Rootstocks for Mandarins Quality & Size

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Spain

Clementines

Paella

XVIII Century

Citrus sinensis (L.) Osb.

Mechanical grading in a Navel sweet orange orchard.

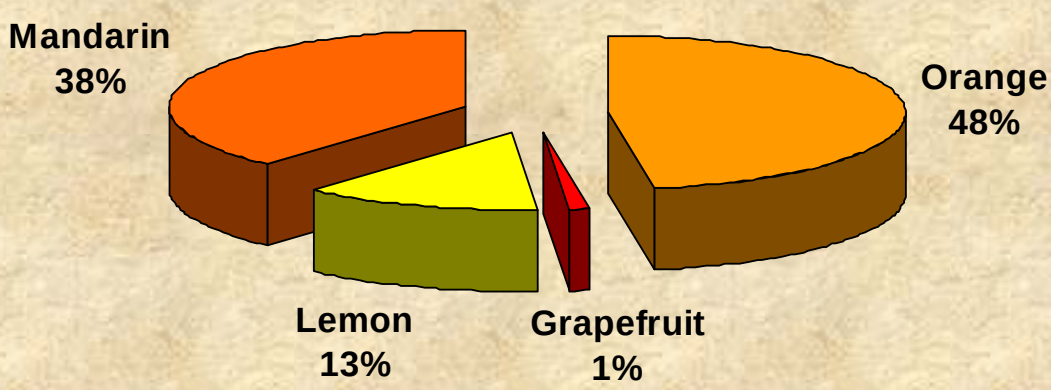
1920

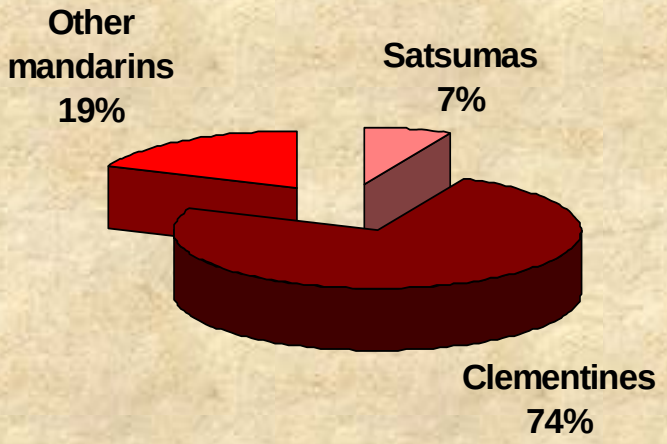
Tillage demonstration with disc harrow in the orange grove of "Granja de Burjasot".

Labels of citrus companies

Spanish production

319.163 ha → 5.480.000 tons.





Citrus Tristeza Virus (CTV)

- First detected in 1957 in Valencia
- All orange and mandarin trees grafted on sour orange died

Rootstocks used in Spain

- Citrange Carrizo..... 80 %
- Mandarino Cleopatra..... 8 %
- *Citrus volkameriana*..... 4 %
- Citrumelo Swingle..... <1 %
- *Citrus macrophylla* ..... 10 %

Rootstocks used in Spain

CITRUS VOLKAMERIANA

- Tolerant to CTV and exocortis.
- Susceptible to xyloporosis and woody gall.
- Good tolerance to iron chlorosis.
- Tolerant to flooding
- Susceptible to *Phytophthora*.
- Susceptible to nematodes.
- Precocious and high yield.
- High fruit size and low fruit quality.
- Monoembrionic seeds

Rootstocks used in Spain

SWINGLE CITRUMELO

- Tolerant to CTV, exocortis and xyloporosis.
- Susceptible to iron chlorosis.
- Resistant to flooding.
- Resistant to *Phytophthora* spp.
- Resistant to nematodes.
- Good productivity.
- Late bearing.
- Good fruit quality.

Rootstocks used in Spain

CITRUS MACROPHYLLA

- Susceptible to CTV.
- Tolerant to iron chlorosis.
- Tolerant to salinity
- Susceptible to cold.
- Resistant to Phytphthora spp.
- Susceptible to nematodes.
- Precocious and high productivity.
- Low fruit quality.

Rootstocks used in Spain

CLEOPATRA MANDARIN

- Tolerant to CTV, exocortis and xyloporosis.
- Tolerant to iron chlorosis.
- Tolerant to salinity
- Susceptible to flooding
- Susceptible to nematodes.
- Low yield with clementines.
- Small fruit size.

Rootstocks used in Spain

CARRIZO CITRANGE

- Tolerant to CTV and xyloporosis.
- Susceptible to exocortis.
- Susceptible to iron chlorosis
- Susceptible to salinity.
- Susceptible to nematodes.
- Problems in bud union.
- Good productivity and good fruit quality
- Early bearing.

New citrus rootstocks breeding program

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- Tolerance to CTV.
- Good adaptation to all kinds of soils:
  Salinity,
  Iron chlorosis, Flooding, Water stress.
- Good affinity with all cultivar.
- Be tolerant of all viruses affecting citrus.
- Being resistant to fungal diseases affecting citrus (*Phytophthora* spp., *Armillaria mellea*...).
- Being resistant to nematodes and other pests.
- Precocity, high yields and good fruit quality (size, juice content, soluble solids...)
- Reduced tree size.

New citrus rootstocks breeding program

Hybridizations	No of hybrids
Troyer citrange x Cleopatra mandarin	47
Troyer citrange x common mandarin	19
Cleopatra mandarin x Poncirus trifoliata	47
Cleopatra mandarin x Flying dragon.	9
Cleopatra mandarin x Troyer citrange	30
Common mandarin x P. trifoliata.	8
Common mandarin x Troyer citrange	7
King mandarin x P. trifoliata	34
King mandarin x 'Flying Dragon'	168
Clementine x P. trifoliata	11
Sour orange x Cleopatra mandarin	13
Grapefruit x P. trifoliata	2
Grapefruit x Troyer citrange	3
Lemon x P. trifoliata	10
Lemon x Troyer citrange	2
Lemon x sour orange	10
C. volkameriana x P. trifoliata	88
T O T A L	508

New citrus rootstocks breeding program

New hybrids rootstocks released in EU

- FORNER-ALCAIDE Nº 5
- FORNER-ALCAIDE Nº13
- FORNER-ALCAIDE Nº418
- FORNER-ALCAIDE Nº517

New citrus rootstocks breeding program

New hybrids with protection sought in EU

- FORNER-ALCAIDE Nº31
- FORNER-ALCAIDE Nº42
- FORNER-ALCAIDE Nº47
- FORNER-ALCAIDE Nº234
- FORNER-ALCAIDE Nº2313
- FORNER-ALCAIDE Nº2324
- FORNER-ALCAIDE NºV41
- FORNER-ALCAIDE NºV94
- FORNER-ALCAIDE Nº5115
- FORNER-ALCAIDE V17
- FORNER-ALCAIDE 1633

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GCM Variedades Vegetales
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citrus genesis

ICCSA

AGROMILLORA

Citrus breeding program: screening trials

ABIOTIC STRESS

Iron chlorosis

Salinity

Water stress

Flooding

BIOTIC STRESS

CTV

Phytophthora spp.

