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Mid Area Experimental Orchard

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Industry context

Current orchards ("H1")

- tree establishment
- fertiliser use efficiency

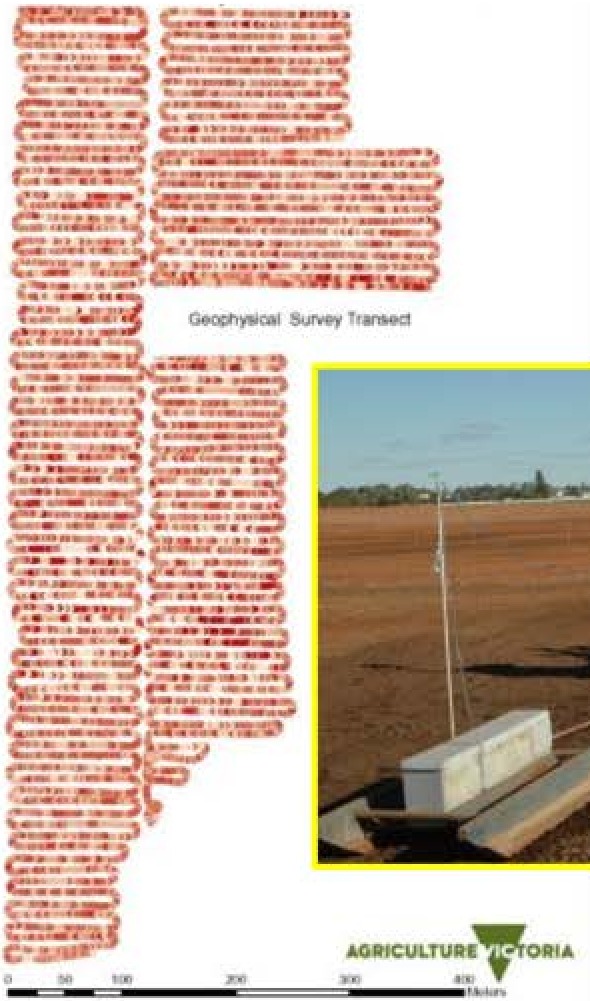
Future orchards ("H3")

- high(er) density plantings
- (shake & catch harvesting)

Research "themes"

- scion × rootstock
- rootstock × fertiliser
- light, flower bud initiation & spur CHO
- tree architecture

Soil survey



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Australian Government
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ALMOND BOARD OF AUSTRALIA

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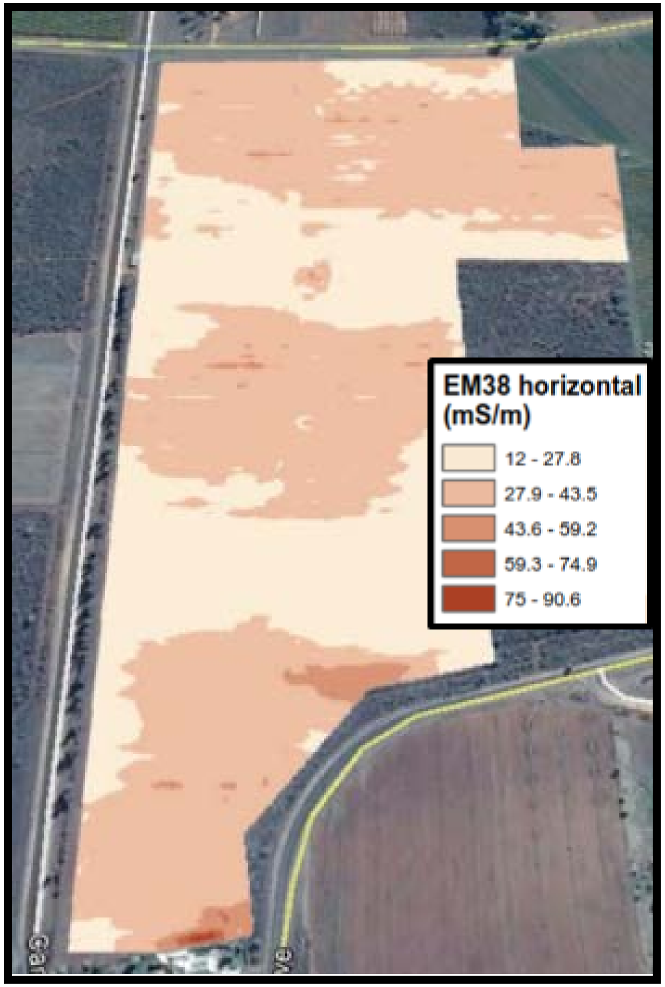
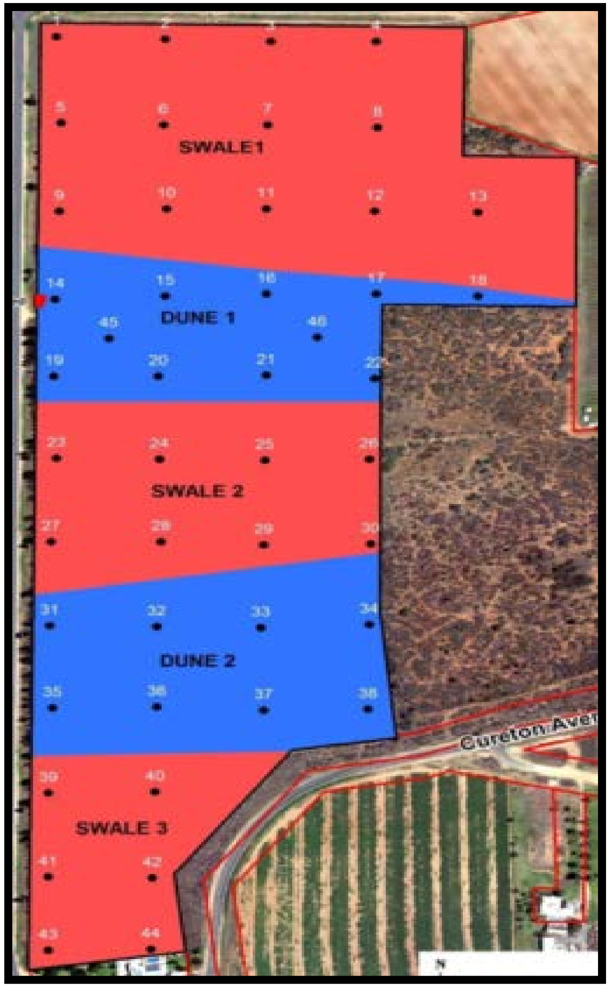

