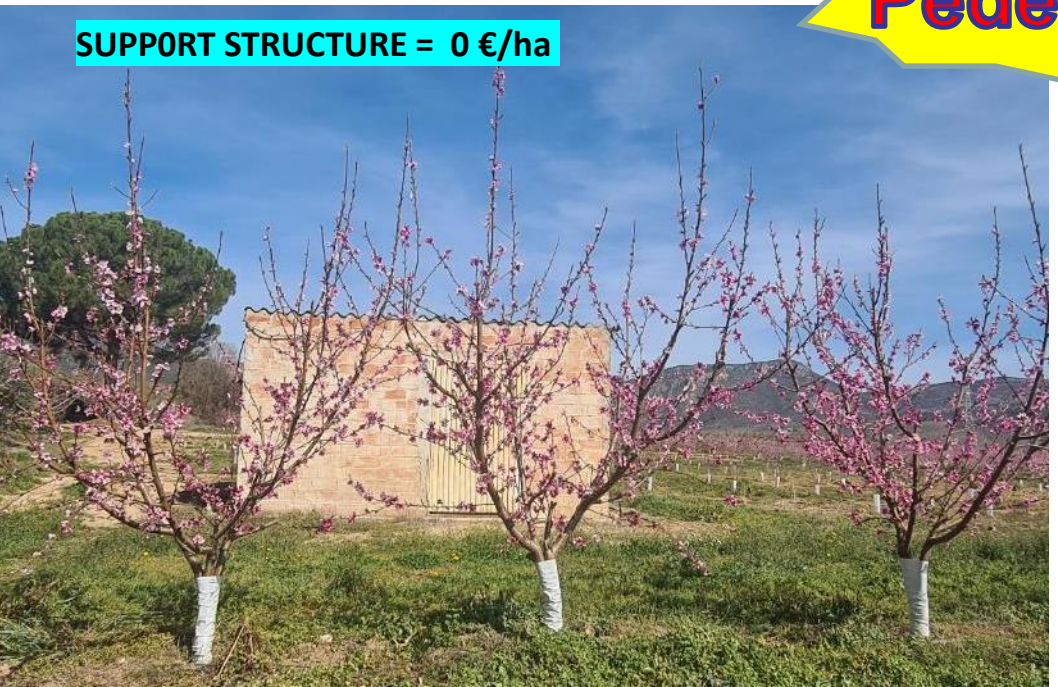
CÓDIGO	MODELO	A cm		€ PRECIO NETO
6FLO110SE	10 elementos y joystick 4+1	250	370	**19.900,00**

www.rinieri.com • TEL +39 0543 86066 • info@rinieri.com • MADE IN ITALY

KINOLEA/RP-20 or RP-40 4,5 x 2 m (1.111 tres/ha) (pla. 25 April 2021, 1 year old tree from "micro graft"



Pedestrian



KINOLEA/RP-20 4,5 x 2 m (1.111 tres/ha) (pla. 25 April 2021, 1 year old tree from “micro graft”

Pedestrian

3D MECHANIZATION OF PRUNING (II)