Nematodes

Citrus breeding program: screening trials

ROOTSTOCK AND SCION COMBINATION

Incompatibility

Bud union

Tree size

Citrus breeding program: screening trials

FRUIT

- Fruit weight
- Fruit conservation
- Juice content
- Soluble solids and Maturity index
- Peel colour index
- Fruit alterations
- Antioxidant content

TREE

- Yield
- Early or late bearing
- Precocity
- Carbon footprint
- Organic

Citrus breeding program: screening trials

ABIOTIC STRESS: Iron chlorosis

Citrus breeding program: screening trials

ABIOTIC STRESS: Iron chlorosis

Forner-Alcaide 5

Rootstocks	P_n [$\mu mol(CO_2)\ m^{-2}s^{-1}$]	C_i [$\mu mol(CO_2)\ mol^{-1}$]	g_s [$mmol(H_2O)\ m^{-2}s^{-1}$]	EVAP(*E*) [$mmol(H_2O)\ m^{-2}s^{-1}$]
F-A5	10.6a	487b	30a	0.73a
F-A517	9.4ab	369c	27a	0.68a
F-A13	7.8abc	449bc	26a	0.67a
F-A418	7.4abc	525ab	29a	0.77a
Carrizo	6.3bc	543ab	6b	0.13b

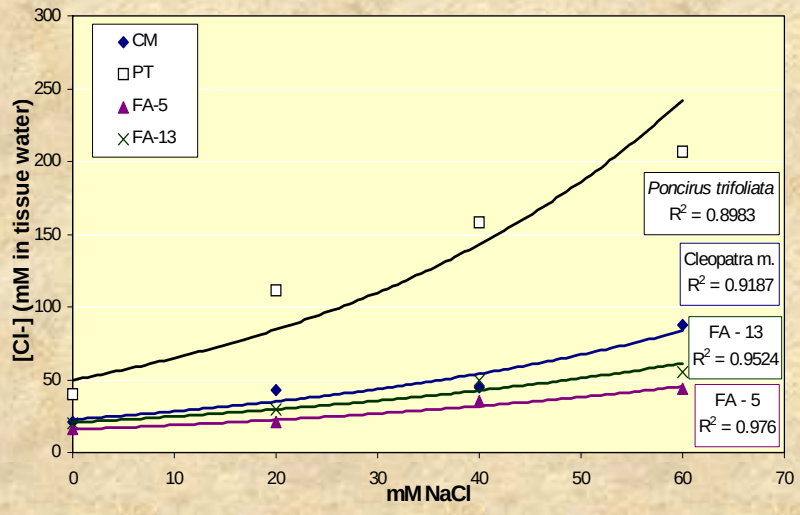
Citrus breeding program: screening trials

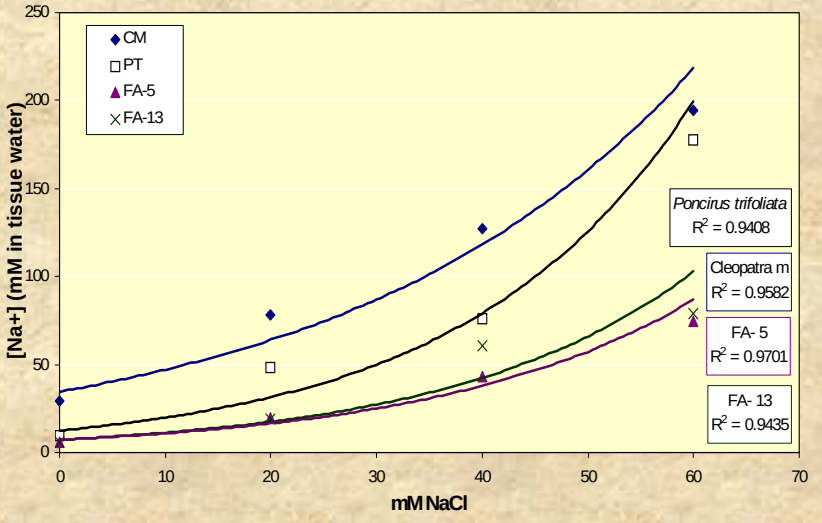
ABIOTIC STRESS: Salinity

Citrus breeding program: screening trials

ABIOTIC STRESS: Salinity

Forner-Alcaide 5





Citrus breeding program: screening trials

ABIOTIC STRESS: Water stress

Citrus breeding program: screening trials

ABIOTIC STRESS: Flooding

Citrus breeding program: screening trials

ABIOTIC STRESS: Flooding

Forner-Alcaide 5

Hybrids	Nº	Susceptible	Tolerant	Resistant
		%	%	%
Troyer x Cleopatra	23	73,8	13,1	13,1
Troyer x common mandarin	4	100,0	0,0	0,0
Cleopatra x P. trifoliata	26	69,2	11,5	19,3
Cleopatra x Troyer	13	84,6	0,0	15,4
common mandarin x P. trifoliata	3	100,0	0,0	0,0
common mandarin x Troyer	2	100,0	0,0	0,0
Clementina x P. trifoliata	3	100,0	0,0	0,0
sour orange x Cleopatra	3	100,0	0,0	0,0
Pomelo x P. trifoliata	2	100,0	0,0	0,0
Troyer		Susceptible		
Carrizo				Resistant
Citrumelo				Resistant
Cleopatra		Susceptible		
Volkameriana				Resistant
Citrus taiwanica		Susceptible		
T. Orlando		Susceptible		

Citrus breeding program: screening trials

BIOTIC STRESS: Phytophthora spp.