EM38 horizontal (mS/m)
12 - 27.8
27.9 - 43.5
43.6 - 59.2
59.3 - 74.9
75 - 90.6


SWALE1
DUNE 1
SWALE 2
DUNE 2
SWALE 3
Cureton Ave

H1: establishment, precociousness, rootstock & N

- **Garnem (high vigour)**
- **Nemaguard (industry standard)**
- **Rootpac 40 (low vigour)**

- **½ × [N]**
- **1 × [N]**
- **2 × [N]**

associated with maximum shoot %N

- **irrigated to RAW extraction & ET_c**

- **kg N/ha = $[N]_{RAW}$ × ML/ha**

- **5 ha**

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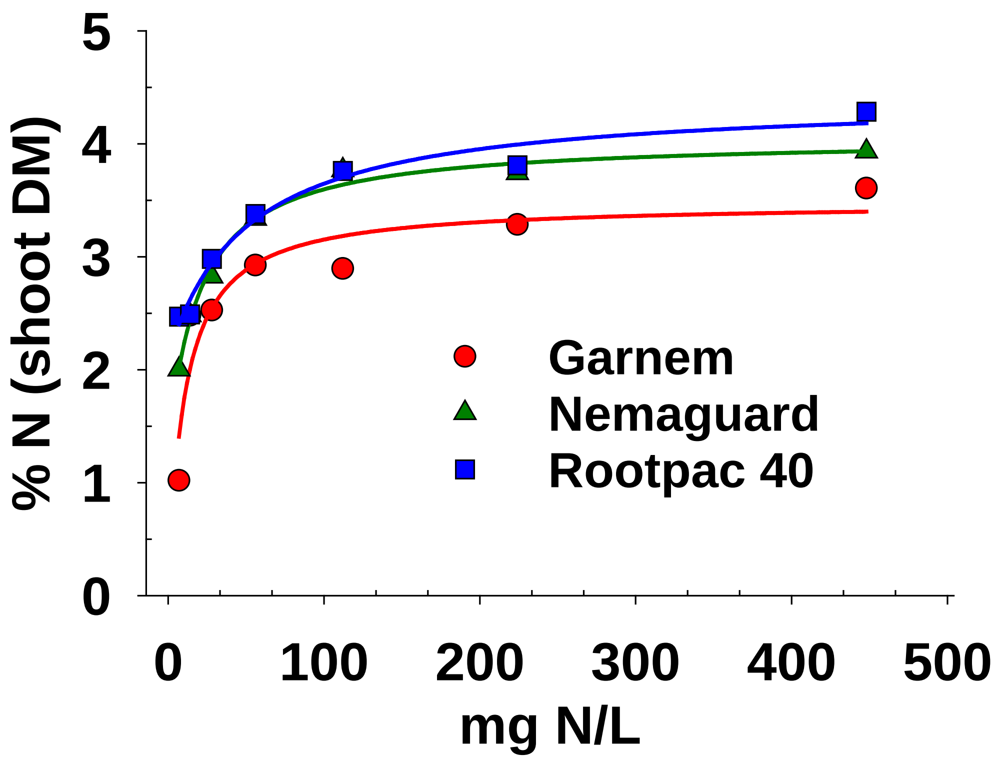
Rootstock responses to [N] in sand culture



mg N/L to kg N/ha

	$[N]_{RAW}$ (mg/L)		
	14	28	56
	estimated ML/Ha		
Garnem	10	12	14
Nemaguard	9	11	13
Rootpac 40	8	10	12

	estimated kg N/Ha		
Garnem	140	336	785
Nemaguard	126	308	729
Rootpac 40	112	280	672

Higher density: not just a matter of more sticks

Current ***best*** H1 ("3-D fruiting space") yield

= 4 t kernels/ha @ 1.3 g/kernel

→ 3.1×10^6 kernels on ~30×10^6 spurs/ha

An ***equally productive*** H3 planting ("2-D") needs

- 9000 spurs/m row to produce
- 1340 kernels/m row (3.35 m)

(row spacing constrained by existing tractor width → 2985 row m/ha)

Rootstocks, scions & higher densities

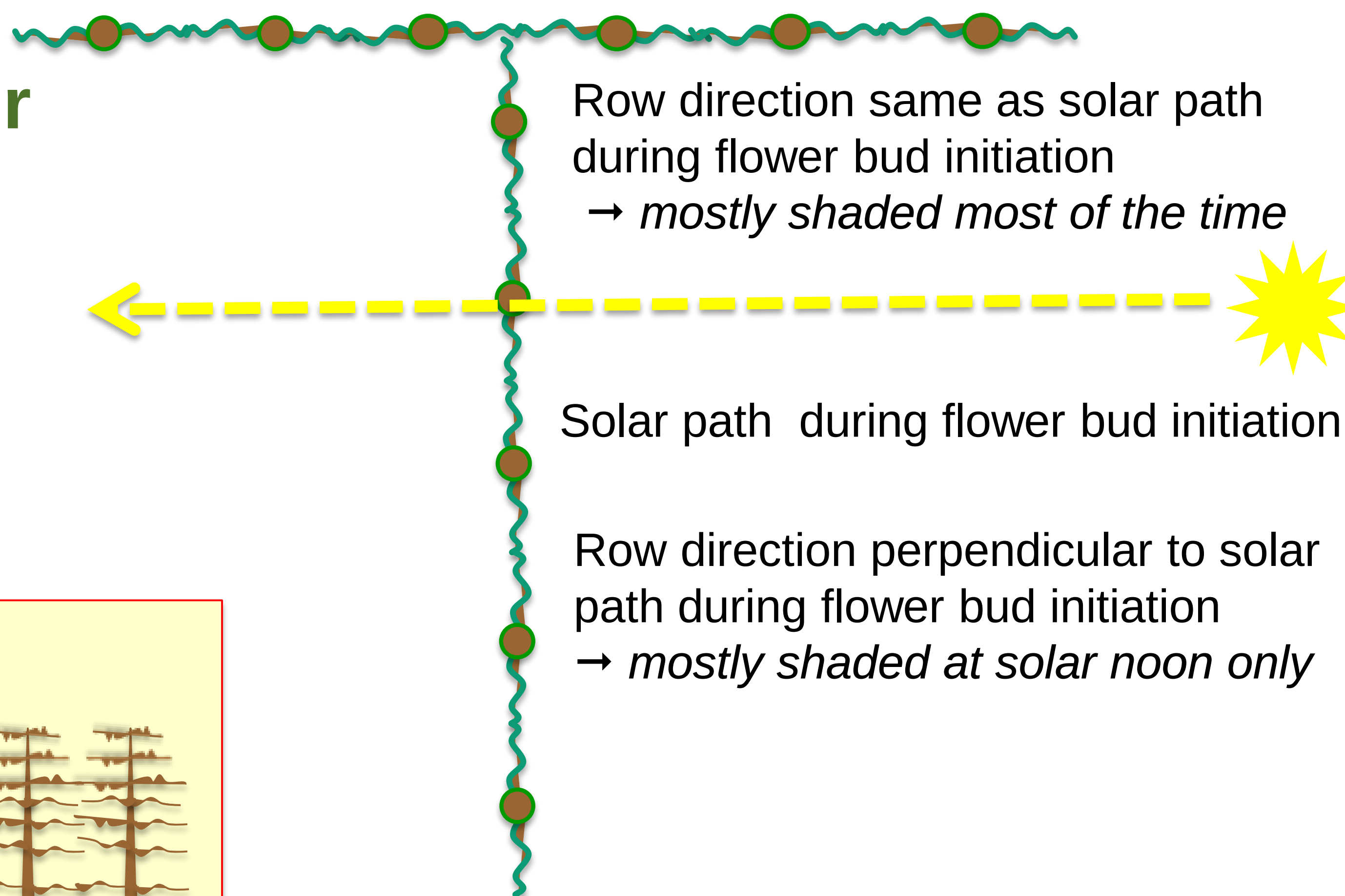
- Garnem (highest vigour)
- Nemaguard
- Rootpac 40
- Rootpac 20 (lowest vigour)