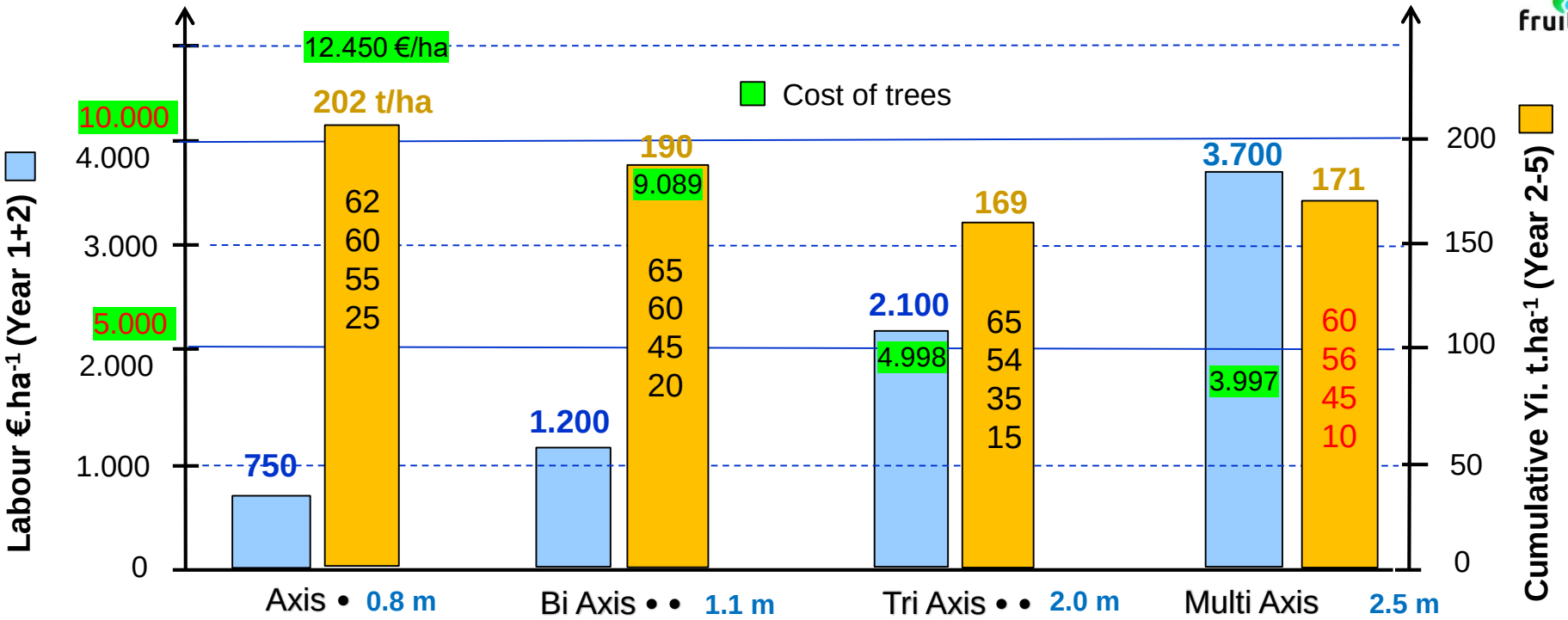
2D TRAINING SYSTEMS, LABOUR REQUIRED (10 €/h) and YIELDS 2022

Mid season cultivar

Final JULY

TRAINING SYSTEM	3.5 x 0.8 m	3.5 x 1.1 m	3.5 x 2.0 m	3.5 x 2.5 m
Tree/ha €/ha x3,5 €	3.571 / 12.450	2.597 / 9.089	1.428 / 4.998	1.142 / 3.997
LA. €/ha* (year 1+2)	750	1.200	2.100	3.700

(*): Labour positioning branches in Winter + pruning + instaling support structure



Training systems, mechanization & cost of production

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SUMMARY OF COSTS RELATED WITH TRAINING SYSTEM

SYSTEM	YIELD (kg/ha)	TOTAL+ COST (€/ha)	OTHER (€/ha)	PESTICIDES + FERTILIZERS* (€/ha)	WINTER PRUNING* (€/ha)	THINNING * (€/ha)	HARVEST* (€/ha)	TOTAL VAR. COST * (€/ha)
OPEN VASE	40,000	14,435	5,407	3,528 (2,293 pest.) (1,235 fert.)	920	1,785	2,975 €/ha 333 h (120 kg/h)	9,028
2D/AXIS	52,000	11,148	4,674	2,810 (1,885 pest.) (1,025 fert.)	750	836	2,078 €/ha 231 h 225 kg/h	6,474
DIFFERENCE	13,000	3,287	-	718	170	949	897	2,554

Labour NE-Spain: 8.5 €/h

(+): including annual amortization difference

OPEN VASE with AXIS = 714 €/ha-year

(*): variable annual cost

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ELSEVIER

Current situation, trends and challenges for efficient and sustainable peach production

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FLOWER THINING-2020

3D

2D

HARVEST

120 kg/h

Vas + trineu

225 kg/h

Palmeta+carro

Lateral + topping summer pruning of TARDERINA
3 axis: 2nd After harvest

30 Sept. 2023

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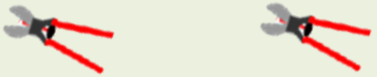
Green/summer pruning time in peach orchards

