Evaluation of superior processing oranges for fresh juice with selected chinese rootstocks

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Department of Primary Industries

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FINAL REPORT

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Project CT07006: Evaluation of superior processing oranges for fresh juice with selected chinese rootstocks

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This report details the development and establishment of a semi-commercial scale evaluation trial to select superior Valencia clones and new trifoliata rootstocks for the Riverina region of NSW. A range of high performing Valencia clones were selected in cooperation with National Foods and were combined with 4 trifoliata rootstocks to assess their performance in a soil type typical of the Riverina region. The aim is to recommend a highly productive Valencia and rootstock combination to support the juice processing industry in the Riverina region of NSW.

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Media Summary

The Australian processing industry is based on the Valencia orange and many of the plantings in the Riverina are well over 40 years of age, having been established in the 1950's and 1960's. The decision to replant with a new Valencia type and rootstock is best achieved with locally derived yield and fruit quality information.

A project was developed between Riverina Citrus, Horticulture Australia and the NSW Department of Primary Industries to establish a semi-commercial block of superior performing Valencia selections from the Riverina region. The project title was: 'Evaluation of superior processing oranges for fresh juice production with selected Chinese rootstocks.' Berri Ltd in Leeton maintains long term production and juice quality records that enabled the selection of 6 Valencia types for the trial. The Valencia's were then propagated onto 3 trifoliata type rootstocks sourced from China and showing promise in evaluation trials at the Dareton Primary Industries Institute. The standard Valencia and trifoliata rootstock available to Australian citrus growers was also included in the trial for comparison.

A site in the Leeton area was chosen for the trial and the existing old citrus orchard cleared and developed for replanting. Tree propagation occurred at Dareton Primary Industries Institute over a two year period and planting occurred in October 2010. Two border rows on either side of the trial were planted with 2 new oranges from China to assess their potential for the Australian processing industry.

The site has also been developed to allow for future mechanical harvesting and will act as a demonstration site for local industry field days and farm walks. The establishment phase of the project is now complete and tree survival has been excellent. The next activity will be to begin tree growth rate measurements in late 2011. An application for on-going funding from Riverina Citrus and Horticulture Australia Ltd will be developed in 2012 to allow the long term collection of yield, fruit quality and tree growth information. It is envisaged that after 4 years of cropping and data collection a recommendation on the best Valencia and rootstock combination for replanting could be given to Riverina growers.

Technical Summary

The Riverina region of NSW is Australia's major orange processing area. The industry is based on the Valencia orange and trifoliata rootstock. Valencia orchards in the Riverina can be over 40 years of age, having been established in the 1950's and 1960's. The decision to replant to a new Valencia clone and rootstock is best achieved with locally derived production and fruit quality data. For processing orange growers to remain viable they must increase their yield per hectare and also maintain or improve fruit quality.

Riverina Citrus, Horticulture Australia Ltd and NSW Department of Primary Industries (DPI) began a project in 2008 to evaluate locally selected Valencia clones that were identified from long term production and juice quality records held by National Foods (Berri Ltd) at Leeton. NSW DPI is currently evaluating a large selection of trifoliata (*Poncirus trifoliata*) rootstock types at the Dareton Primary Industries Institute, introduced to Australia from the Peoples Republic of China. Three high performing trifoliata rootstocks were selected from this evaluation program and combined with 6 superior Valencia clones as the basis of the Riverina trial. The project title was: 'Evaluation of superior processing oranges for fresh juice production with selected Chinese rootstocks.' The standard Valencia clone (Keenan) and trifoliata selection (Tri 22) supplied to the industry by Auscitrus was also included in the trial as standards.
The 3 high performing Chinese trifoliata selections are Tanghe No 6, Donghai and Zao Yang. The inclusion in this semi-commercial planting will assess their performance in a 'heavier' sandy clay soil type. The initial screening of all the introductions from China has been in a sandy loam soil type at Dareton Primary Industries Institute.

A site was selected in the Leeton region and the existing old orange trees removed and the site cultivated. Gypsum and manure was then spread on the site and planting mounds formed. The site was left for 12 months then an EM38 soil survey conducted to select areas of the trial for soil core collection and analysis. The combined information from the EM38 survey and soil analysis enabled a biometric trial design to be imposed on the site to account for minor soil textural variability. The Valencia trees were planted in October 2010 and the site buffered on both sides by rows of 2 new Chinese processing oranges – Bintangcheng No 2 and Jincheng. These were established on a wider range of Chinese trifoliata selections and should provide useful information on their potential in the Riverina.

Three weeks after planting each of the 751 trees received a basal drench of Confidor® Guard systemic insecticide to protect the young trees from sucking insects, notably citrus leaf miner, black citrus aphid and scale insects. The chemical proved very effective and canopy development was not hindered by insect pressure. Tree survival was excellent with only one buffer tree requiring replacement. The high density planting at the site of 1.8m between the trees along the row was selected to suit future mechanical harvesting. Mechanical harvesting will be the preferred method of fruit removal for processing oranges in the future.