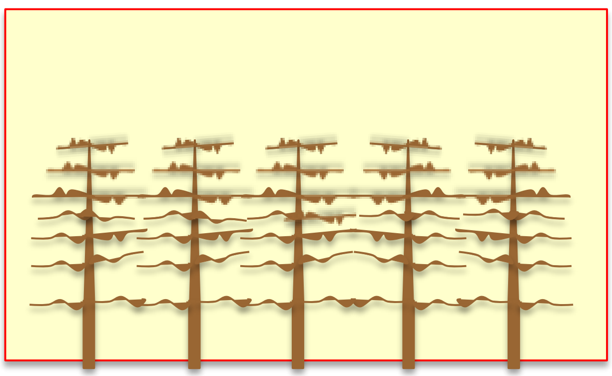
- Vela (Almond 10)
- Carina (Almond 1)
- Almond 21

- 4 × 3.35 → 746 trees/ha
- 2 × 3.35 → 1,492 ″
- 1 × 3.35 → 2,985 ″

- 3.5 ha

Quantifying the light/spur fertility relationship to underpin H3 design





Tree training

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Identifying factors that influence spur productivity in almond (AL14005)

(Monks,) Taylor, Faulkner, Hancock & Treeby

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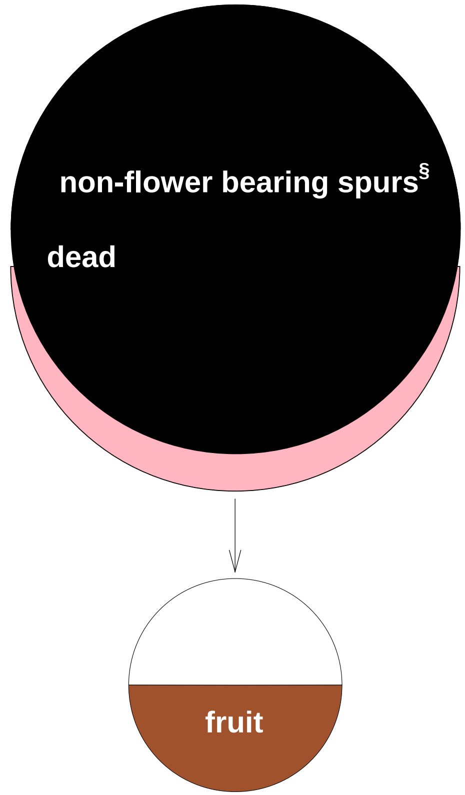
“Spurs are the main fruit-bearing shoot type in mature almond trees”[†]

Spur = short stem that [may] bear flowers and fruits[‡]



[†]Lampinen *et al*. (2011) citing Kester *et al*. (1996)
[‡]https://en.wikipedia.org/wiki/Spur_(stem)
[§]Tombesi *et al*. (2011)

Growing Spurs Not Trees

Should we starting thinking about growing spurs rather than growing trees?

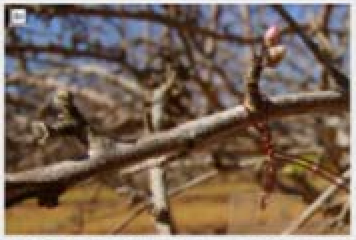
Dr Dave Monks and Cathy Taylor

This year, DEPI is starting a new ABA/HAL funded research project to focus on spur-level responses to changing light environments, water and nutrient management. We're going to undertake field experiments investigating the effects of light, nutrients and water on spur productivity over time. This new experiment expands on a 10-year study of spurs in California (Tombesi *et al.*, 2011).

To help describe the way spurs function over multiple seasons, we're going to measure the:

. number of spurs
. number of flowers
. fruit set
. fruit retention
. nut dry weight
. and light interception

The data will be used to better understand spur productivity under Australian conditions.



The main fruit-bearing shoots in almond trees are spurs. An understanding of the factors that influence spur fruitfulness and longevity is required to understand seasonal fluctuation in fruit behaviour, and to develop appropriate management practices that will deliver higher spur productivity and yield.

We will collaborate with scientists from around the world on this work—including CSIRO here is Australia and UC Davis, in the USA.

References
- Tombesi, S., Lampinen, B.D., Metcalf, S., DeJong, T.M. 2011. Relationships between spur and orchard-level fruit bearing in almond (Prunus dulcis). Tree Physiology 31, 1413-1421.

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Department of Environment and Primary Industries

Victoria

Current best (practice) H1 productivity …..

