Effects of rootstock and crop load management on yield and fruit quality of early-season nectarine 'Rose Bright' and late-season peach 'September Sun'

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Abstract

The Australian summer fruit industry has identified that sales growth is impeded by low consumer satisfaction with fruit quality, leading to low prices and static consumption. The effect of rootstock and crop load on fruit production was studied in an experimental orchard at Tatura, Australia. The objective of the study was to identify combinations of rootstock and crop load management practices, under a vase training system, to enable peach 'September Sun' and nectarine 'Rose Bright' to maximise fruit quality. Crop loads were applied to induce a range of competitive source/sink responses between fruits and available assimilates. Different thinning regimes were implemented in season 2016/17 to establish the following crop load treatments: 1) high: minimally thinned; 2) medium (commercial standard as control): moderately thinned; and 3) low: heavily thinned. Rootstocks included Nemaguard (commercial standard as control), Elberta, Krymsk® 86, Cadaman® and Cornerstone. Crop load and rootstock did not affect flowering date. 'Krymsk® 86' produced smaller tree size measured as canopy radiation interception (f_{PAR}) for both cultivars. For nectarine, high crop load produced high yields, low fruit weight, reduced sweetness (°Brix), delayed maturity, increased firmness and lower pack-out percentage. Krymsk® 86 outperformed Elberta rootstock in terms of fruit size, red skin coloration and pack-out. For peach, highest yield occurred on Cornerstone trees compared to Elberta. This yield difference was reflected in yield components (fruit number, fruit size), and attributed to the capacity of available fruiting wood and photosynthetic capability governed by tree size (f_{PAR} and branch size). Irrespective of cultivar, low crop load produced larger fruit and advanced maturity. Cornerstone produced sweeter fruit, while Krymsk® 86 had lower sweetness with greater red skin coloration. In autumn, earlier leaf drop (senescence) occurred under high crop loads and on Elberta rootstock. Presence of rootstock suckers was greatest on Krymsk® 86 and Nemaguard trees, while crop load did not impact suckers.

Keywords: firmness, maturity, sweetness, thinning, uniformity

INTRODUCTION

Most of Australia's peach and nectarine production (~130,000 t), valued at AUD$ 328 M, occurs in the Goulburn Valley and Sunraysia regions of Victoria. Approximately 66% of fruit is consumed fresh domestically, with 23% processed and the rest (~11%) exported as fresh product, primarily to Hong Kong and UAE. Summer fruit is sold loose and priced per kg, but a growing trend of retailers is to sell pre-packed fruit to drive sale volumes.

The Australian summer fruit industry has become focused on export prospects, with China representing a major growth opportunity, while Chile being a main competitor. The industry has the potential to grow fruit to market specification, taking advantage of new and existing free trade agreements with Asian countries, driving up export volumes. On the domestic front, creating new niche markets for premium products should offer growers greater returns.

Sales growth of stone fruit is impeded by low consumer satisfaction with fruit quality, leading to low prices and static consumption that is threatening the survival of many producers. Consistency in fruit quality is made more difficult as the industry grows>150

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cultivars of nectarine and peach across diverse planting systems and climatic regions. These trends pose a major threat to the growth and viability of the domestic industry, which is also experiencing an increased strong competition from other seasonal crops including mango and table grapes. Variable fruit quality, particularly in taste and texture, and general consumer dissatisfaction have been identified as the major impediments to increased sales on both domestic and export markets.

Agronomic techniques can manipulate the source-sink ratio and assimilate partitioning to fruit. In this study we examine modifications of sink size via crop load management and source strength via rootstock vigour with a focus on the effect on yield, fruit size and sweetness. Fruit thinning activities contribute to the cost of orchard production via labour required, however low crop loads offer savings through reduced picking, packing and transport costs. Rootstock vigour dictates tree survival, vegetative growth and development, suckering and tree size, impacting pruning management, tree structure traits, crop water and nutrient requirements, fruit quality and yield potential.