Tree growth rate measurements will begin 12 months from trees establishment and an application developed for on-going funding support in 2012. Data collected from the site would include tree growth rates, tree nutrient status, yield, cropping efficiency, the alternate bearing index, maturity period, juice quality attributes such as °Brix, Acid%, B:A ratio, TSS per tonne and juice sensory assessment.

The trial site provides a significant resource for the Riverina citrus industry for both scion and rootstock evaluation. It has been developed to best practice standard and will provide a demonstration site for farm walks and field days related to processing orange production. Data collected from the site will be applicable to both Riverina citrus producers and other regions in Australia with clay based soil types. After 4 years of cropping (2013 – 2016) and data collection the outcome of the trial would be to provide a replanting recommendation to Riverina growers of the highest performing Valencia and trifoliata rootstock combination.

Recommendations

- Tree growth rate data collection begins in November/December 2011 with establishment of painted trunk bands and measurements of tree height and diameter.

- The trial site receives a second Confidor® Guard soil drench treatment in November/December to suppress damage to the young canopy from leaf eating/sucking insects.

- A HAL submission (VC) for continuing funding should be developed with Riverina Citrus during 2012. Yield and fruit quality data collection to begin in 2013.

Acknowledgements

We wish to acknowledge the long term commitment and support from the trial cooperator – John Davidson, Leeton who provided the trial site in the Riverina. We also wish to acknowledge the technical support of Troy Witte and Jason Bowes (Technical Assistants NSW DPI) in conducting nursery propagation and trial establishment. The involvement of Riverina District Horticulturist - Andrew Creek (NSW DPI) is also acknowledged for his assistance in trial establishment, trial management and on-going commitment to achieving commercial outcomes from the trial.

Introduction

Background

The project was initiated through discussions between John Davidson – Fruit Purchasing Manager - National Foods and Peter Morrish ex CEO Riverina Citrus and NSW Department of Primary Industries (NSW DPI) in 2005. A need was identified to select high producing local selections of Valencia for future replanting of old Valencia blocks. This will help to ensure the continuing supply of high quality Valencia fruit, in sufficient volumes, to meet the processing needs of the local citrus industry in the Riverina.

The 2003 Citrus National Plantings Database gave the Riverina region of NSW 8,687ha which is 29% of the Australian industry. Citrus production from the region (which included coastal NSW and Bourke statistics) was 236,000 tonnes at the 2005/06 harvest. Valencia oranges constituted 103,000 tonnes or 58% of orange production, predominantly for processing. Citrus processing constituted a significant component of the Riverina citrus industry with approximately 60% of bearing trees used for processing. There are long term and on going contractual arrangements to supply processing fruit to National Foods (Berri Ltd) and Golden Circle for fresh juice production. The commitment to orange processing by Berri Ltd in the Riverina has been demonstrated by the relocation of the South Australian processing operations from South Australia to Leeton and the contracting of 500ha of new mid season oranges. Varieties such as Hamlin and Salustiana have been planted to fill the early July to late October window when high quality Valencia oranges are not available. The Australian processing orange industry is based on the Valencia variety.

Concerns have been raised regarding the age of Valencia plantings in the Riverina with many plantings exceeding 40 years of age, having been established in the 1950's and 1960's. Old trees are more likely to alternate bear and be difficult to harvest due to their size. The size issue is particularly important with the probable move to mechanical harvesting operations for processing oranges in the near future. The decision to replant with a new Valencia clone and rootstock is best achieved with locally derived tree yield and fruit quality information.

The project aim was to combine a range of high performing Valencia clones that have been identified by Berri Ltd, from long term processing records, with selected Chinese trifoliata rootstocks *(Poncirus trifoliata)* identified by NSW DPI as worthy of further investigation in clay loam soil types. Trifoliata is the dominant rootstock used in the Riverina with 75% of trees established on this stock.
Australia (NSW) is the only country to be given access to the Chinese rootstock genetic material and it has been undergoing screening and assessment since the mid 1990's. The Chinese material entered Australia via two Australian Centre for Agricultural Research Centre (ACIAR) projects. These were a cooperative arrangement between NSW DPI, CSIRO Division of Horticulture and the People's Republic of China. Seeds of imported rootstocks were grown into seedlings and screened for trueness to type, salt tolerance and susceptibility to root pathogens (phytophthora). In field testing of rootstock performance has been recently funded through the 'National program for screening and evaluation of new citrus rootstocks'

by Dr Tahir Khurshid – NSW DPI. Horticulture Australia Ltd has provided on-going funded support to this program with the aim of developing new commercial rootstocks for Australia. The first step in the commercialisation process is to select the superior rootstocks from the Dareton Primary Industries Institute trials and establish these in semi- commercial scale plantings. It is necessary to critically evaluate the commercial potential of the best performing selections in different soil and climatic conditions. In conjunction with semi-commercial scale trials, rootstock source trees are being established through Auscitrus for the future supply of seed to the Australian industry.