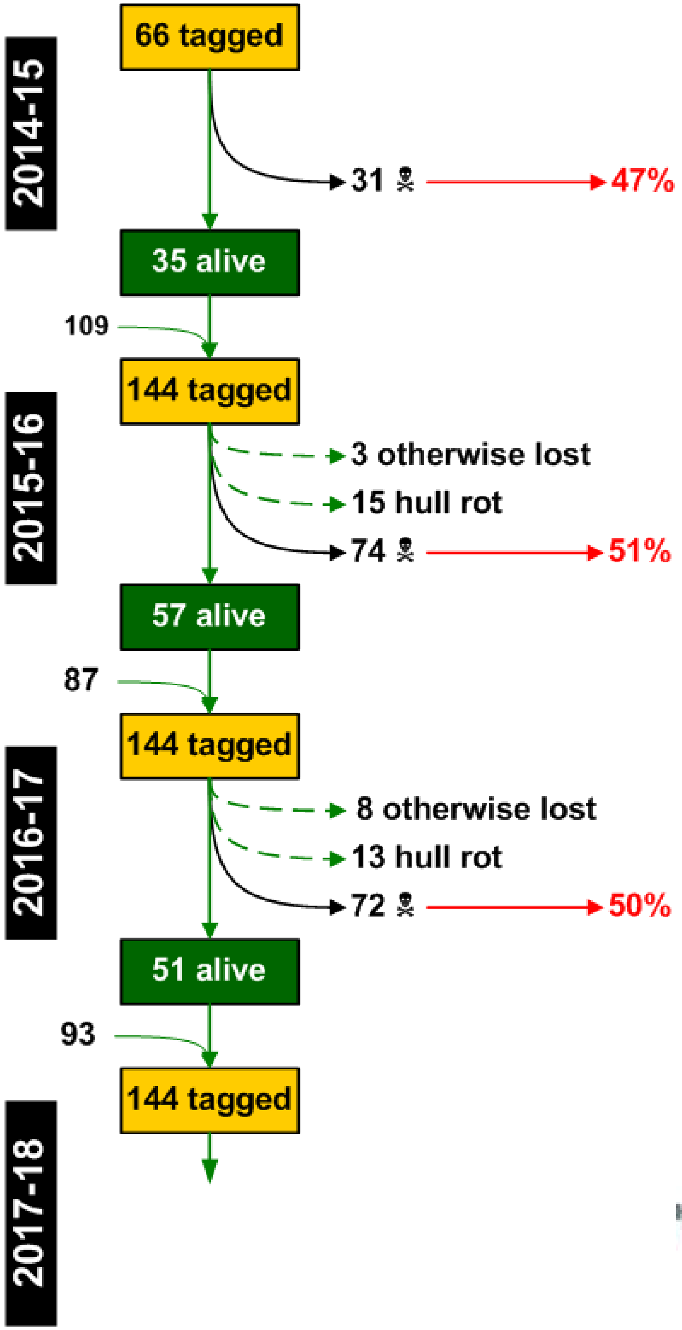
= 4 t kernels/ha

@ 1.3 g/kernel
→ 3.1×10^6 kernels
on ~30×10^6 spurs/ha

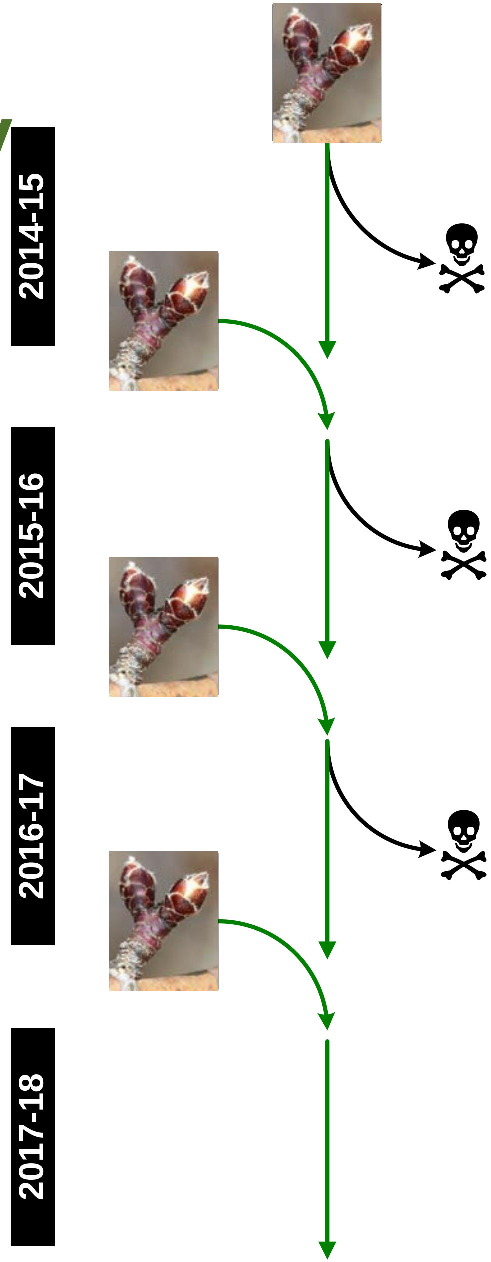





Nonpareil annual spur mortality

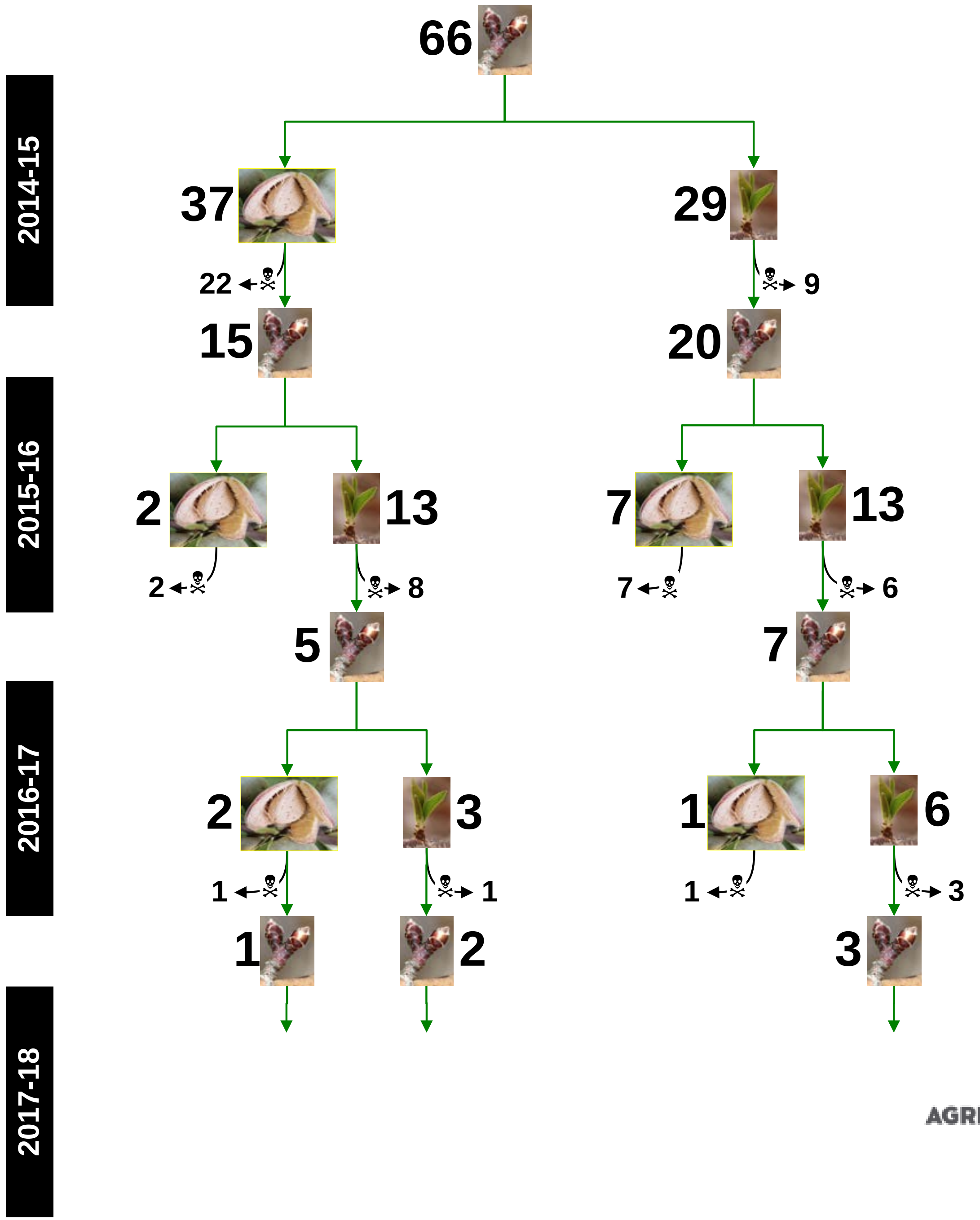


Spur mortality



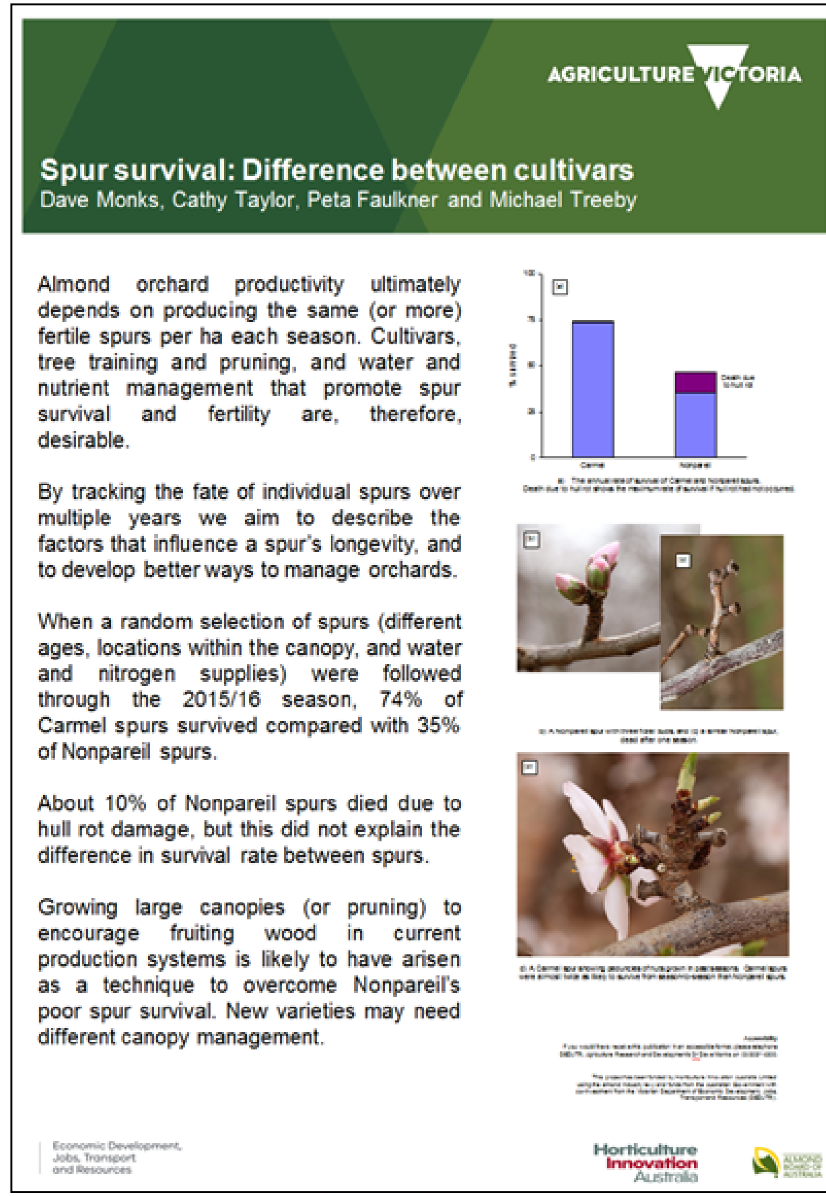
Nonpareil	Carmel
% of population	
47	22
51	19
50	17

Fate of Nonpareil spurs over seasons



Spur behaviour: probabilities of ….

	Nonpareil	Carmel
	% probability	
being productive	43	23
being productive in successive seasons	5	24
dying after being productive	67	33
being alive after 3 seasons	9	44
leafy spurs dying	41	21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Spur survival: Difference between cultivars

Dave Monks, Cathy Taylor, Peta Faulkner and Michael Treeby

Almond orchard productivity ultimately depends on producing the same (or more) fertile spurs per ha each season. Cultivars, tree training and pruning, and water and nutrient management that promote spur survival and fertility are, therefore, desirable.

By tracking the fate of individual spurs over multiple years we aim to describe the factors that influence a spur's longevity, and to develop better ways to manage orchards.

When a random selection of spurs (different ages, locations within the canopy, and water and nitrogen supplies) were followed through the 2015/16 season, 74% of Carmel spurs survived compared with 35% of Nonpareil spurs.

About 10% of Nonpareil spurs died due to hull rot damage, but this did not explain the difference in survival rate between spurs.