November	February	----	April	May	June	July	August	Septem.	October

1.- WINTER PRUNING



2.- SUMMER PRUNING

1st summer pruning

2nd summer pruning

HRAVEST

Early

Mid Season

From 45 days (early) to 2 months before harvest

Late

6 weeks before harvest (cultivars with lack of colour and/or vigorous

From 1 to 2 months after harvest if more vigour.
Until final september

TRIPLE EIX TARDERINA / GF-677: 4,0 x 2,0 m

1 agost.- 2022

The compact effect of summer pruning on 2D canopies

PRUNING

Relative rootstock size

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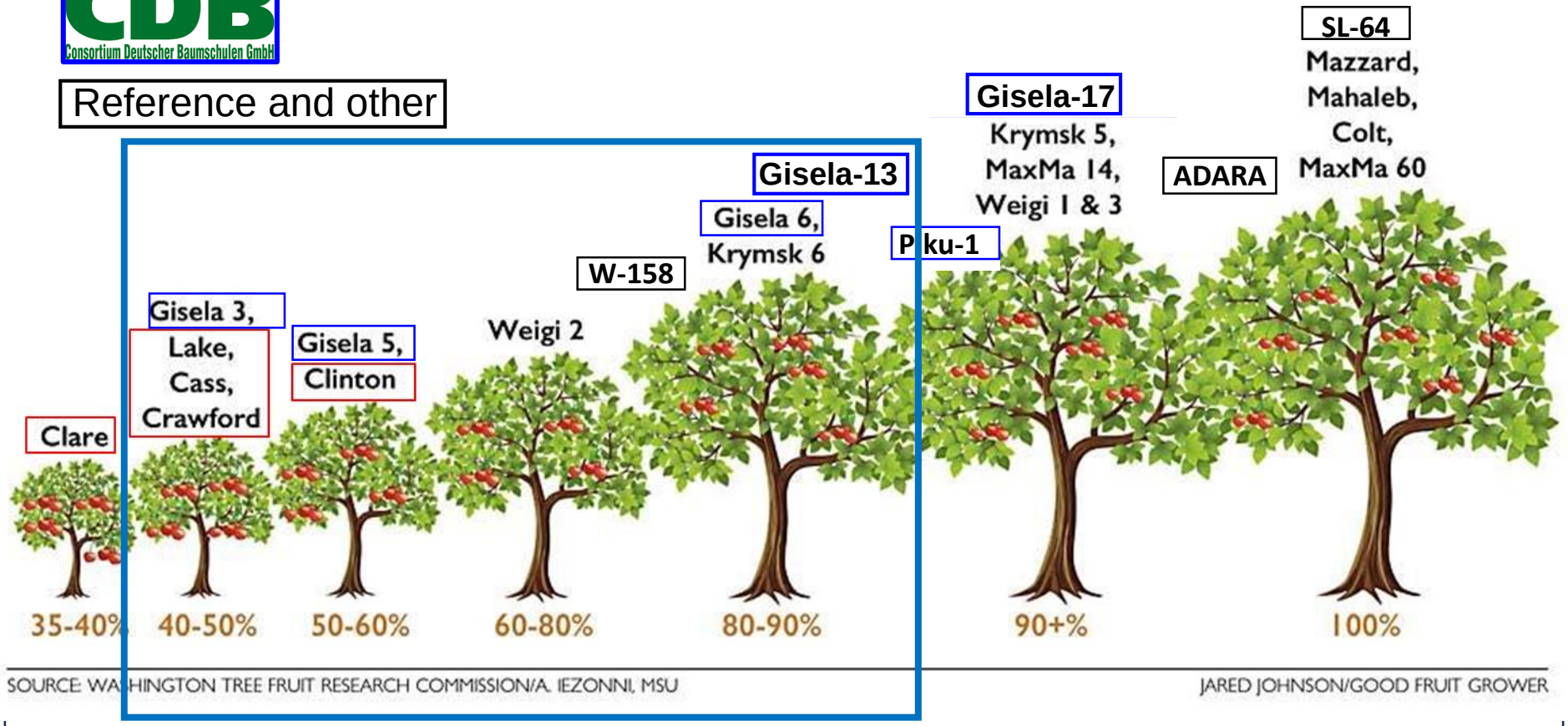
MICHIGAN STATE UNIVERSITY

CDB Consortium Deutscher Baumschulen GmbH

Reference and other



SOURCE: WASHINGTON TREE FRUIT RESEARCH COMMISSION/A. IEZONNI, MSU

JARED JOHNSON/GOOD FRUIT GROWER

THE EFFECT OF INTENSIFICATION ON YIELD AND FRUIT SIZE OF THREE CULTIVARS

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®	3.50x0.50	3.3	6.5	15.1	18.4	16.3*	59.6	100% (28+)	28-30	7.7
S. Saretta®	3.50x0.50	3.8	7.7	18.3	22.8	20.7*	73.3	100% (30+)	30-32	8.2
Kordia'	3.50x0.50	3.0	6.5	12.6	13.1	5.2*	40.4	90% (28+)	28-30	7.4