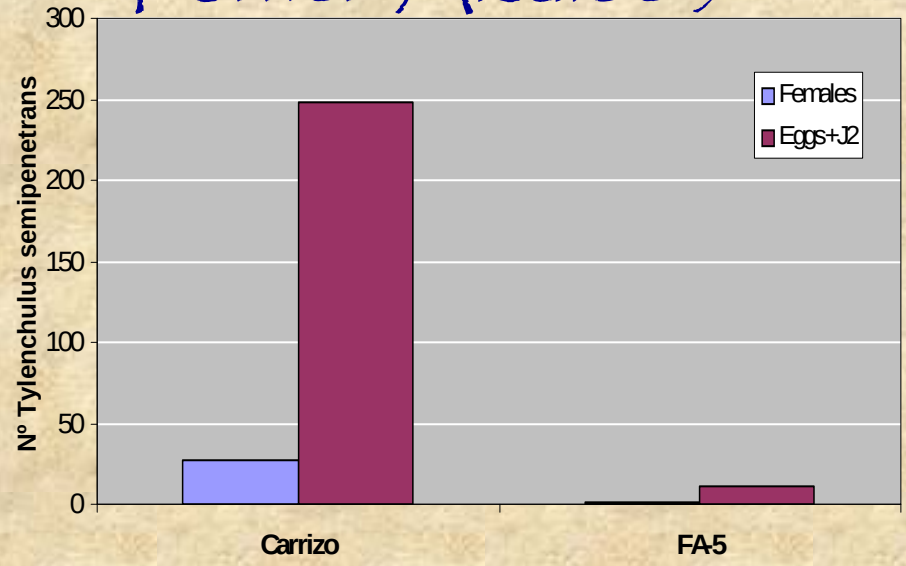
Citrus breeding program: screening trials

BIOTIC STRESS: Tylenchulus semipenetrans

Citrus breeding program: screening trials

BIOTIC STRESS: Tylenchulus semipenetrans

Forner-Alcaide 5



Citrus breeding program: screening trials

UNION ROOTSTOCK/SCION

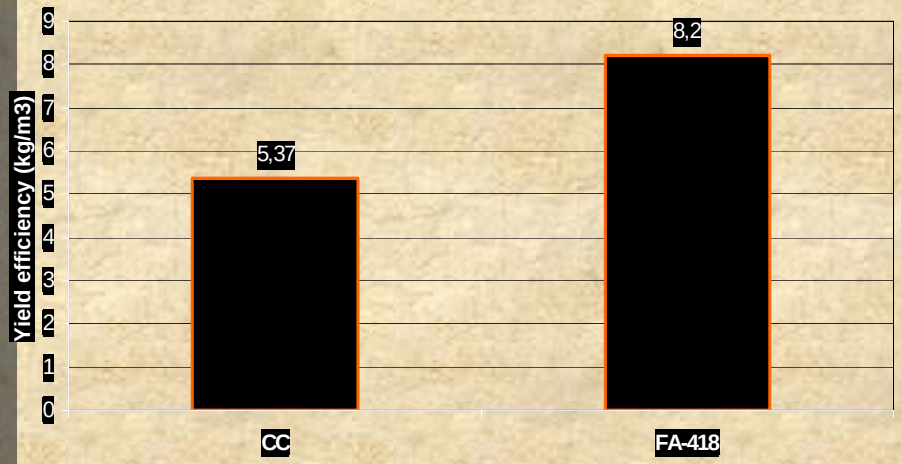
Citrus breeding program: screening trials

INCOMPATIBILITY

Citrus breeding program: screening trials

TREE SIZE

Forner-Alcaide 418

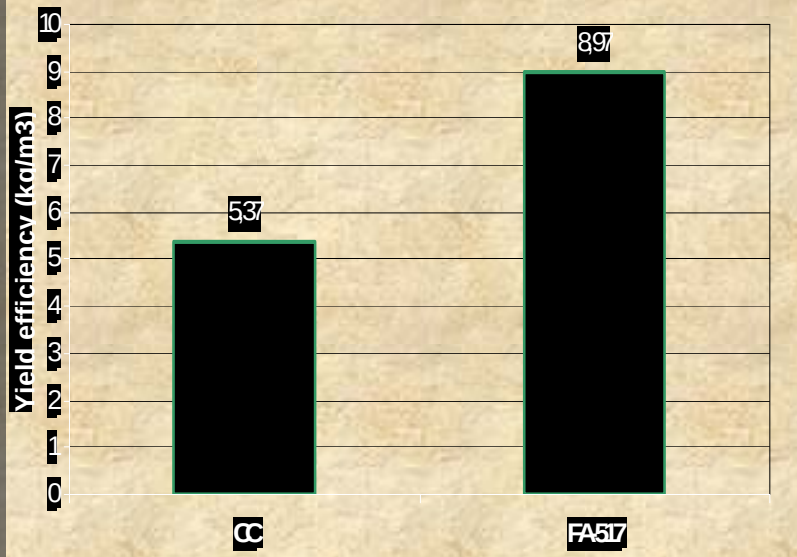


Forner-Alcaide 418

Troyer citrange x common mandarin

- Dwarfing.
- Tolerant to citrus tristeza virus.
- Susceptible to calcareous soils.
- Intermediate tolerance to salinity.
- Susceptible to citrus nematode.
- Susceptible to *Phytophthora* spp. ("root rot").
- High productivity.
- Excellent fruit quality.