Growing large canopies (or pruning) to encourage fruiting wood in current production systems is likely to have arisen as a technique to overcome Nonpareil's poor spur survival. New varieties may need different canopy management.

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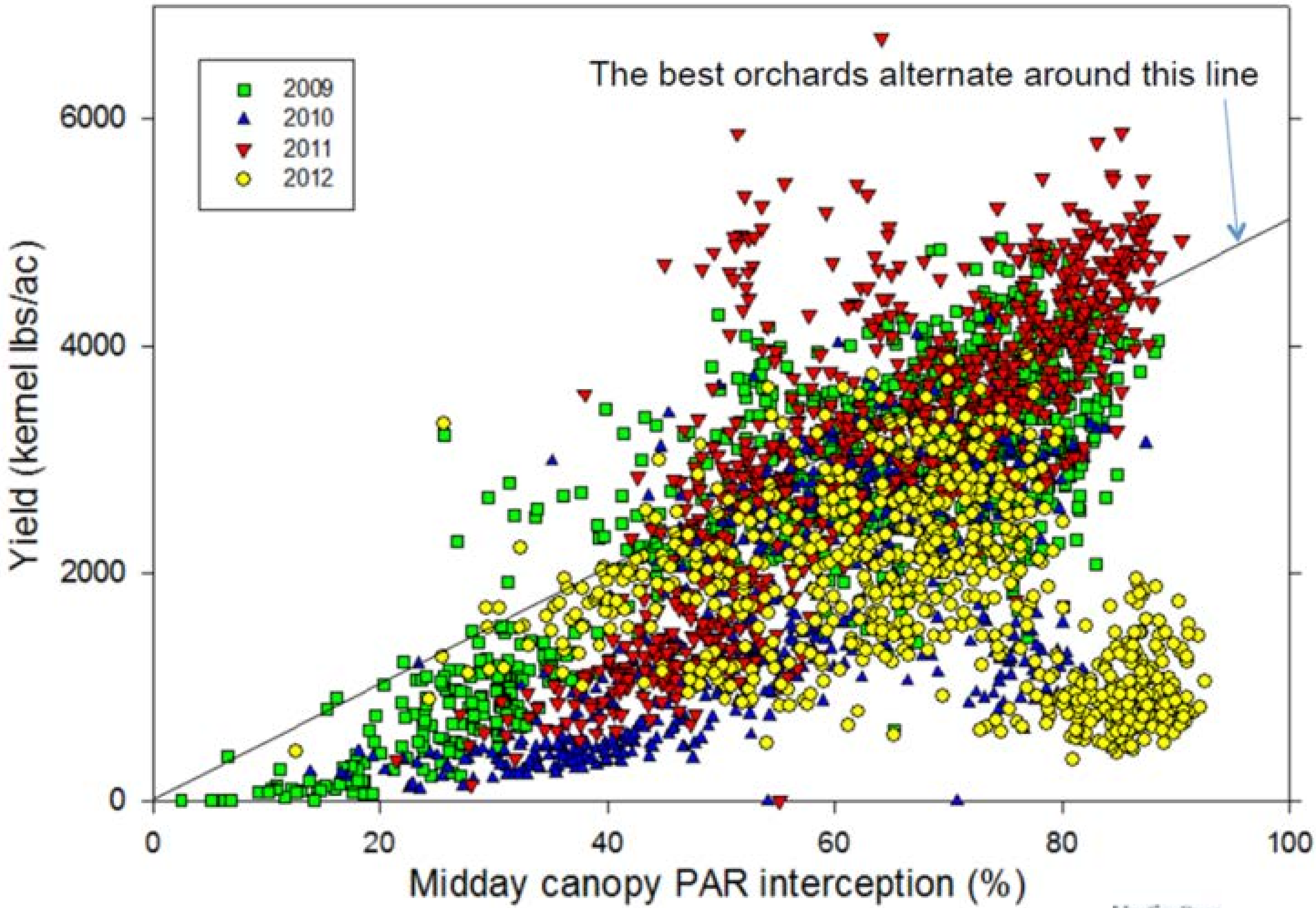
Light & kernel yield in Californian almond orchards



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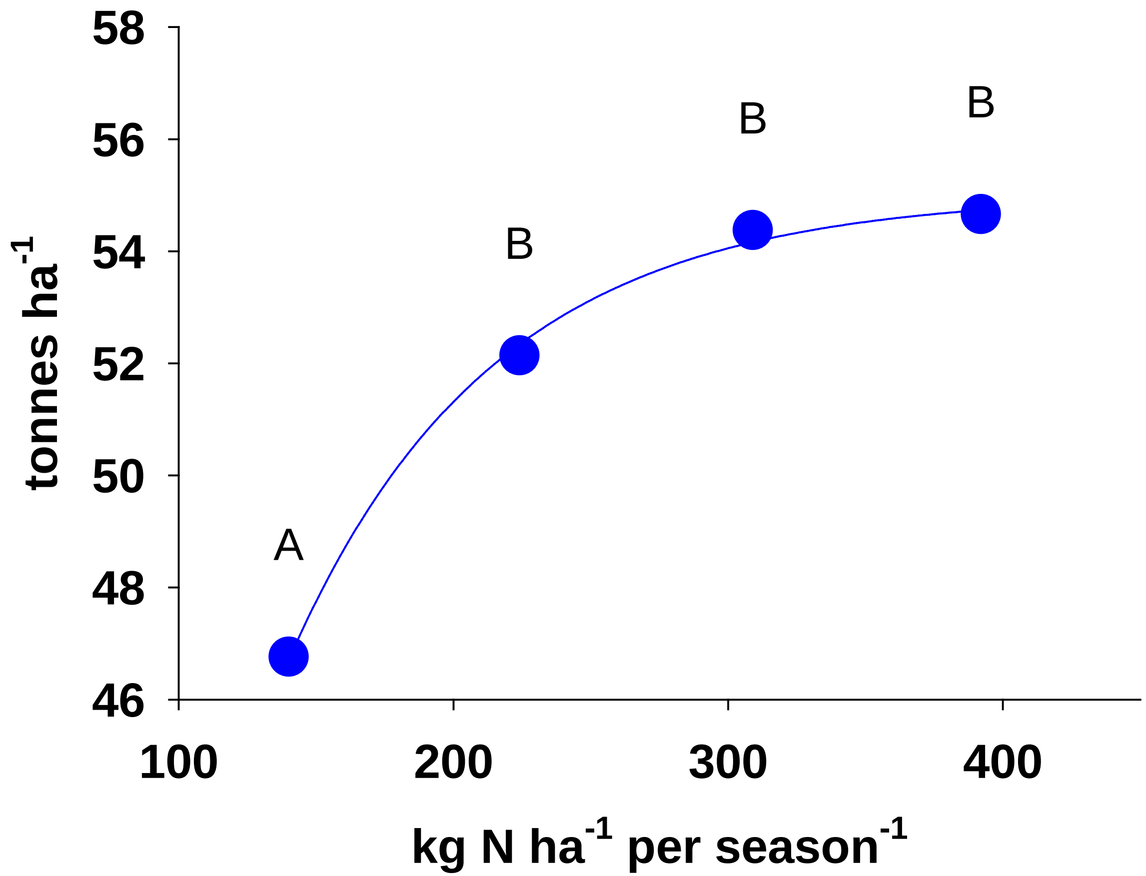
Lampinen, B. "Almond Yield Potential – How Much is too Much?" (http://ucanr.edu/sites/Nut_Crops/files/169707.pdf)