Materials and Methods

Collection of Valencia scions

Six Valencia selections were collected in the Riverina in January 2005, in cooperation with Berri Ltd. Blocks selected had a long term history of high yields and superior processing qualities such as high Total Soluble Solids (TSS) and juice % identified from Berri Ltd records (Table 1). A source tree was selected in each block by Pat Barkley (former NSW DPI Citrus Pathologist) and budwood collected. Budwood was returned to Dareton Agricultural Research Institute and mother trees propagated for the supply of propagating material and virus indexing (Figure 1).

Table 1. Riverina Valencia selections – collected 25/1/2005

Grower	Location	Tree ID	Comment
1	via Yanco	T1 R6	Planted 1947 Trees from Catt's Nursery, Ermington Fruit picked March, April, May. Regreen then go orange again.
2	via Yanco	R2 T3	Trees 57 years old. Rounded fruit shape. Trees sold by Catt's Nursery
3	Corbie Hill, via Leeton	R4 T8	Rocky soil on side of hill.
4	Corbie Hill, via Leeton,	R4 T7	Trees 1950's planting.
5	Stanbridge, via Leeton,	Valencia sport	High ºBrix. Superior juice colour.
6	Tharbogang, via Griffith,	R20 T1	Upright tree shape.

General Comments
Trees planted in late 1940's /1950's except Grower 5 which is a sport. At least 3 different clones of Valencia collected: Able to visually differentiate in the field.
1. (long harvest period – re-green then colours again)
2. (round fruit shape)
5. (high ºBrix readings, high juice colour)
3 and 4. (similar appearance of tree and fruit, could be the same clone?)

Figure 1. Valencia mother trees established for budwood supply

Valencia mother trees were held in the Dareton nursery until funding was obtained to begin the project. In conjunction with the establishment of Valencia mother trees two Chinese processing oranges were introduced to Australia and were rapidly multiplied to establish trees for future field assessment. Both Chinese scion varieties were subsequently propagated onto a wider range of Chinese trifoliata rootstocks and included in the Riverina trial as buffer rows. The Chinese scions (Bintangcheng No 2 orange and Jincheng Bei Bei 447 orange) were obtained as budwood ex Post Entry Quarantine (PEQ) and of a high health status.

The Valencia selections from the Riverina were field collected from predominantly old trees with an unknown health status. Budwood from the mother trees grown at Dareton was supplied to the Elizabeth Macarthur Agricultural Institute for virus indexing (Table 2).

Table 2. Virus Indexing of Valencia clones

Test pathogen	Test method	Result (Valencia clone)					
		1	2	3	4	5	6
Viroids (including CEV)	Etrog citron indicator plants	No viroid symptoms observed	No viroid symptoms observed	No viroid symptoms observed	No viroid symptoms observed	No viroid symptoms observed	No viroid symptoms observed
Citrus tristeza virus (CTV)	West Indian lime indicator plants	Moderate CTV symptoms observed	Moderate – severe CTV symptoms observed	Moderate CTV symptoms observed	Moderate CTV symptoms observed	No CTV symptoms observed	Moderate CTV symptoms observed
CTV – seedling yellows (SY) strains	Eureka lemon indicator plants	SY CTV symptoms observed	SY CTV symptoms observed	SY CTV symptoms observed	Slight SY CTV symptoms observed	No SY CTV symptoms observed	SY CTV symptoms observed
CTV	Direct tissue blot immunoassay	CTV detected	CTV detected	CTV detected	CTV detected	CTV not detected	No result
Psorosis and psorosis like viruses	Symons sweet orange indicator plants	No Psorosis symptoms observed	No Psorosis symptoms observed	No Psorosis symptoms observed	No Psorosis symptoms observed	No Psorosis symptoms observed	No Psorosis symptoms observed
Psorosis and psorosis like viruses	Emperor mandarin indicator plants	No Psorosis symptoms observed	No Psorosis symptoms observed	No Psorosis symptoms observed	No Psorosis symptoms observed	No Psorosis symptoms observed	No Psorosis symptoms observed
Citrus tatter leaf virus (CTLV)	Rusk citrange indicator plants	No CTLV symptoms observed	No CTLV symptoms observed	No CTLV symptoms observed	No CTLV symptoms observed	No CTLV symptoms observed	No CTLV symptoms observed

Indexing was conducted on indicator plants and also supported by ‘direct tissue blot immunoassay’ for detection of Citrus tristeza virus (CTV). Five clones carried moderate strains of CTV which is typical of older citrus trees in Australia. CTV was not detected in clone 5 which is unusual. Severe strains of CTV, viroids such as Citrus exocortis viroid (CEV), psorosis virus and tatterleaf virus were not detected.

Propagation of Rootstock seed

Rootstock fruit was collected from Chinese trifoliata source trees established at Dareton and the seed extracted. The Australian standard trifoliata selection supplied to industry (Tri 22) was ordered and obtained from Auscitrus.