Forner-Alcaide 517



Forner-Alcaide 517

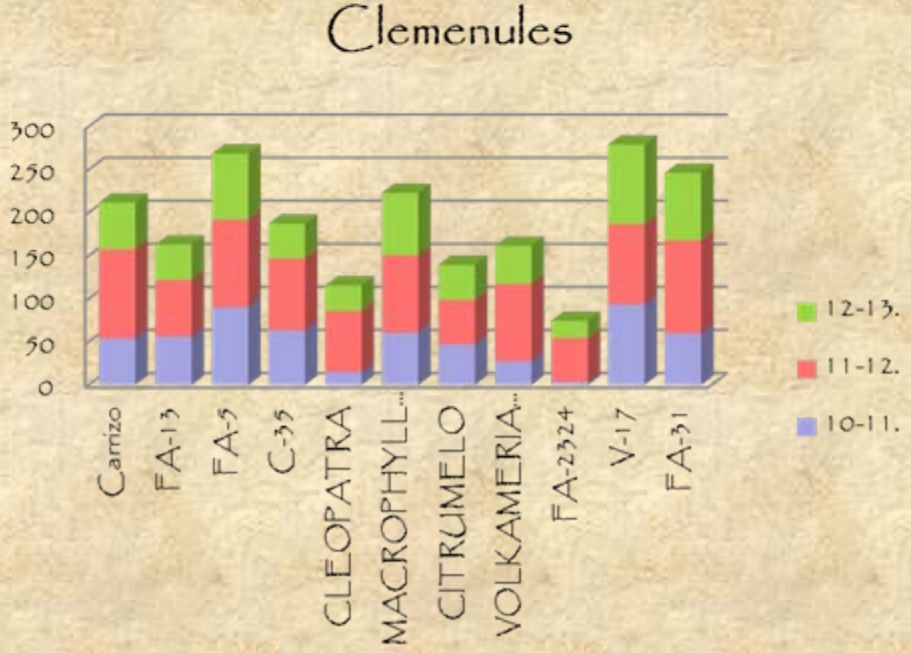
King mandarin x *Poncirus trifoliata*

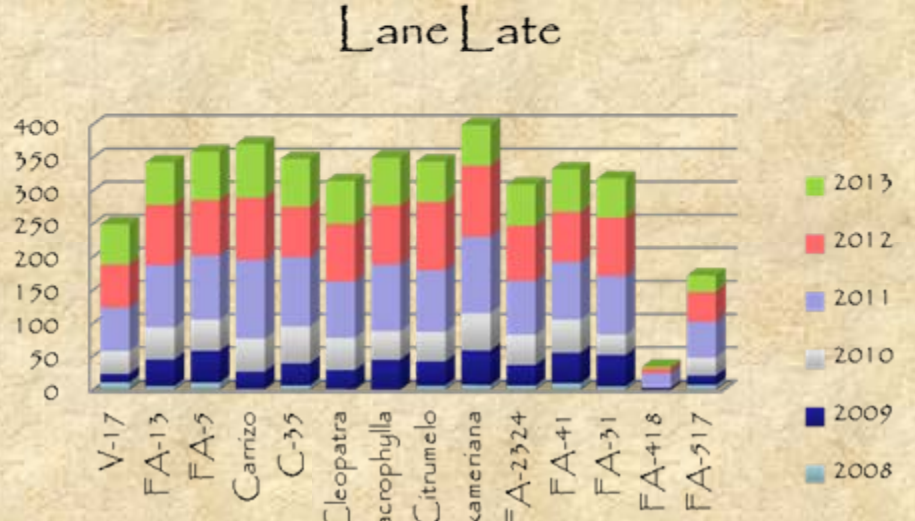
- Dwarfing.
- Resistant to citrus tristeza virus.
- Tolerant to calcareous soils.
- Good tolerance to salinity.
- Resistant to citrus nematode.
- Excellent productivity and fruit quality.

Hiigh density plants (4 x 1.5 m)

Citrus breeding program: screening trials

AGRONOMIC PERFORMANCE: Yield





Citrus breeding program: screening trials

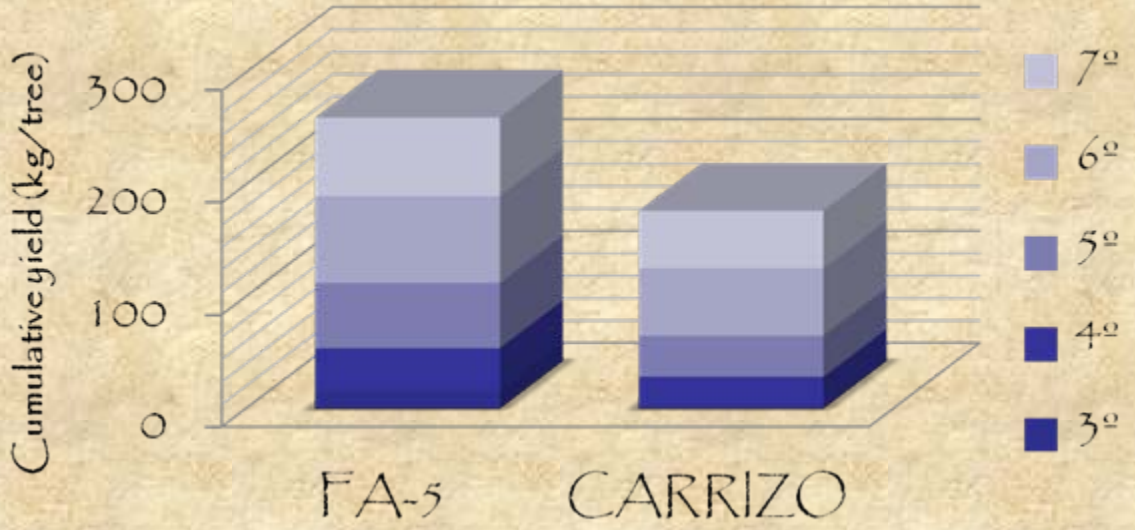
AGRONOMIC PERFORMANCE: Fruit quality

Clementina de Nules

	FA-13	FA-5	CARRIZO	C-35	CLEOPATRA	MACROPHYLLA	C. SWINGLE	VOLKAMERIANA	FA-2324	V-17	FA-31	FA-517
Fruit weight (g)	119,11	113,78	109,56	104,00	114,65	108,44	104,89	98,00	95,33	126,44	104,22	122,22
Juice (%)	58,13	59,67	56,00	59,16	57,89	53,18	57,59	55,09	55,35	55,61	58,54	55,77
Total acids (%)	7,00	7,00	7,50	8,00	7,50	6,50	8,00	6,50	7,00	7,00	7,50	8,50
Total soluble solids (%)	13,10	13,63	13,33	13,40	13,10	12,60	13,10	13,43	12,90	13,20	14,03	13,63
Total soluble solids Total acids-1	14,62	15,51	13,89	13,09	13,65	15,14	12,79	16,14	14,40	14,73	14,61	12,53
Peel colour index	8,25	8,63	9,13	6,24	6,79	9,15	5,63	11,39	4,18	11,47	11,00	11,11

Forner-Alcaide 5

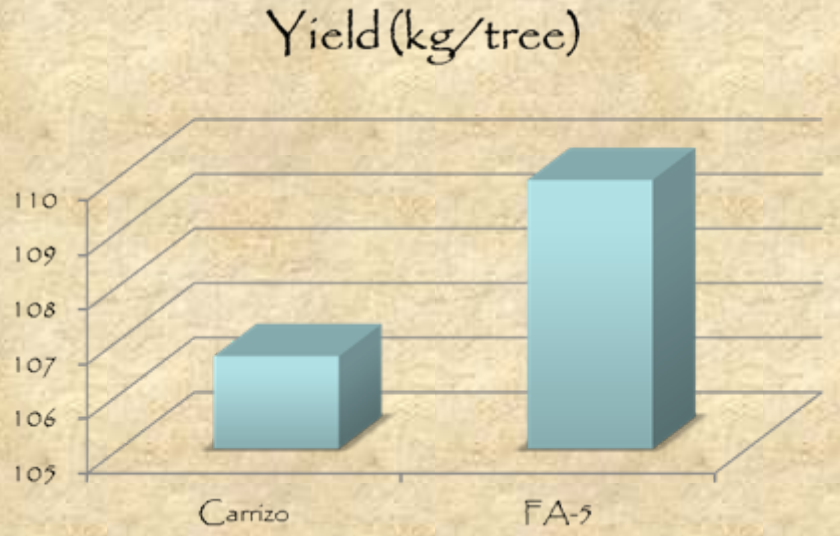
- Navelina



Rootstocks	Canopy volume (m3)	Yield efficiency (kg/m3)	Juice (%)	Soluble solids (%)	TSS:TA	Colour
Forner-Alcaide 5	5,71	46.3	55.11	11.18	8.23	8.35
Carrizo citrange	6,47	27.35	55.93	11.42	8.89	7.96