To the best of our knowledge, there is limited information available on the effects of crop load and/or rootstock on fruit quality attributes, particularly sweetness and tree growth effects for stone fruit crops under Australian conditions. Furthermore, contrasting production outcomes using semi-dwarfing rootstocks on peach are reported in the literature. The degree of the adaptability response to rootstock/scion emphasizes the complexities in pedo-climatic conditions, planting systems and level of management (water, nutrient) inputs (e.g., Giorgi et al., 2005; Remorini et al., 2008). In Europe, Gullo et al. (2014) showed improvements in fruit quality using a lower vigour (Penta vs. GF677) rootstock. Likewise, rootstock control of tree vigour improved agronomic outcomes (Jiménez et al., 2011). However, Tsipouridis and Thomidis (2005) and Forcada et al. (2012) report vigorous GF677 outperformed several rootstocks with respect to yield and fruit quality.

Lopresti et al. (2014) highlighted the need for improved orchard management practices and a better understanding of effects on fruit quality and taste for stone fruit. The Department of Economic Development, Jobs, Transport and Resources (DEDJTR), with the support of the Australian Summerfruit industry and Hort Innovation, investigated and developed orchard management practices that can increase productivity and grower returns through improved eating quality and consumer satisfaction.

The objective of the study was to identify combinations of rootstock and crop load management practices, under a vase training system, to maximise quality of 'September Sun' peach and 'Rose Bright' nectarine.

MATERIAL AND METHODS

Experiment conditions

The experiment was conducted on 3-year-old trees of 'September Sun' peach and 'Rose Bright' nectarine [*Prunus persica* (L.) Batsch] at Tatura (36.43°S; 145.28°E, elev. 114 m) in SE Australia. Climate is temperate, and rainfall is evenly distributed throughout the year. Irrigation is used to counter the high evaporative demand experienced in summer months. Irrigation requirements were determined using a weather-based evapotranspiration FAO-56 approach with a crop coefficient adjusted for tree size, measured as the fractional photosynthetically active radiation (PAR) interception (f_{PAR}). Irrigation water was of high quality and applied daily via a single drip line comprising of in-line pressure compensating emitters (1.6 L h^{-1} discharge, 0.5 m spacing). Trees were trained as free-standing vase canopy system with 4.5×2.0 m spacing, in north-south tree rows of a 3-ha experimental stone fruit orchard. Trees were irrigated, fertilised, pruned, and pest/disease managed according to established local commercial practices.

Treatments

Fruit were hand thinned during October (~65 days after bud burst) to establish the different crop load treatments. Thinning treatments were undertaken by the initial removal of fruit from end of branches, 'doubles', small, disfigured and damaged fruit followed by even thinning of remaining fruitlets to the desired crop load target. Both experiments had three crop loads (high, medium and low) as treatments. The crop loads were:

- high: minimally thinned to maximise competition between fruit and available assimilate;
- medium (control): moderate thinned to minimise competition between fruit and available assimilate; and
- low: heavily thinned to eliminate competition between fruit and available assimilate.

The rootstock treatments were: Nemaguard (commercial standard, control), Elberta, Krymsk® 86, Cadaman® and Cornerstone, however, the 'Rose Bright' nectarine study did not include Cadaman®. Experimental layout for neighbouring fields of peach and nectarine was a randomized block design with 15 and 12 treatments replicated 6 times, respectively. Each plot consisted of five trees. The central tree in each plot was used to record measurements of study variables.

Yield and fruit quality

To determine optimal harvest date, fruit maturity was expressed as index of absorbance difference, IAD by using a portable Vis/NIR spectrophotometer (DA-meter; Model 53500, TR Turoni, Italy). IAD was measured on both fruit cheeks in situ on ~20 fruit on the control trees at weekly intervals starting 4 weeks prior to harvest. At harvest, all fruit were handpicked. Fruit weight, number, internal quality (maturity, firmness, sweetness) and external attributes (colour, blemish) were measured on individual fruit and sorted on a plot-by-plot basis using a commercial fruit grader equipped with optical sensors (Compac InVision 9000, Compac Sorting Equipment Ltd., Australia) and a near infrared (NIR) reflectance spectrometer (Taste Technologies Ltd, New Zealand). A total of 3,909 and 14,536 peach and nectarines were assessed for rootstock/crop load regimes, respectively. Fruit-size and quality distributions were determined from data sets obtained by the commercial grading machine. Yield was calculated as the product of fruit number and weight. The NIR spectra (~30 scans fruit^{-1}) over the spectral range of 300-1100 nm was used to develop multivariate prediction models for sweetness, maturity and firmness. Fruit NIR reference data were collected using the conventional destructive methods with local duplicate (paired hemispheres) measures (sample size ~100 fruit) to extend model application to the experimental data. Fruit flesh firmness (kgf) was measured after exposing the flesh to a penetrometer (Model FT10, Wagner Instruments, Connecticut, USA) fitted with an 8-mm tip. Fruit juice sweetness (°Brix) was measured using a digital refractometer (Model PR-1, Atago Co., Japan). Fruit maturity (IAD) was measured using a DA-meter. Premium pack-out was calculated the proportion of fruit meeting thresholds of fruit quality (fruit size,≥180 g and sweetness,≥12 °Brix). Waste was calculated as fruit size <65 g.