Chinese rootstock selections: Donghai, Tanghe No 6, Zao Yang and Australian Tri 22 were sown on a propagation heat bed at Dareton in July 2008 (Figure 2). The seedlings were ready for 'pricking – out' and moving to a larger 4 litre container in December 2008 (Figure 3)

Figure 2. Rootstock seed germinated in propagation trays on a heated sand bed at Dareton Primary Industries Institute nursery – November 2008.

Figure 3. Seedlings are 'grown – on' in 4 litre plastic bags.

Figure 4. Chinese rootstock fruit appearance and seed size L to R: Zao Yang, Tanghe No 6 and Donghai trifoliata selections.

Trial tree propagation

Rootstocks were grown to pencil thickness and budded with the 6 Valencia selections plus the Australian standard Valencia – Keenan in early spring 2009. Figures 5 and 6 show the young trial trees in late November 2009.

Figure 5. Trial trees propagated and growing in the Dareton Primary Industries Institute nursery late – November 2009.

Figure 6. Valencia selections propagated onto Chinese rootstock and 'grown – on' in 4 litre plastic bags.

Jincheng and Bintangcheng processing oranges (public access varieties) from China were propagated onto Chinese trifoliata rootstocks (Donghai, Tanghe No 6, Zao Yang, Houpi, Zhoupi, Lunan) and Tri 22 to be used as buffer rows to the Valencia evaluation trial. Buffer trees are 12 months older than the Valencia selections in the trial (Figure 7).

Figure 7. Jincheng and Bintangcheng orange trees to be used as buffer rows

So the scion and rootstock combinations in the trial are:
6 Riverina Valencia selections + Keenan Valencia (standard for comparison) = 7
3 Chinese trifoliata selections – Donghai, Tanghe No 6, Zao Yang + Tri 22 (standard) = 4
Treatments = 28

Site Preparation

The trial site was cleared of an old citrus planting, cultivated, mounds formed and the site rested for 12 months prior to planting the scion/rootstock trial. Before the mounds were formed 2 tonne to the acre of cow manure and 1 tonne per acre of gypsum was spread over the site and worked into the soil.
Mound height is 60 cm and the soil classified as Stanbridge sandy clay loam. Tree positions were marked with stakes positioned 1.8m between trees within the row and 5.0m between the rows. This would allow a planting density of 1111 trees to the hectare.

Soil survey

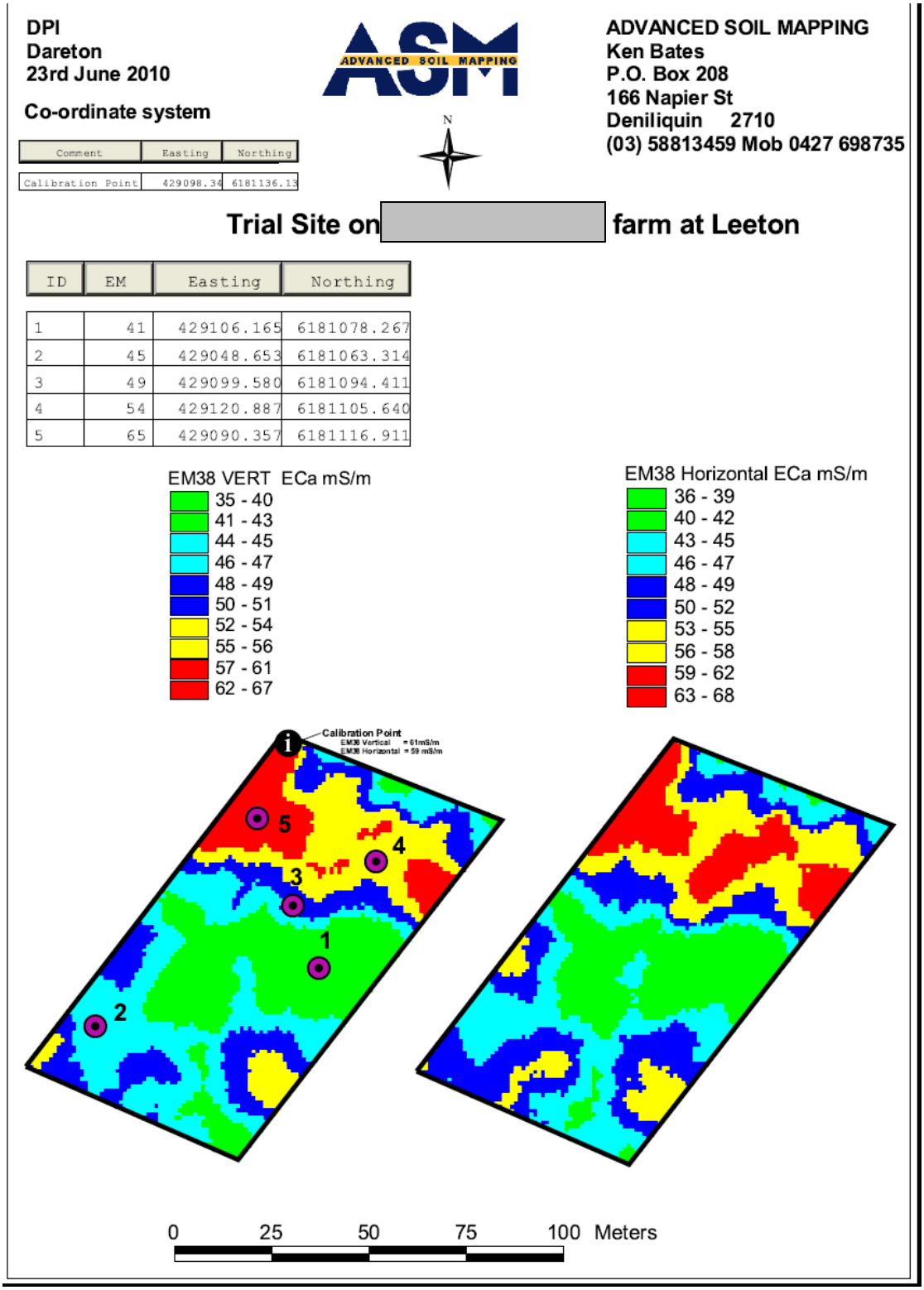
An EM38 soil survey (figure 8) was conducted in June 2010 to illustrate soil texture through the profile along with providing an estimate of soil electrical conductivity (salinity). Soil cores were also extracted to depth between the rows (figure 9) and hand cores collected within the mounded soil. The site has low electrical conductivity and the salinity risk is minimal. Trifoliata rootstocks do have sensitivity to salinity which can lead to reduced tree vigour and seasonal leaf drop.