Iglesias and Torrents, 2022

SWEET SARETA/GiSelA®5 3.5 x 0.5 m

THE EFFECT OF CULTIVAR, ROOTSTOCK AND TRAINING SYSTEM ON MEAN HARVEST RATE

Orchard system has significant influence on harvest efficiency

Cultivar		Training System	Mean Harvest Rate (kg/min)
	'Bing'/Mazzard	Traditional open center	***0.47 ± 0.12***
	'Sweetheart'/CAB6P	Garcés Tunnel	***0.51 ± 0.15*** *(+9%)*
	'Chelan'/Mazzard	steep leader (4-5 upright leaders)	***0.53 ± 0.13*** *(+13%)*
	'Tieton'/'Gisela5'	Central leader	***0.64 ± 0.19*** *(+36%)*
	'Sweetheart'/Mazzard	KGB	***0.72 ± 0.17*** *(+53%)*
	'Cowiche'/'Gisela12'	UFO	***0.81 ± 0.18*** *(+72%)*
	Apple	spindle	***3.6 – 4.5***

M. Whiting, personal com. (2018)

FLOWER THINNING: ASSISTED BY HAND AND MECHANICAL THINNING WITH DARWIN

European and Japanesse plum

SHD 6th year: Peralillo, O'Higgins (CHILE)

35-40 t/ha

HARVESTING AGEN/RP-20 SHD 6th year: Peralillo, O'Higgins (CHILE)

28 febr.(ago.) 2021

M. Giori

Emilia Romagna (3r year)
STANLEY/RP-20 3x0,8 m

August-2019

M. GIORI

Cuadro 1. Marcos de plantación, producciones y calidad de fruto de diferentes variedades de ciruela europea y japonesa en diferentes países con sistema de formación en eje central y patrón Rootpac®20.

Variedad	Marco plant. (m)	Producción (t/ha)						Calibre (mm)
		2º	3º	4º	5º	6º	Acum.	
	Emilia Romagna – Ferrara (Italia)							
'Stanley'	3,0 x 0,5	20	45	65	48	52 54 58	230	40
	Veneto – Verona (Italia)							
'Agust Delight®'	3,5 x 0,8	16	52	–	–	–	68	55
'Blue Moon®'	3,5 x 0,8	13	48	–	–	–	61	55
'Owen T®'	3,5 x 0,8	11	45	–	–	–	56	60
'Crimson Gloo®'	3,5 x 0,8	14	49	–	–	–	63	60
	Banat (Serbia)							
'Stanley'	3,0 x 0,5	35	45	55	52	58	80	40
'Angeleno®'	3,0 x 0,5	15	30	40	18	25	45	55

‘APRIMED’ (AP-65) (PAC-00.05)

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PAC 00-05

General information

Specie: Plum apricot hybrid [(*P. besseyi* x *P. armeniaca*) x *P. cerasifera*)]
Origin: Breeding and selection program of Agromillora.
Breeders code: PAC 00-05.
Estado Sanitario: Virus free: PPV, PNRV, PDV, ACLSV ApMV, PLMVd and phytolasmas.
Deposit: *Prunus* collection in Monistrol, Barcelona, Spain., and in Chile in 2009.
Status: Experimental rootstock in field testing in several European countries.

Agronomic Traits

Vigour: Medium similar to Adesoto.
Compatibility: Good with apricot and Japanese plum varieties. Forms very even graft unions with apricot varieties.
Growth habit: Erect and somewhat open.
Productivity: Very productive with all tested apricot varieties.
Fruit size: Forms fruit with good calibre.
Propagation: Does well by *in vitro*. Difficult by hard wood and Herbaceous cuttings.
Adaptability: Adapts well to the growing conditions in Spain.
Others: Has a rigid stem with little or no ramification in the first year. Leaves are very apricot like. Productive, does not form suckers (root or crown suckers). Generates trees that are very homogeneous with all the tested apricot varieties.