Tree growth

Tree survival, suckering, pruning biomass, bud break and flower development stages and autumn leaf drop (senescence) were determined on each plot. Seasonal change of branch cross-sectional area (cm^2) was calculated from branch (4 tree^{-1}) circumference measures at 10 cm above the crotch on each tree. Measures of branch circumference were conducted in the winter prior to the commencement of the crop load treatments and again during dormancy after harvest. Tree size (fPAR) was measured during mid-summer representing the period of maximum foliage cover, on a clear day using a hand-held ceptometer (Model SF80; Decagon Devices Inc., Pullman, Washington, USA) at 12:30 h (solar noon). fPAR was calculated as: fPAR = 1-(PART/PAR), where PAR was the incident flux of PAR measured above the canopy (approximately 1.5 m above ground level in an open region within the orchard), and PART was the transmitted flux of PAR measured at the base of the canopy. Estimates of fPAR were obtained from approximately 10 and 40 ceptometer measurements above and below the canopy in each plot, respectively. Data were subject to analysis of variance (ANOVA) using GenStat 18.1 (VSN International Limited, Oxford, UK). Significant differences between treatments were determined using Fisher's unrestricted LSD at P=0.05.

RESULTS

Tables 1 and 2 present tree survival, suckering, leaf drop (senescence), main branch size, pruning weight, fruit number and tree size (fPAR) for peach and nectarine, respectively. No treatment (crop load and/or rootstock) differences were observed in full bloom dates for peach or nectarine, per se (data not shown). For 'September Sun' peach, poor tree survival occurred on Krymsk® 86 (39%) and Cadaman® (62%) roots, whereas acceptable survival rates (≥97%) occurred on all rootstocks for nectarine 'Rose Bright'. For 'September Sun' peach, greater suckering occurred on Krymsk® 86 and Nemaguard trees compared to Elberta, Cornerstone and Cadaman® trees. Similarly, Krymsk® 86 roots produced highest suckering on nectarine. High crop load increased suckering on 'Rose Bright'. Leaf drop occurred earlier under high crop load regimes on peach 'September Sun'. Likewise, 'September Sun' scion on Elberta trees commenced senescence before Cadaman®, Cornerstone, Krymsk® 86 and Nemaguard rootstocks. However, leaf drop on the earlier maturing nectarine was not impacted by crop load and/or rootstock. Tree size (fPAR) increased progressively throughout the 2016/17 growing season under all rootstock and crop load regimes for peach and nectarine. Smaller tree size was consistently observed under Krymsk® 86 rootstock, at early, mid- and late-season growing periods. No interaction between rootstock and crop load in fPAR was observed. For 'September Sun' peach, vegetative growth of main leaders (branch cross-sectional area, winter 2017) was highest under Cornerstone rootstock, lowest on Krymsk® 86 trees, corresponding to tree size (fPAR) regimes. Pruning biomass was lowest under Krymsk® 86. For nectarine 'Rose Bright', no main branch size (rootstock and/or crop load) differences were measured, however, high crop load reduced pruning biomass.