An EM38 map (figure 10) is generated from the data collected and is GPS accurate thus allowing specific soil sampling sites (1-5) to be selected to support the EM38 survey and provide more detailed soil data.

Figure 8. EM38 data collection instrument pulled between mounded rows

Figure 9. Deep soil samples collected between rows by a pneumatic 'hammer' corer

Figure 10. EM38 Soil Survey at Leeton, NSW trial site June 2010



The site has a slightly heavier soil texture on one third of the image shown by the red and yellow colours. This area has traditionally been more likely to have water 'standing' on the surface following rain than the other sections of the site. Mounding the soil and the application of gypsum would alleviate any potential water logging issues with this 'heavier' section of the site. The trial design layout was based on the EM38 soil survey results and took account of the 'heavier' soil texture on part of the trial area.

Site Biometric Design

Valencia trial area

The trial is a 'randomised complete block design' (RCBD) generated from the statistical program Genstat 11.

There are 7 Valencia selections and 4 trifoliata rootstocks = 28 treatments.

The treatments are replicated 3 times and aligned to account for the soil texture variability at the trial site.

Each treatment is a 5 tree plot and the total number of trees in the trial area is:

28 treatments x 3 replicates x 5 trees = 420

Valencia scions: Val 1,Val 2, Val 3, Val 4, Val 5, Val 6 and *Keenan Valencia (Control)*

Trifoliata rootstocks: Donghai, Tanghe No 6, Zao Yang and *Trifoliata 22 (Control)*

The scion and rootstock controls are the Australian standards for Valencia and Trifoliata.

Buffer rows

The trial area is also buffered by 2 rows each side and individual trees both ends.

The buffer rows are 2 Chinese processing oranges (Bintangcheng No 2 and Jincheng) recently introduced to Australia. These have been placed on a wider range of Chinese trifoliata selections than the formal Valencia processing trial.

Chinese scion varieties: Bintangcheng No 2, Jincheng Bei Bei 447

Trifoliata rootstocks: Donghai, Tanghe No 6, Zao Yang, Zhoupi, Lunan, Houpi and *Trifoliata 22 (Control)*