Nitrogen supply & almond yield
(cumulative 2008-2014)



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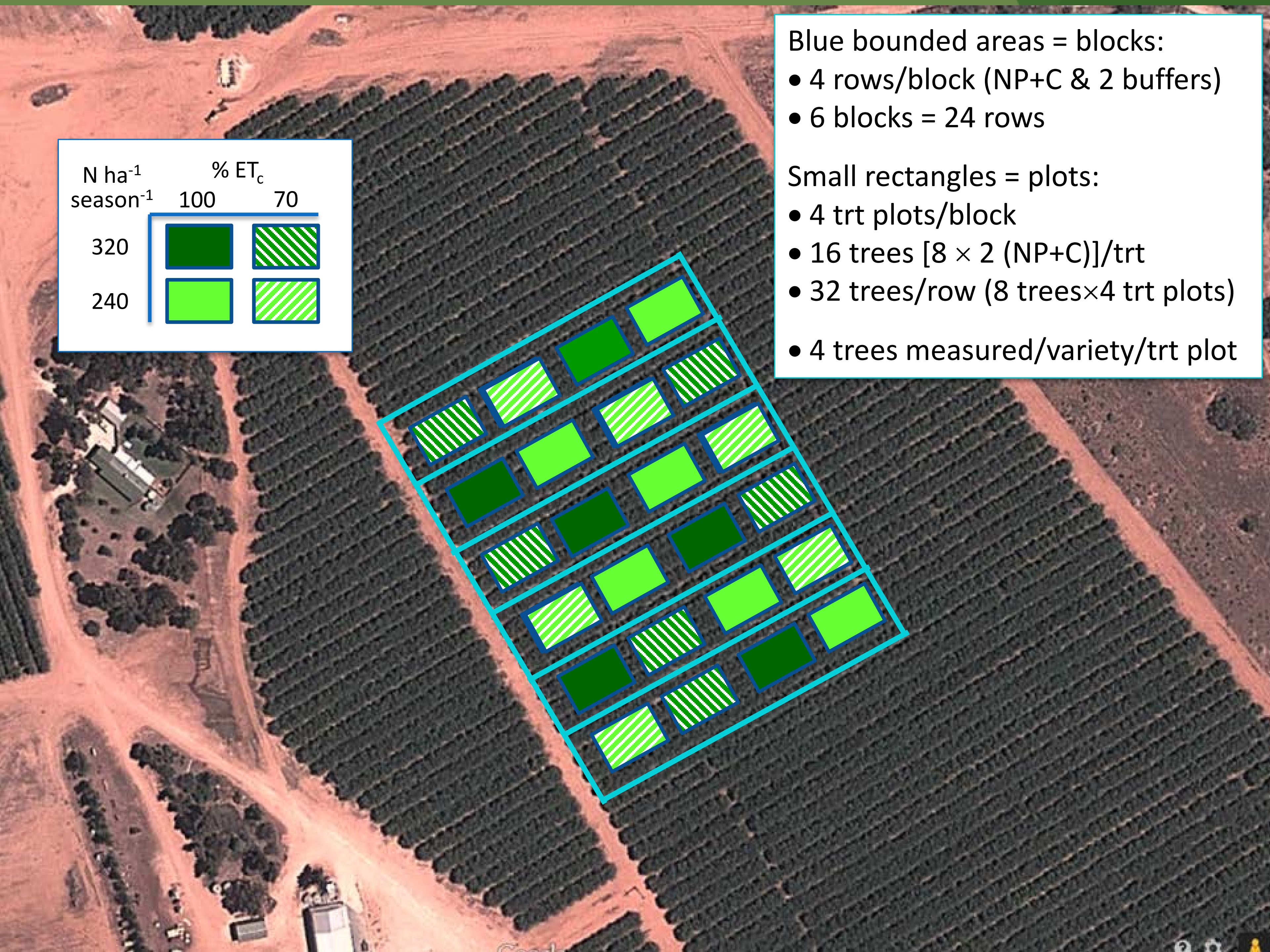
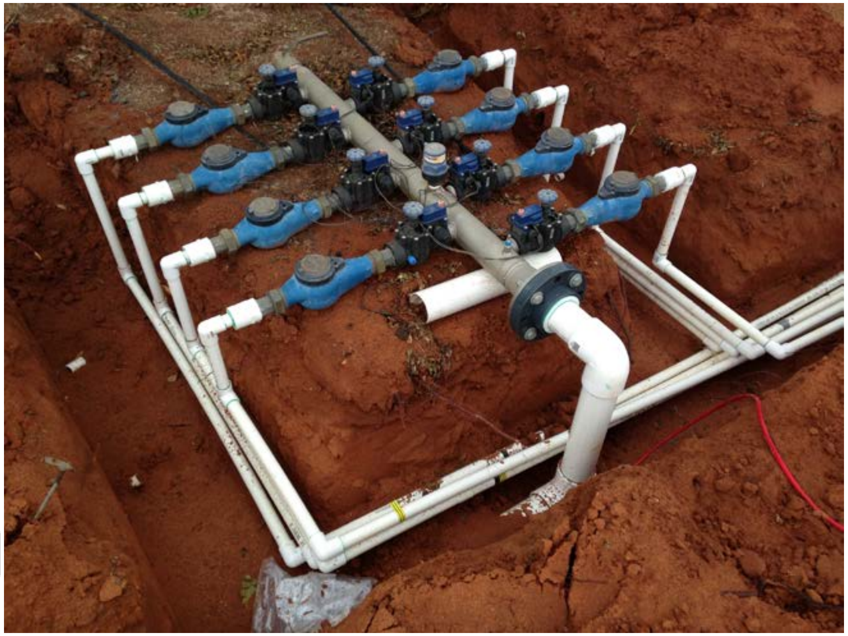
Adapted from Muhammad *et al*. (2015)