Tables 3 and 4 present crop productivity and fruit quality characteristics under various rootstock and crop load regimes for peach and nectarine, respectively. For peach, highest yield occurred on Cornerstone trees compared to low yields on Elberta (Table 3). This yield difference reflects yield components (fruit number, fruit size), the capacity of available fruiting wood (branch size) and, photosynthetic capacity governed by tree size (fPAR). Overall, most fruit exceeded the minimum size of 65 g, thereby very low waste levels (≤1%) were achieved irrespective of rootstock-cropping level. Premium pack-out (size≥180 g and sweetness≥12 °Brix) increased in line with reduced fruiting levels; 66, 83 and 88% under high, medium and low crop loads, respectively. Elberta roots had highest proportion of 'premium' fruit (89%), followed by Nemaguard, Cadaman® and Cornerstone (74-83%), then Krymsk® 86 at 68%. A crop load-rootstock interaction occurred, where lower premium pack-out were measured under high fruiting levels in combination with Nemaguard, Krymsk® 86 and Cornerstone. Low fruiting levels produced larger fruit at the expense of yield (Table 3). Neither rootstock or crop load impacted fruit firmness, however, lower IAD was observed on high crop load trees. Likewise, Elberta rootstock trees produced large fruit with delayed (IAD) maturity, compared to other rootstocks (Cadaman®, Krymsk® 86, Cornerstone). Fruit sweetness was highest under Cornerstone and lowest on Krymsk® 86 trees. Krymsk® 86 fruit had greater red skin coloration than Cadaman®, Elberta, Cornerstone and Nemaguard.

For nectarine, no significant differences in yield were observed due to rootstock, whereas, yield declined in line with cropping level (Table 4). High fruit weight was observed under Krymsk® 86 rootstock. Cropping levels influenced fruit size and pack-out performance, with negative trends with increased fruit number. High crop load trees had high yields, low fruit weight, reduced brix values, delayed maturity (higher IAD and firmness) and a lower pack-out. Krymsk® 86 trees outperformed Elberta trees in terms of fruit size, red skin coloration and pack-out. High wastage due to small fruit (<65 g) was greatest on Elberta and Nemaguard. 'Rose Bright' fruit failed to reach premium pack-out.

DISCUSSION

Optimal fruiting levels and rootstock selection are important for orchard management as they govern labour costs, yield and final fruit size. Strategies to target export specifications for high quality fruit therefore need an optimisation of the balance between vegetative growth, marketable yield and labour and fruit handling costs. This study found crop load and rootstock treatments influenced yield, fruit quality (weight, sweetness, maturity, firmness) and tree growth and development.

Table 1. Branch size, pruning weight, rootstock sucker rating, tree size, expressed as fractional midday radiation interception (f_{PAR}), commencement of end-of-season senescence (leaf drop) and tree survival in response to rootstock (Nemaguard, Krymsk® 86, Elberta, Cadaman®, Cornerstone) and crop load (high, medium, low) treatments of peach 'September Sun' under a vase canopy system at the Stonefruit Field Laboratory, Tatura, during the 2016/17 season.

Treatment	Branch cross sectional area Winter 2017 (cm^2)	Pruning weight Season total 2016/17 (g dry weight $tree^{-1}$)	Sucker score Winter 2017 (0-3)	f_{PAR} Summer 2017 (%)	Leaf drop score Autumn 2017 (0-5)	Tree survival Winter 2016 (%)	Fruit number (fruit $tree^{-1}$)
Cadaman®	12 B	1488 B	0.4 A	43 A	4.2 A	62 B	38 AB
Cornerstone	14 C	1720 B	0.0 A	45 A	4.3 A	92 C	91 C
Elberta	13 BC	1662 B	0.2 A	44 A	3.4 B	99 C	22 A
Krymsk®86	8 A	1083 A	1.3 C	38 B	4.3 A	39 A	34 AB
Nemaguard	14 BC	1809 B	0.8 B	43 A	4.2 A	90 C	56 B
ANOVA	***	**	***	*	**	***	***
High	11 a	1418	0.6	40	4.3 a	77	75 c
Medium	14 b	1595	0.6	45	4.0 ab	76	49 b
Low	11 a	1644	0.5	43	3.9 b	77	21 a
ANOVA	**	ns	ns	ns	*	ns	***
Cad - high	11	1563	0.3	39	4.8	73	67
Cad - medium	14	1609	0.5	42	3.9	50	28
Cad - low	10	1291	0.3	46	4.0	63	19
Cor - high	14	1651	0.0	45	4.3	90	152
Cor - medium	15	1432	0.0	47	4.3	93	85
Cor - low	13	2077	0.0	45	4.2	93	36
Elb - high	12	1393	0.3	41	3.5	100	20
Elb - medium	14	1762	0.0	45	3.5	97	36
Elb - low	13	1830	0.3	46	3.2	100	10
K86 - high	5	677	1.6	33	4.5	30	42
K86 - medium	11	1230	1.3	44	4.4	47	42
K86 - low	9	1241	1.0	35	4.0	40	19
Nem - high	13	1803	0.7	44	4.3	90	92
Nem - medium	15	1743	0.7	44	4.0	97	54
Nem - low	13	1780	1.2	42	4.2	83	21
ANOVA	ns	ns	ns	ns	ns	ns	ns