Bintangcheng No 2 = 138 trees Rows 10, 11

Jincheng = 137 trees Rows 1, 2

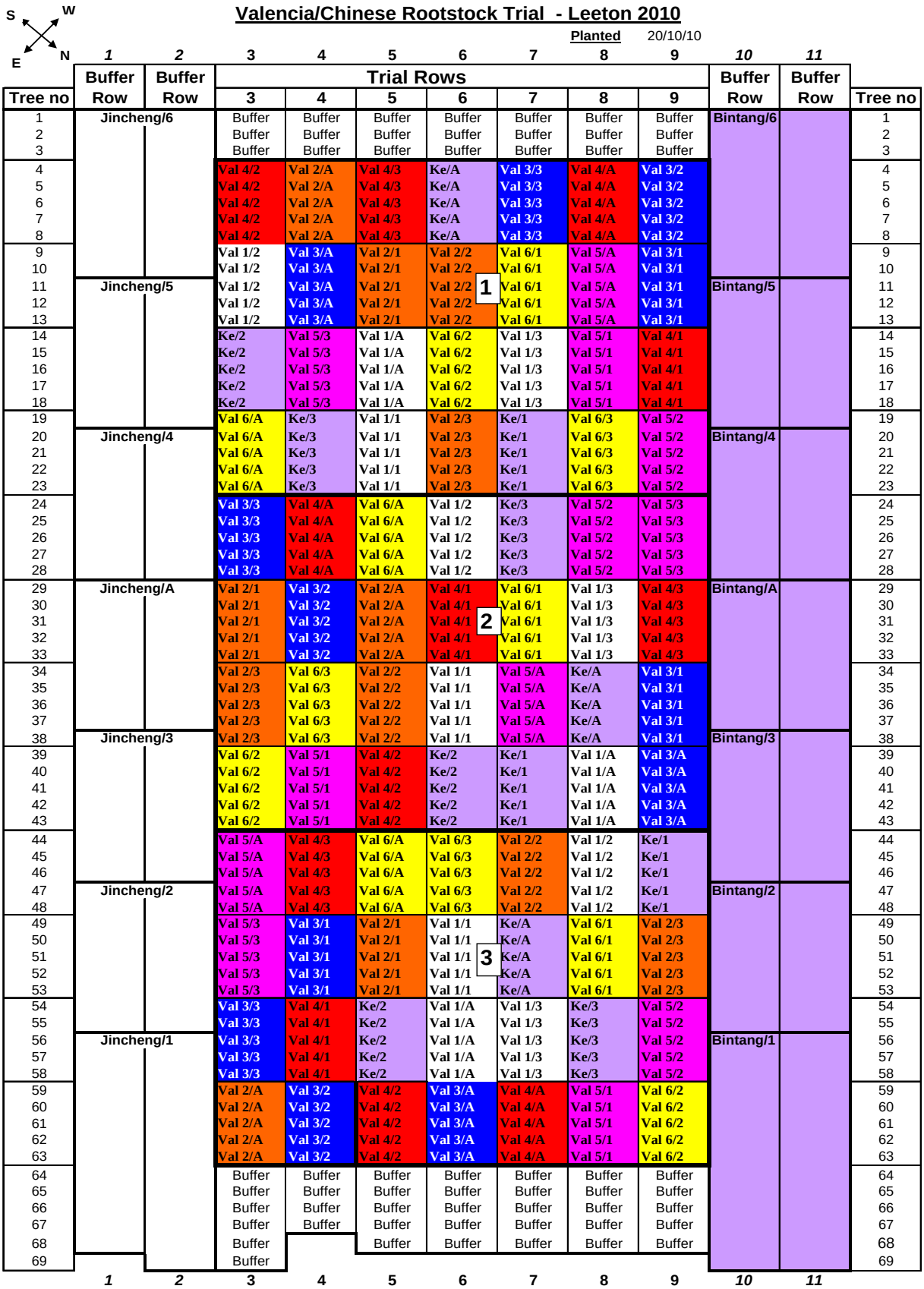
Valencia = 56 trees Rows 3 – 9

Total tree number = 420 + 138 + 137 + 56 = 751

Note

The trial plan (figure11) is coded with numbers for both Valencia and rootstock selections due to the probable future commercialisation of the superior performing combinations identified from this trial.

Figure 11. Trial Plan October 2010



Results

Trees establishment

Tree establishment occurred over a 3 day period from the 18th to the 20th October (figures 12-17). Trees were transported to Leeton from the Dareton Primary Industries Institute in a hire truck on the 18th October. Trees were positioned in accordance to the trial plan on the 19th October and planting began in the late afternoon. Planting was completed on the 20th of October and trees 'watered in' by hand, with the drip irrigation lines lain along the tops of the rows on the following day.

Figure 12. Tree transportation to trial site in Leeton, Riverina region of NSW

Figure 13. Moving trees to the planting site

Figure 14. Placing trees in their planting positions based on the trial design

Figure 15. Tree planting.

Figure 16. Trees with protective foil covers and top growth pruned

Figure 17. Trees hand ‘watered in’ with an individual basin for each tree prior to installation of drip irrigation

Soil Core Tests

Soil cores were collected in June 2010, in conjunction with the EM38 soil survey. They were analysed to provide base data on both the physical and chemical composition of the mounds and inter-row area of the site. Soil core sites were determined from the EM38 survey map to best represent the soil texture variability at the site. A majority of the tree root system will be contained within the mounds and this should reduce any significant variability in tree performance across the site related to soil texture. The topsoil collected into the mounds would hold the manure and gypsum spread prior to mound formation and have higher organic matter content when compared to the inter-row area.

Core sample numbers 1-5 relate to map positions as shown in Figure 10. Soil sampling through the mound occurred adjacent to the inter-row deep cores and were collected at two depths 0-20cm and 20-60cm. Row height was 60cm and the samples collected by hand auguring to the required depth, mixing the soil and taking a subsample for analysis

Table 3. Inter-row soil cores 0 – 120cm

Date: 15/07/10
Client: DPI
Property: Grower cooperator
Purpose: Soil texture cores
Method: 40mm core sample
Texturing Technique: Northcote (1979)