Resistances and (or) tolerances

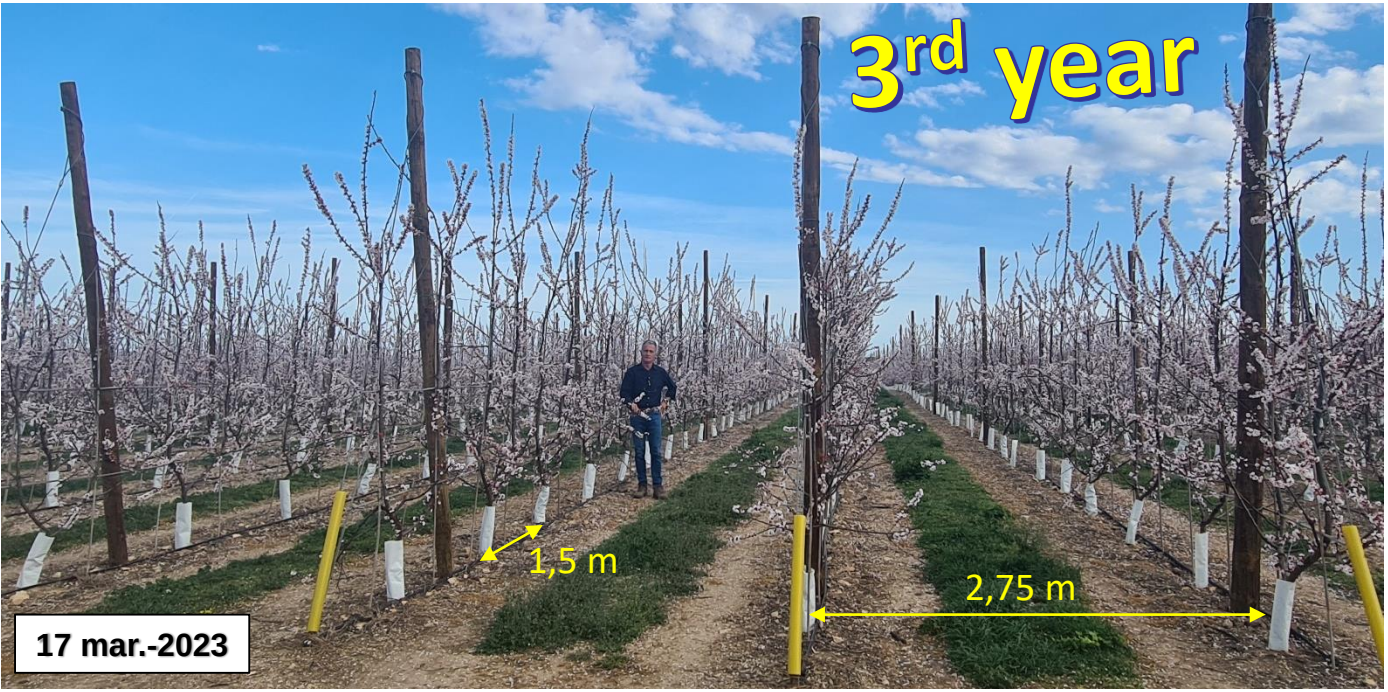
Cold: Apparently tolerant
Drought: Unknown.
Asphyixia: Highly tolerant
Chlorosis: Tolerant.
Salinity: Sensitive.
Root-knot nematodes: Highly resistant to immune.
Lesion nematodes: Unknown.
***Agrobacterium tumefaciens*:** Unknown.
***Armillaria mellea*:** Unknown.
***Rosellinia necatrix*:** Unknown.

Global rating: Very interesting rootstock for apricots. Good replacement for standard rootstocks used for apricots such as Adesoto, apricot seedling rootstocks, Marianna and Myrobalan type rootstocks.

A new and distinct hybrid plum-apricot plant used as a rootstock that exhibits root-knot nematode resistance, high tolerance to root asphyxia, and compatibility with apricot and plum varieties.