Forner-Alcaide 5

- Navelate



Rootstocks	Juice (%)	Acids (gr/l)	ºBrix	MI	% Fruit drop
Forner-Alcaide 5	43,97	10,31	11,58	11,29	11,72
Citrange Carrizo	42,85	9,8	11,86	12,2	14,94

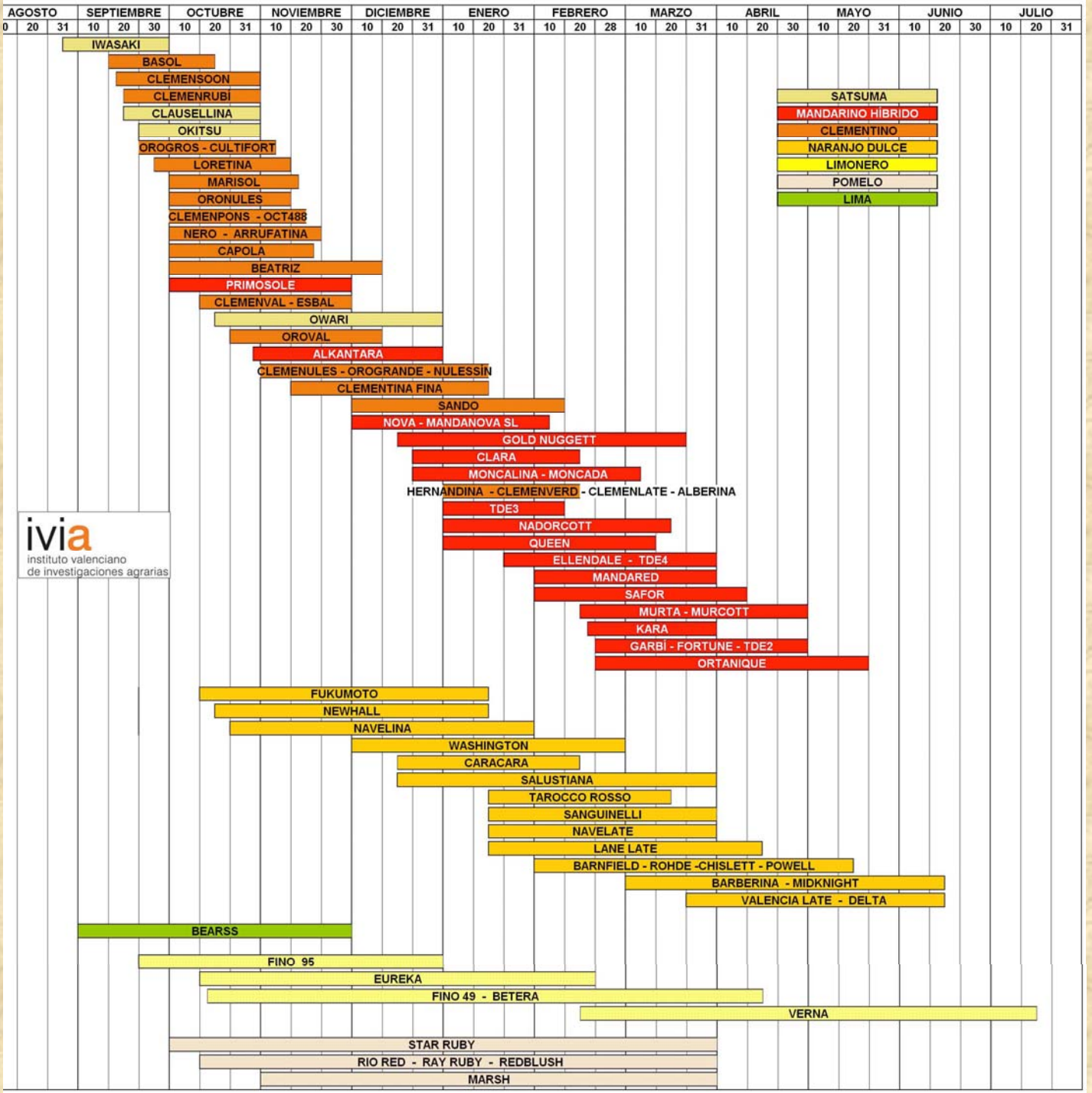
Forner-Alcaide 5

- Okitsu

Rootstocks	Yield (kg/tree)	Fruit weight (gr)	Juice (%)	Soluble solids	TSS:TA
Carrizo citrange	38,00	99,90	57,40	9,00	7,20
Forner-Alcaide 5	47,70	103,40	56,80	8,60	7,50

- Fino 49

Rootstocks	Yield (Kg/tree)	Fruit weight (gr)	Juice (%)	Soluble solids	TSS:TA
Forner-Alcaide 418	20,25	151,64	38,57	7,63	1,39
Forner-Alcaide 5	62,41	184,25	38,49	7,96	1,32