ns, *, ** and *** indicate non-significant or significant differences at P<0.05, 0.01 or 0.001, respectively, for the two way interaction rootstock×crop load treatments. Significant differences (P<0.05) between crop load treatments are denoted with different lower case letters. Differences between rootstocks are indicated by different upper case letters. Sucker score ranking: 3 major suckering, 0 no suckering. Leaf drop score ranking: 5 full leaf, 0 no leaf. Rootstock abbreviations: Cadaman® (Cad), Cornerstone (Cor), Nemaguard (Nem), Elberta (Elb), Krymsk® 86 (K86),.

For peach, Krymsk® 86 produced smaller fruit size and showed lower levels of vegetative growth and vigour, typical traits of a dwarfing rootstock, as evident by low pruning biomass, lower intercepted radiation (fPAR) and smaller main branch size. However, Krymsk® 86 had greater suckering compared to other higher vigour rootstocks, despite identical tree density, age and agronomic (irrigation, nutrition, pest/disease) inputs. However, Krymsk® 86 on 'Rose Bright' nectarine produced high fruit weight and pack-out.

Thinning regimes impacted the source-sink relationships to increase fruit size and sweetness. Low fruiting levels (sink-limited) produced large sweet fruit, irrespective of rootstock. For nectarine, source-limitations under high crop loads resulted in poor fruit outcomes: low marketable yield due to small fruit size, low sweetness, firmer and less mature fruit. These findings suggest a delayed fruit maturation because of the increased fruit demand for assimilates under high fruit number (sink size).

Table 2. Branch size, pruning weight, rootstock sucker rating, tree size, expressed as fractional midday radiation interception (f_{PAR}), commencement of end-of-season senescence (leaf drop) and tree survival in response to rootstock (Nemaguard, Krymsk® 86, Elberta, Cornerstone) and crop load (high, medium, low) treatments of nectarine 'Rose Bright' under a vase canopy system at the Stonefruit Field Laboratory, Tatura, during the 2016/17 season.

Treatment	Branch cross sectional area Winter 2017 (cm^2)	Pruning weight Season total 2016/17 (g dry weight $tree^{-1}$)	Sucker score Winter 2017 (0-3)	f_{PAR} Summer 2017 (%)	Leaf drop score Autumn 2017 (0-5)	Tree survival Winter 2016 (%)	Fruit number (fruit $tree^{-1}$)
Cornerstone	19	3044	0.0 A	37 B	4.1	94	217
Elberta	20	3257	0.1 A	38 B	3.9	100	239
Krymsk®86	19	2944	0.6 B	31 A	4.3	99	167
Nemaguard	20	3080	0.1 A	36 B	4.2	97	222
ANOVA	ns	ns	***	***	ns	ns	ns
High	16	2369 a	0.9 b	35	4.1	99	333 a
Medium	18	2906 b	0.4 a	35	4.1	95	219 b
Low	18	2998 b	0.3 a	36	4.1	99	81 c
ANOVA	ns	***	**	ns	ns	ns	***
Cor - high	17	2551	0.0	35	4.3	100	338
Cor - medium	21	3401	0.0	39	4.2	83	240
Cor - low	18	3181	0.0	37	3.8	100	77
Elb - high	18	2727	0.2	36	4.0	100	370
Elb - medium	19	3276	0.2	38	4.0	100	252
Elb - low	24	3767	0.0	42	3.8	100	95
K86 - high	17	2590	1.0	31	3.7	100	231
K86 - medium	22	3249	0.5	30	4.5	100	184
K86 - low	18	2994	0.3	34	4.2	97	86
Nem - high	19	2681	0.3	39	4.2	93	402
Nem - medium	21	3317	0.0	33	4.3	97	203
Nem - low	19	3241	0.0	35	4.2	100	62
ANOVA	ns	ns	ns	ns	ns	ns	ns