Sample ID	Horizon	Approx start depth (cm)	Approx finish depth (cm)	Texture	Colour (Visual)	Colour (Munsell)	Notes - Fragments, Drainage Root Presence, Coarse Fragments	Soil Class
Core 1	A_1	0	12	SL	Dk RB	5YR 3/3		Calcarious red earth
	B_1	12	45	SC	RB	5YR 5/4	Diffuse boundaries	(CRE)
	C	45	110	SC	StB	7.5YR 5/8	Grey-brown mottles @110 cm	
	C	110	120	SC	YB	10YR 5/8	20-30 mm stones	
Core 2	A_1	0	10	SL	Dk B	7.5 YR 4/4		CRE
	B_1	10	30	SC	StB	7.5 YR 5/4	Diffuse boundaries	
	C	30	120	LC	StB	7.5YR 5/6	Grey-brown mottles @100 cm	
Core 3	A_1	0	10	SL	Dk B	7.5 YR 4/4		CRE
	B_1	10	35	SC	StB	7.5 YR 5/4	Diffuse boundaries	
	C	35	120	LC	StB	7.5YR 5/6	Grey-brown mottles @80 cm	
Core 4	A_1	0	8	SL	Dk B	7.5 YR 4/4		CRE
	B_1	8	40	SC	StB	7.5 YR 5/4	Diffuse boundaries	
	C	40	120	LC	StB	7.5YR 5/8	Grey-brown mottles @110 cm	
Core 5	A_1	0	8	SL	Dk B	7.5 YR 4/4		CRE
	B_1	8	35	SC	StB	7.5 YR 5/4	Diffuse boundaries	
	C	30	120	LC	StB	7.5YR 5/6	Grey-brown mottles @110 cm	

The inter-row surface soil at 0-8/12cm is classified as sandy loam. Core 1 has a sandy clay texture extending from 12 cm to the core sampling depth of 120cm while a light clay texture begins at the other core sites a between 30-40cm.

Abreviations

Texture

S	Sand
SL	Sandy Loam
LSCL	Light Sandy Clay Loam
LSCL (Z)	Light Sandy Clay Loam (Silty)
SCL	Sandy Clay Loam
CL	Clay Loam
CL (Z)	Clay Loam (Silty)
SC	Sandy Clay
LC	Light Clay
LMC	Light-Medium Clay
MC	Medium Clay
MHC	Medium-Heavy Clay
HC	Heavy Clay

Reactions to HCl

N	Nil
S	Slight
M	Moderate
H	High
V	Very High

Colours

B	Brown
RB	Red-Brown
OB	Orange-Brown
DB	Dark Brown
LB	Light Brown
GB	Grey-Brown
YB	Yellow-Brown
G	Grey
DG	Dark Grey
O	Orange
OG	Orange-Grey
P	Pinkish
GG	Greenish-Grey
W	White
Y	Yellow

References:
Northcote, K.H. 1979, *A Factual Key for the Recognition of Australian Soils* , Relim Technical Publications, Coffs Harbour, N.S.W.
Munsell Soil Color Charts, 1975 Edition, Munsell Color, Baltimore, Maryland, USA.

Table 4. Planting mound chemical analysis

Customer Advanced Soil Mapping

Job Processing Orange site

Code	Depth	Conductivity	pH Level (CaCl2)	pH Level (H2O)	Ammonium chloride exch. Ca	Ammonium chloride exch. K	Ammonium chloride exch. Mg	Ammonium chloride exch. Na	CEC	ESP %
		dS/m	pH	pH	meq/100g	meq/100g	meq/100g	meq/100g		
1	0-20	0.149	7.5	8.4	6.10	0.43	2.32	0.25	9.1	2.7
2	0-20	0.094	7.4	8.1	8.13	0.53	2.59	0.20	11.5	1.7
3	0-20	0.193	7.6	8.2	14.95	0.67	4.73	0.83	21.2	3.9
4	0-20	0.178	7.4	8.0	13.59	0.43	4.86	0.58	19.5	3.0
5	0-20	0.244	7.4	8.1	14.31	0.45	6.90	1.45	23.1	6.3
1	20-60	0.131	6.8	7.5	8.42	0.53	4.97	0.50	14.4	3.5
2	20-60	0.154	7.3	7.9	16.68	1.03	5.74	0.40	23.9	1.7
3	20-60	0.344	7.8	8.2	27.52	0.96	7.59	1.57	37.6	4.2
4	20-60	0.238	7.5	8.2	22.75	0.61	8.30	1.28	32.9	3.9
5	20-60	0.296	8.0	8.7	28.03	0.68	11.09	3.02	42.8	7.1

Soil ph ($CaCl_{2)}$) within the mound ranges from 6.8 - 8.0 and is within an acceptable range for citrus production.

Soil electrical conductivity which is a measure of dissolved salts (salinity) in the profile is low and poses no risk to newly planted citrus trees. A level of 0.75dS/m is considered a moderate soil electrical conductivity and the highest reading in the mounded soil is 0.34dS/m at sampling site 3 between 20 – 60cm soil depth.

Exchangeable Calcium **(Ca)** exceeds 5.0 meq/100g and suggests that no additional calcium amendment is required.