AGOSTO
SEPTIEMBRE
OCTUBRE
NOVIEMBRE
DICIEMBRE
ENERO
FEBRERO
MARZO
ABRIL
MAYO
JUNIO
JULIO
IWASAKI
BASOL
CLEMENSOON
CLEMENRUBI
CLAUSELLINA
OKITSU
OROGROS - CULTIFORT
LORETINA
MARISOL
ORONULES
CLEMENPONS - OCT488
NERO - ARRUFATINA
CAPOLA
BEATRIZ
PRIMOSOLE
CLEMENVAL - ESBAL
OWARI
OROVAL
ALKANTARA
CLEMENULES - OROGRANDE - NULESSIN
CLEMENTINA FINA
SANDO
NOVA - MANDANOVA SL
GOLD NUGGETT
CLARA
MONCALINA - MONCADA
HERNANDINA - CLEMENVERD - CLEMENLATE - ALBERINA
TDE3
NADORCOTT
QUEEN
ELLENDALE - TDE4
MANDARED
SAFOR
MURTA - MURCOTT
KARA
GARBI - FORTUNE - TDE2
ORTANIQUE
FUKUMOTO
NEWHALL
NAVELINA
WASHINGTON
CARACARA
SALUSTIANA
TAROCCO ROSSO
SANGUINELLI
NAVELATE
LANE LATE
BARNFIELD - ROHDE -CHISLETT - POWELL
BARBERINA - MIDKNIGHT
VALENCIA LATE - DELTA
BEARSS
FINO 95
EUREKA
FINO 49 - BETERA
VERNA
STAR RUBY
RIO RED - RAY RUBY - REDBLUSH
MARSH
SATSUMA
MANDARINO HIBRIDO
CLEMENTINO
NARANJO DULCE
LIMONERO
POMELO
LIMA
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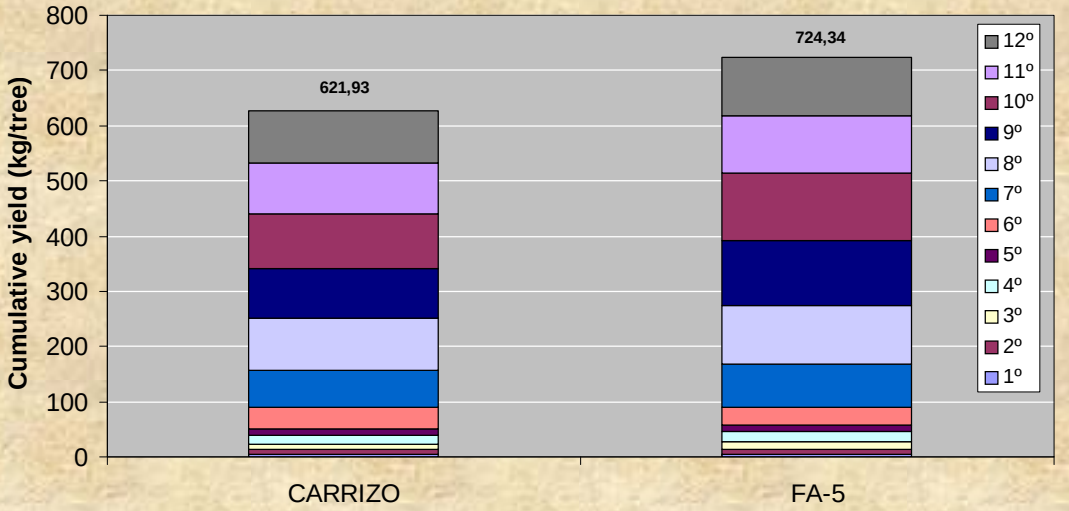
Forner-Alcaide 5

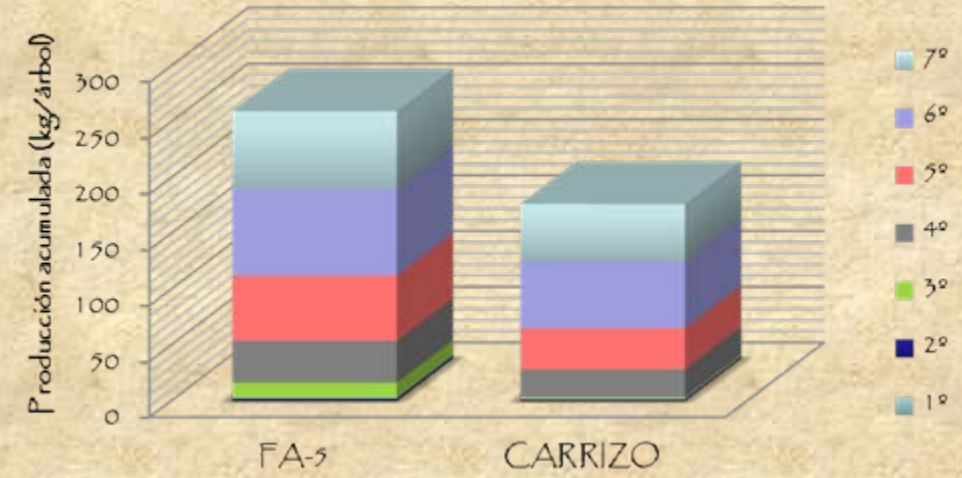
- Clementina de Nules



Rootstocks	Fruit diameter (mm)	Fruit weight (gr)	Juice (%)	Acids	Soluble solids (%)	TSS:TA	Colour
Forner-Alcaide 5	59.95	91.20	52.61	10.30	12.00	11.65	8.66
Carrizo citrange	57.20	81.36	47.72	9.72	12.00	12.35	6.71

Forner-Alcaide 5

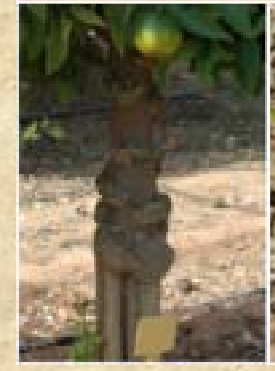
- Orogrande

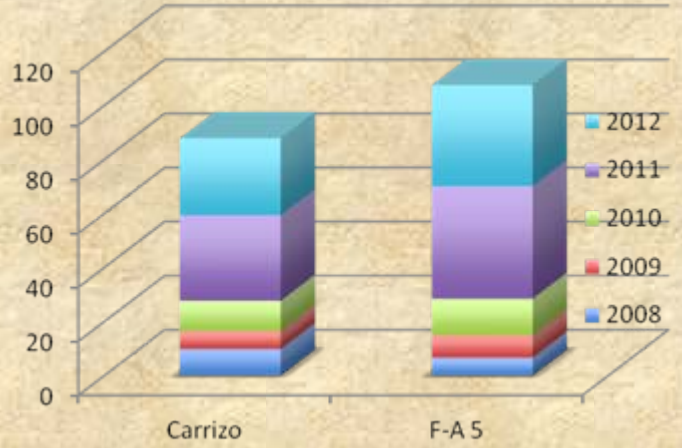


Rootstocks	Yield (Kg/tree)	Juice (%)	Soluble solids	Maturity index
Carrizo citrange	39.66 b	39.03 a	11.48 bc	15.67 b
Forner-Alcaide 5	47.67 a	41.60 a	11.90 ab	16.46 a