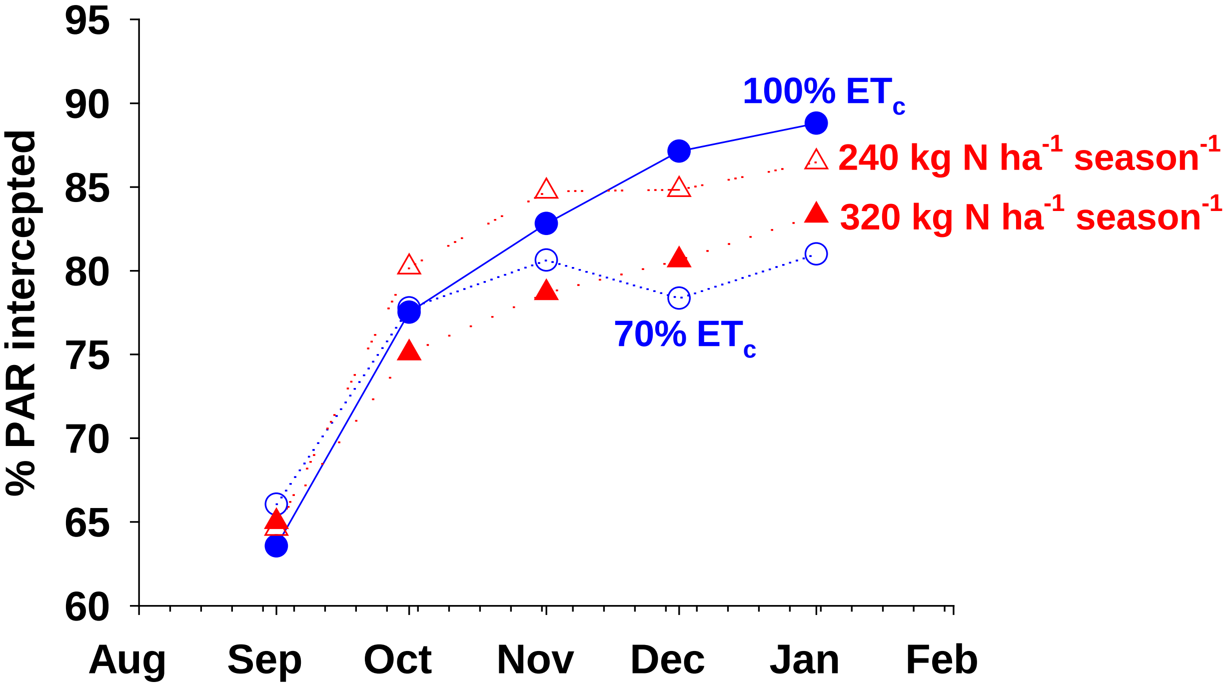

N ha-1 season-1
% ETc
100
70
320
240
Blue bounded areas = blocks:
• 4 rows/block (NP+C & 2 buffers)
• 6 blocks = 24 rows
Small rectangles = plots:
• 4 trt plots/block
• 16 trees [8 × 2 (NP+C)]/trt
• 32 trees/row (8 trees×4 trt plots)
• 4 trees measured/variety/trt plot

Imposing water and N supply treatments



	Irrigation (% ET_C)	N supply (kg ha^{-1} $season^{-1}$)	2014-15	2015-16	2016-17	2017-18	2018-19
(control)	100	320	✓	✓	✓	✓	✓
	100	240	-	✓	✓	✓	✓
	70	320	-	✓	✓	✓	✓
	70	240	-	✓	✓	✓	✓

Effect of irrigation management & N supply on light interception (2016-17 season)



Spur mortality: seasons, irrigation management & N supply for each variety

		Irrigation (% ET_c)			
		100	100	70	70
		kg N ha^{-1} $season^{-1}$			
		320	240	320	240
Variety	Season	*% tagged spurs dead at end of each season*			
Nonpareil	2014-15	47	-	-	-
	2015-16	51	52	51	47
	2016-17	50	58	39	60
Carmel	2014-15	13	-	-	-
	2015-16	19	22	22	19
	2016-17	17	37	22	42

Spur leaf area in previous season & productive status in current season

Variety	Spur type (#)	Previous season's leaf area (mm^2/spur)
Nonpareil	fruiting (37)	284
	nonfruiting (171)	243
Carmel	fruiting (67)	301
	nonfruiting (321)	247

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Spurs: Driving productivity

Dave Monks, Cathy Taylor and Michael Treeby

Spurs are the main fruit-bearing parts of almond trees. An understanding of the factors that influence spur fruitfulness and longevity is important in the development of appropriate management practices that deliver higher productivity.

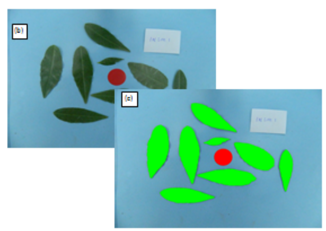
The amount of carbohydrate almond trees have available to grow and mature nuts is directly related to the amount of light the leaves are able to capture. Therefore, yield from an almond block can be predicted from the amount of light each spur can capture.

Each spur's light interception is positively related to the spur's leaf area, but measurements of leaf area are destructive and labourious.

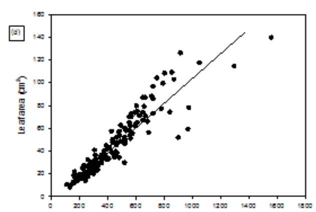
We related simple, non-destructive field-based measurements (the number of leaves and the length of the longest leaf per spur) to leaf area per spur for more than 700 spurs.

Establishing this robust relationship means an individual spur's light capture potential can be estimated in the field, without destroying the leaves.

a) Removing leaves from a spur, in preparation for overhead photography.



b) Leaves prepared for leaf area analysis, and (c) as rendered by the software program.



d) The relationship between easily measured variables and leaf area of individual 'Nonpareil' spurs.

Accessibility

If you would like to receive this publication in an accessible format, please telephone DEDJTR, Agriculture Research and Developments Dr Dave Monks on 03 5051 4500.

This project has been funded by Horticulture Innovation Australia Limited using the almond levy and funds from the Australian Government.

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Fate of spurs within different zones

Thank you