Exchangeable Potassium (K) exceeds 0.4 meq/100g and is at a sufficient level for young, non bearing trees. The 0-20cm soil depth generally has the lower exchangeable K levels and a soil application of K should be applied to the site prior to first crop production in 2013.

Exchangeable Magnesium (Mg) is useful for determining a Ca to Mg ratio. Magnesium deficiency is more likely when the ratio of Ca/Mg is greater than 4 or 5.

Ca^{2+}/ Mg^{2+} ratio = Exchangeable Ca^{2+} / Exchangeable Ca^{2+}

The soil at both depths within the planted mound has a Ca/Mg ratio of <4 at all test sites in the trial.

Exchangeable Sodium (Na) in a soil is used to calculate soil sodicity and is best expressed in terms of the exchangeable sodium percentage (ESP%).

$$ESP\% = \frac{\text{Exchangeable sodium concentration}}{\text{Cation exchange capacity (CEC)}} \times 100$$

Cation Exchange Capacity (CEC) is a measure of a soils ability to retain cations. Of particular importance are the exchangeable cations Ca^{2+}, K^{+}, Mg^{2+} and Na^{+}. The amount and balance of these cations affect the physical and chemical characteristics of a soil. Sandy soils tend to have a low CEC whereas soils with greater clay content generally have higher CEC.

Exchangeable Sodium Percentage (ESP%) gives a measure of the structural stability of the soil. When ESP% is > 5% (Australian standard) the soil is likely to disperse and adversely affect the soil structure causing reduced water infiltration and drainage. Crusting and sealing of the surface soil can also occur. ESP% does exceed 5% at the 0-20cm (6.3%) and 20-60cm (7.1%) soil depths at core site 5. This section of the trial site is covered by replicate 1 and replicates 2 and 3 have ESP% < 5. Additional gypsum amendments may be required to this section of the trial site in the future if water infiltration problems develop. It is recommended to retest core site 5 in two years to see if irrigation and the gypsum applied at mound formation has lowered the ESP%.

Tree Management October 2010 to July 2011

- Confidor® Guard insecticide soil drench applied to the trees (figure 18) for systemic protection against sucking and chewing insects. Insect attack, particularly by citrus leaf miner, on newly planted trees can severely retard growth rate and canopy development.
- Fertigation and herbicide programs were done in accordance with the cooperating farmer's standard practice for newly established orchards.
- Ant nests that developed within some tree guards were controlled by lifting the tree guard, disturbing the nest and drenching with an insecticide. The long term presence of an ant nest in a tree guard can lead to collar rot on young trees due the trunk being in continual contact with moist soil.
- Tree survival has been excellent with only one buffer tree requiring replacement.

Figure 18. Application of Confidor® Guard insecticide 3 weeks after tree planting

Figure 19. Trees planted 20th October 2010

Figure 20. Trial site 12th July 2011

Discussion

A planning process began in 2005 to establish a semi-commercial evaluation site of locally selected Valencia clones in the Riverina. To add value to this proposal it was decided to include high performing, Chinese trifoliata rootstocks under evaluation at Dareton Primary Industries Institute. Funding was secured in 2008 and rootstock propagation began which led to site establishment in October 2010.

A site was selected, cleared of existing citrus, cultivated, mounded, soil surveyed and tested. A trial design was imposed on the site to account for soil texture variability and the site buffered by two Chinese processing orange varieties, new to Australia, on a wide range of Chinese trifoliata rootstocks. The site has also been planted with a tree and row spacing suitable for future mechanical harvesting.

Tree establishment and growth have been excellent due to the high quality pot grown seedling trees, sandy clay loam soil type, drip irrigation, initial application of an insecticidal soil drench and favorable spring/summer growing conditions. The site is now well established and should produce its first assessable crop in 2013.

This trial site will provide a valuable local resource for Riverina citrus growers and allow future replanting decisions for the citrus processing market to be developed from information collected in their specific soil and environmental conditions. The Valencia clones collected for this trial have a long production history and have been productive under local conditions. The trial site also has the advantage of demonstrating the potential benefits of superior new rootstocks suited to sandy clay loam/sandy clay soil types. The inclusion of buffer rows of Chinese processing oranges also expands the demonstration value of this site along with the future mechanisation of the fruit harvest. Profitability in the processing industry is linked to productivity, juice yield and quality. The trial will allow the assessment and recommendation of the best Valencia and rootstock combination for replanting in the Riverina region of NSW and also have relevance to other citrus producing regions of Australia.

Technology Transfer

Industry publications

Sanderson, G.P and Khurshid, T (2009) Processing Orange Trial for the Riverina. Riverina Citnews, Feb. 2009: 5

Industry presentations (excluding conferences)

25th & 26th Nov. 2009	CITTgroup seminars at Leeton and Griffith. ‘Rootstocks, Varieties and IPM’. (‘Riverina processing orange trial with Chinese rootstocks’ – G. Sanderson)
18th Nov. 2010	Riverina Citrus Growers End of Season Review, Griffith. ‘Processing orange/rootstock trial establishment and plans for the future’ – A.Creek.