Forner-Alcaide 5

- Clemenrubi

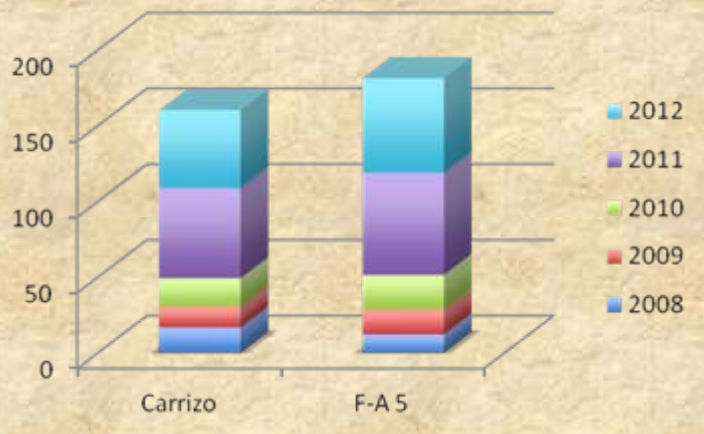




	Carrizo	Forner-Alcaide 5
Fruit diameter (mm)	53,69	55,34
Fruit high (mm)	49,53	50,83
D/H	1,08	1,09
Peel thickness (mm)	2,76	2,37
Fruit weight (g)	76,06	86,99
Juice (%)	44,97	54,71
Dry fruits (%)	30,43	1,39
total acids (%)	0,94	0,98
T.S.S. (%)	11,09	11,76
Maturity index	11,79	12,1
Peel colour index	-4,07	-4,41

Forner-Alcaide 5

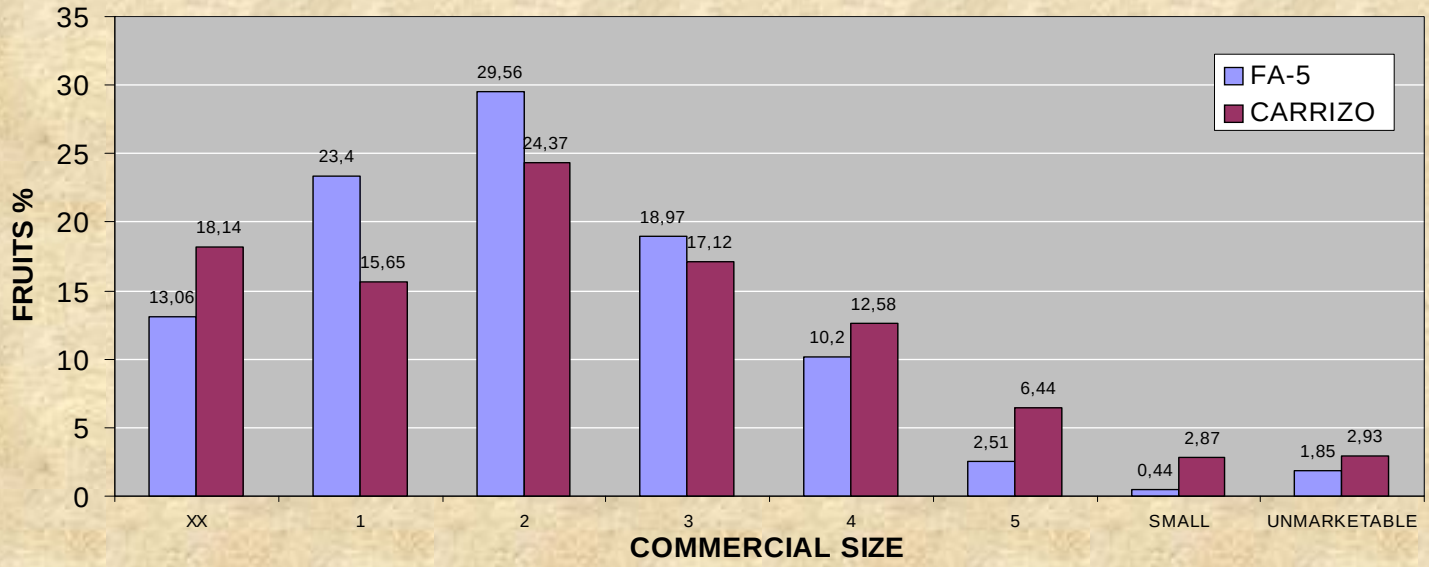
- Orogrós



	Carrizo	Forner-Alcaide 5
Fruit diameter (mm)	51,6	54,77
Fruit high (mm)	48,21	50,55
D/H	1,07	1,08
Peel thickness (mm)	2,33	2,08
Fruit weight (g)	72,79	86,65
Juice (%)	53,53	58,75
Dry fruits (%)	7	1
total acids (%)	1,01	0,94
T.S.S. (%)	10,8	10,85
Maturity index	10,68	11,55
Peel colour index	-12	-10,81

Citrus breeding program: screening trials

AGRONOMIC PERFORMANCE: Fruit quality



Citrus breeding program: screening trials

AGRONOMIC PERFORMANCE:
Early or late maturing

Citrus breeding program: screening trials

Forner-Alcaide V17

TSS	13-0ct	20-oct	27-oct	03-nov	09-nov	12-nov	17-nov	24-nov	08-dic
C. Carrizo	10,42	11,68	11,78	11,98	12,8	12,7	13,1	12,6	13,53
V-17	13,1	13,1	12,8	12,7	21,7		13,77	13,2	13,53
ACIDS									
C. Carrizo	10,5	10	9,5	8,3	7,9	8,1	7	7	7,5
V-17	9,5	9,5	9	8,9	7,5		7	8	7
TSS:TA									
C. Carrizo	7,75	9,13	9,69	11,28	12,66	12,25	14,62	14,06	14,09
V-17	10,7	10,77	11,11	11,15	13,23		15,37	12,89	15,1
COLOUR									
C. Carrizo	0,42	0,88	1,18	2,3	1,32	1,1		7,27	13,43
V-17	1,19	1,82	3,78	6,58	3,9			11,77	15,75
JUICE									
C. Carrizo	46,55	56,72	63,46	50,65	45	58	60,71	48,13	53,09
V-17	56,9	58,82	59,09	53,69	60		56,25	57,04	59,42