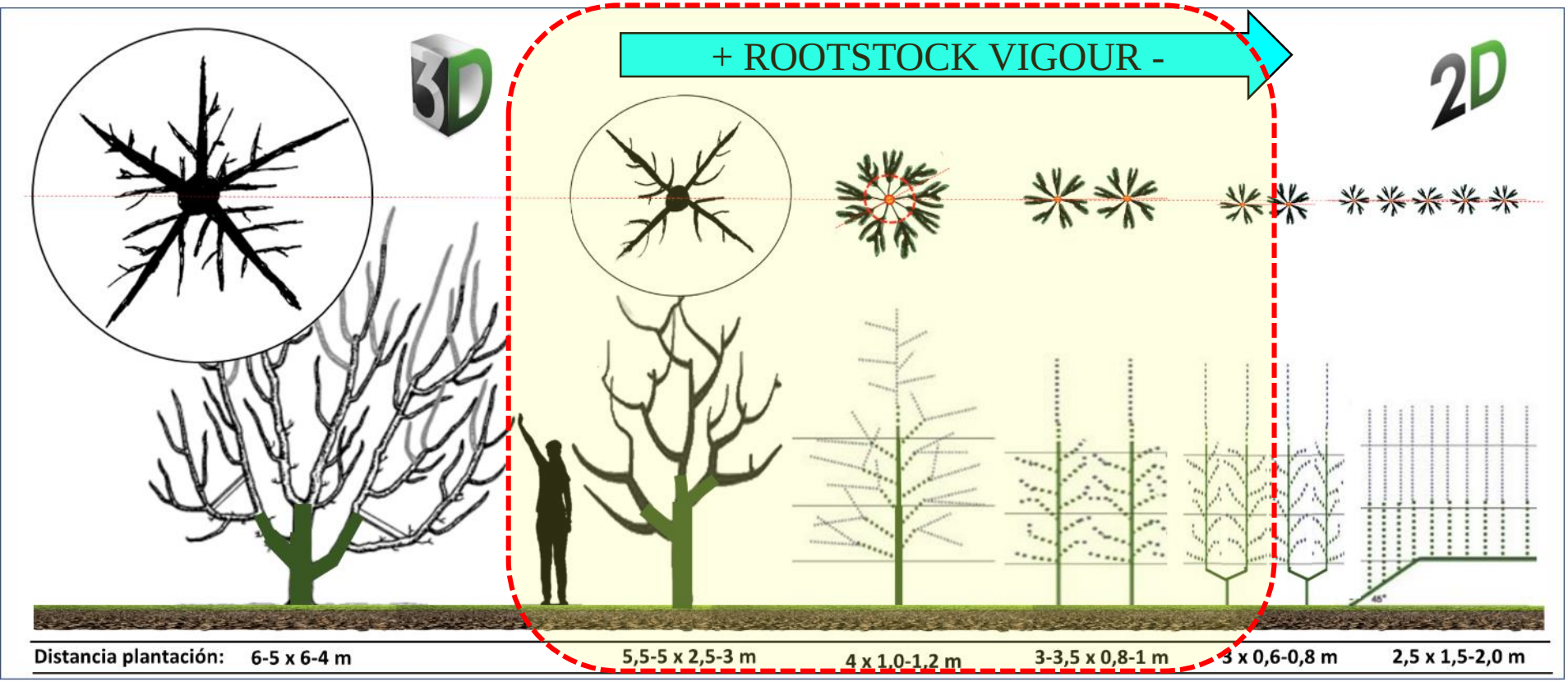
NELSON /AP-65: 4,5 x 2,5 m. Planted dormat bud February 2022

NELSON /AP-65: 2,75 x 1,5 m. Planted dormat bud February 2021



WHAT'S NEXT?

CHANGING TREE ARCHITECTURE + DEVELOPMENT OF VIGOUR CONTROL ROOTSTOCKS IN PEACH



Iglesias & Echeverría, 2022

WHAT'S NEXT?

1998

1945

2010

FRUIT VISIBILITY
CANOPY ACCESIBILITY
Flying Autonomous Robots

HMC FARMS

TEVEL

TEVEL Aerobotics Technologies

Autonomous Fruit Harvesting, On-Demand

https://youtu.be/kLmersqggOY

KLEPPE (Alto Valle, Argentina)

April, 2024

ADVANCED FARM

advanced.farm.

30 apples/min

CONCLUSIONS

- ✓ *Constant increase of production cost, in particular labour, requires a reduction based of **mechanization** for thinning, pruning and harvest.*
- ✓ *Efficient mechanization and labour use requires planar or bi-dimensional canopies. In the meantime these **planar canopies** are more efficient in the use of inputs (water, fertilizers, phytosanitary products, etc.)*
- ✓ *Planar canopies associated to intensive orchards requires **size controlling rootstocks** and results in early and high yields and labour cost for training trees during the first 2-3 years.*
- ✓ *Intensive systems associated to planar canopies are the keys for an **efficient and sustainable production** (environmentally and grower's profit) in Prunus species.*
- ✓ *Planar canopies open the door to **precision fruit production** in aspects as robotic thinning, pruning and harvest, precision counting (forecast) and pests and diseases monitoring, among other.*

THANK YOU!!!