ns, *, ** and *** indicate non-significant or significant differences at P<0.05, 0.01 or 0.001, respectively, for the two way interaction rootstock×crop load treatments. Significant differences (P<0.05) between crop load treatments are denoted with different lower case letters. Differences between rootstocks are indicated by different upper case letters. Sucker score ranking: 3 major suckering, 0 no suckering. Leaf drop score ranking: 5 full leaf, 0 no leaf. Rootstock abbreviations: Cornerstone (Cor), Elberta (Elb), Krymsk® 86 (K86), Nemaguard (Nem).

Fruit composition, particularly sweetness and firmness, plays an essential role in meeting consumer expectations for flavour and taste. The potential for an expansion in production of peach/nectarine to meet export opportunities (e.g., China) will only be achieved if fruit, either for the fresh market or for storage, reach the customer in prime condition. This study showed the need for manipulation of fruiting levels and rootstock selection to achieve large fruit, high sweetness, maximum pack-out and domestic/export quality fruit. Further, the utility of a commercial NIR sorting equipment to measure every fruit to assess the agronomic study of crop load-rootstock regimes on production outcomes and fruit quality variables (size, sweetness, maturity, firmness) was invaluable.

Table 3. Fruit quality performance statistics in response to rootstock (Nemaguard, Krymsk® 86, Elberta, Cadaman®, Cornerstone) and crop load (high, medium, low) treatments of peach 'September Sun' under a vase canopy system at the Stonefruit Field Laboratory, Tatura, during the 2016/17 season.

Treatment	Cropping level (fruit cm^{-2} branch cross sectional area)	Yield (t ha^{-1})	Fruit weight (g)	Fruit sweetness (°Brix)	Fruit maturity (I_{AD} value)	Fruit firmness (kgf)	Fruit colour (% dark red)
Cadaman®	5.5 AB	10.3 AB	257 B	22.9 BC	0.9 BC	7.6	16 A
Cornerstone	10.6 C	21.0 C	243 AB	23.2 C	0.8 AB	7.7	16 A
Elberta	2.5 A	6.3 A	288 C	21.8 AB	1.0 D	7.3	16 A
Krymsk®86	9.9 C	8.2 AB	226 A	21.5 A	0.8 A	7.0	23 B
Nemaguard	8.4 BC	12.9 B	239 AB	21.9 AB	0.9 CD	7.3	15 A
ANOVA	**	***	***	*	***	ns	**
High	12.3 b	15.9 b	220 a	22.1	0.8 a	7.3	17
Medium	6.1 a	12.8 b	252 b	22.4	0.9 b	7.5	18
Low	3.8 a	6.6 a	280 c	22.3	0.9 b	7.4	17
ANOVA	***	***	***	ns	***	ns	ns
Cad - high	8.5	17.0	229	23.1	0.8	7.7	15
Cad - medium	3.8	8.2	269	22.0	0.9	7.1	17
Cad - low	4.2	5.8	273	23.8	0.9	8.0	17
Cor - high	17.0	29.9	190	22.3	0.7	7.4	16
Cor - medium	10.8	20.9	243	23.8	0.8	8.0	17
Cor - low	4.1	12.2	296	23.5	0.9	7.8	14
Elb - high	2.5	5.9	282	21.6	1.0	7.2	14
Elb - medium	3.8	10.0	281	22.9	0.9	7.7	15
Elb - low	1.2	3.2	301	20.9	1.0	6.9	17
K86 - high	17.3	8.6	193	21.9	0.6	6.9	23
K86 - medium	6.4	10.4	222	21.0	0.8	7.0	22
K86 - low	6.0	5.5	262	21.6	0.8	7.2	26
Nem - high	15.9	18.1	204	21.6	0.8	7.2	16
Nem - medium	5.9	14.2	245	22.4	0.9	7.6	14
Nem - low	3.3	6.2	269	21.7	1.0	7.3	14
ANOVA	ns	ns	ns	ns	ns	ns	ns