Citrus breeding program: screening trials

AGRONOMIC PERFORMANCE: Antioxidant activity

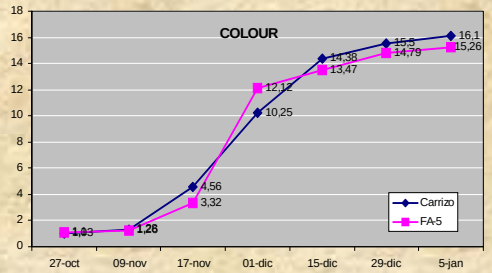
Rootstock	Acids (%)					Sugars (%)			
	Citric	Tartaric	Malic	Ascorbic	Total acids	Sucrose	Glucose	Fructose	Total sugars
Carrizo citrange	0,99±0,11 ab	0,02±0,00 bc	0,29±0,02 a	0,05±0,00 a	1,35±0,11 ab	4,60±0,13 bc	1,67±0,06 ab	1,61±0,07 a	7,87±0,24 bc
Cleopatra mandarin	1,04±0,04 bc	0,02±0,00 b	0,33±0,01 ab	0,06±0,00 b	1,45±0,04 bc	4,65±0,09 bc	1,74±0,04 ab	1,69±0,04 ab	8,08±0,17 bc
020324	1,30±0,10 d	0,02±0,00 bc	0,31±0,00 ab	0,06±0,00 ab	1,69±0,11 d	4,68±0,16 bc	1,81±0,14 b	1,74±0,16 ab	8,24±0,45 bc
F&A 418	1,33±0,03 d	0,02±0,00 c	0,34±0,02 bc	0,08±0,00 d	1,77±0,03 d	5,52±0,16 d	2,17±0,09 c	2,15±0,08 c	9,84±0,26 d
F&A 13	1,01±0,07 b	0,02±0,00 bc	0,31±0,01 ab	0,06±0,00 b	1,40±0,07 ab	4,75±0,06 c	1,90±0,07 bc	1,96±0,08 bc	8,62±0,21 c
030118	1,02±0,11 bc	0,01±0,00 a	0,38±0,03 c	0,06±0,00 b	1,47±0,10 bc	4,21±0,16 ab	1,71±0,07 ab	1,78±0,07 ab	7,70±0,30 abc
030127	1,22±0,05 cd	0,02±0,00 bc	0,33±0,01 ab	0,07±0,00 c	1,64±0,06 cd	4,23±0,20 ab	1,75±0,10 ab	1,66±0,12 a	7,64±0,42 abc
030131	0,78±0,01 a	0,01±0,00 a	0,34±0,01 bc	0,06±0,00 b	1,20±0,02 a	3,77±0,02 a	1,52±0,04 a	1,55±0,04 a	6,84±0,08 a
030212	0,95±0,07 ab	0,02±0,00 a	0,38±0,01 c	0,06±0,00 b	1,40±0,08 ab	4,07±0,35 a	1,65±0,16 ab	1,65±0,15 a	7,37±0,60 ab
030230	1,02±0,01 bc	0,02±0,00 a	0,32±0,01 ab	0,06±0,00 b	1,41±0,02 ab	4,89±0,11 c	1,81±0,09 b	1,84±0,09 ab	8,53±0,30 c

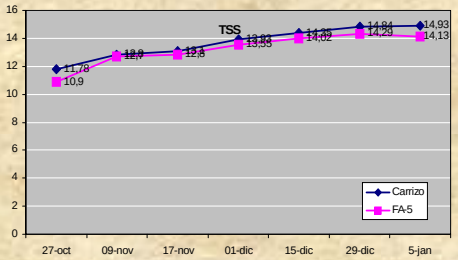
Citrus breeding program: screening trials

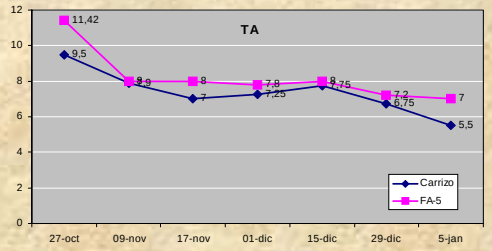
AGRONOMIC PERFORMANCE:

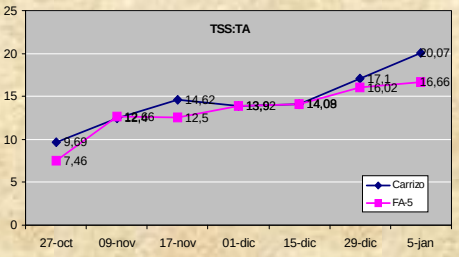
Fruit conservation

Clementina de Nules: Internal fruits parameter









Citrus breeding program: screening trials

AGRONOMIC PERFORMANCE:
Fruit alterations

Citrus breeding program: screening trials

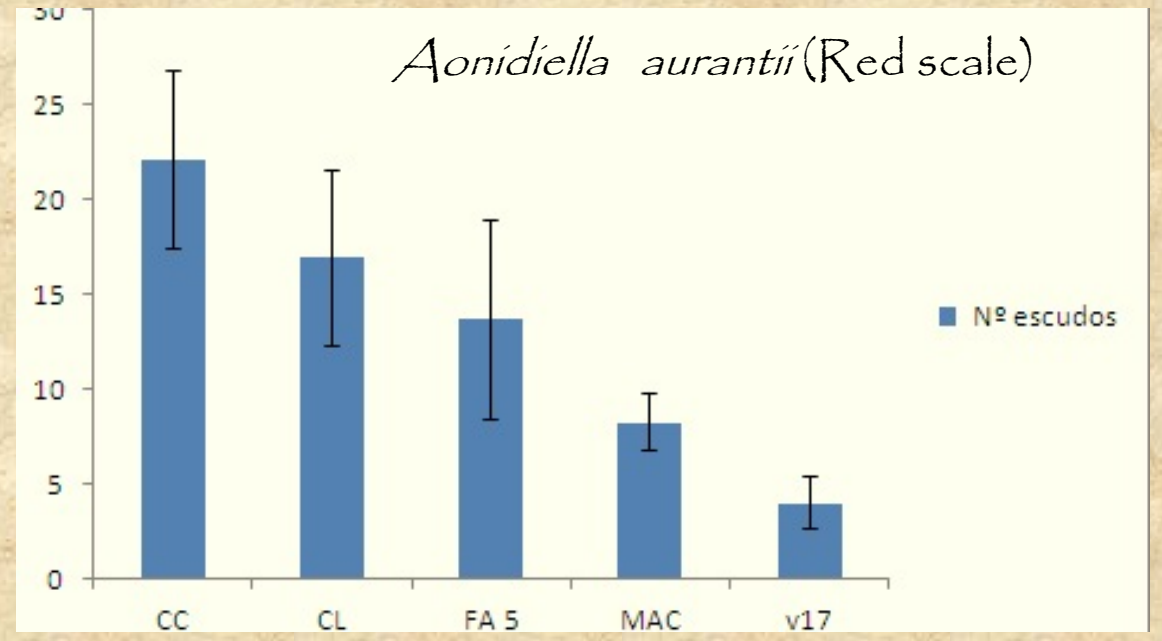
AGRONOMIC PERFORMANCE:

Carbon footprint

Forner-Alcaide 13

Citrus breeding program: screening trials

AGRONOMIC PERFORMANCE: Organic production



Forner-Alcaide 5

Cleopatra mandarin x *Poncirus trifoliata*

- ✓Resistant to citrus tristeza virus.
- ✓Good tolerance to calcareous soils.
- ✓Excellent tolerance to salinity.
- ✓Resistant to flooding.
- ✓Resistant to citrus nematode.
- ✓Excellent productivity.
- ✓Excellent fruit quality.

THANK YOU