ns, *, ** and *** indicate non-significant or significant differences at $P<0.05$, 0.01 or 0.001, respectively, for the two way interaction rootstock×crop load treatments. Significant differences ($P<0.05$) between crop load treatments are denoted with different lower case letters. Differences between rootstocks are indicated by different upper case letters. Rootstock abbreviations: Cadaman® (Cad), Cornerstone (Cor), Elberta (Elb), Krymsk® 86 (K86), Nemaguard (Nem),

CONCLUSIONS

We tested combinations of rootstock and crop load management practices, under a vase training system, to enable peach 'September Sun' and nectarine 'Rose Bright' to maximise uniformity in fruit quality. Results of this study support the need for thinning to ensure that fruit attains fresh market quality standards. The study identified that rootstock impacts tree size to govern photosynthetic capacity (source strength) to support an optimum fruiting level (sink size) that defines the yield limit within which the required premium quality attributes of fruit size and sweetness may be achieved. Further work on crop load and rootstock responses is required to validate these findings. Further studies to measure within canopy effects of cropping levels and rootstocks, and relate fruit size and quality to light interception regimes are warranted.

Table 4. Fruit quality performance statistics in response to rootstock (Nemaguard, Krymsk® 86, Elberta, Cornerstone) and crop load (high, medium, low) treatments of nectarine 'Rose Bright' under a vase canopy system at the Stonefruit Field Laboratory, Tatura, during the 2016/17 season.

Treatment	Cropping level (fruit cm^{-2} branch cross sectional area)	Yield (t ha^{-1})	Fruit weight (g)	Fruit sweetness (°Brix)	Fruit maturity (I_{AD} value)	Fruit firmness (kgf)	Fruit colour (% dark red)
Cornerstone	29	20.9	97 BC	13.1	0.2	4.8 B	97 BC
Elberta	137	20.8	87 A	12.6	0.2	4.6 B	87 A
Krymsk®86	112	17.0	98 C	12.8	0.2	4.6 AB	98 C
Nemaguard	158	18.7	90 AB	13.5	0.2	4.3 A	90 AB
ANOVA	ns	ns	*	ns	ns	*	**
High	96 ab	26.8 a	78 a	11.5 a	0.3 a	5.0 a	78 a
Medium	208 a	21.7 b	93 b	12.8 b	0.2 b	4.5 b	93 b
Low	23 b	9.5 c	108 c	14.7 c	0.2 c	4.2 c	108 c
ANOVA	*	*	***	***	***	***	ns
Cor - high	48	28.2	78	11.5	0.2	5.0	78
Cor - medium	39	25.0	97	12.9	0.2	4.6	97
Cor - low	1	9.5	115	14.9	0.2	4.7	115
Elb - high	234	28.4	72	11.3	0.3	5.0	72
Elb - medium	108	22.8	84	12.5	0.2	4.8	84
Elb - low	69	11.1	106	14.0	0.2	4.1	106
K86 - high	50	21.8	92	11.7	0.2	4.9	92
K86 - medium	276	19.2	96	12.7	0.2	4.6	96
K86 - low	11	9.9	104	14.1	0.2	4.2	104
Nem - high	50	29.1	70	11.6	0.2	5.0	70
Nem - medium	412	19.8	94	13.1	0.2	4.2	94
Nem - low	10	7.3	107	15.7	0.1	3.7	107
ANOVA	ns	ns	ns	ns	ns	ns	ns

ns, *, ** and *** indicate non-significant or significant differences at $P<0.05$, 0.01 or 0.001, respectively, for the two way interaction rootstock x crop load treatments. Significant differences ($P<0.05$) between crop load treatments are denoted with different lower case letters. Differences between rootstocks are indicated by different upper case letters. Rootstock abbreviations: Cornerstone (Cor), Elberta (Elb), Krymsk® 86 (K86), Nemaguard (Nem).

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