The New Zealand Institute for Plant & Food Research Limited

Plant & Food RESEARCH
RANGAHAU AHUMĀRA KAI

Alternate bearing in ‘Hass’ avocado: possible role of carbohydrates and boron

Grant Thorp, Helen Boldingh, Andrew Barnett and Peter Minchin

Presentation to 4th Australian and New Zealand Avocado Growers Conference in Cairns, 23-24 July 2009

Alternate bearing in ‘Hass’ avocado

Does supply, transport and/or utilisation of carbohydrate and/or boron limit fruit set in avocado?

The projects are examining:

1. seasonal ***availability*** of carbohydrate and boron in the tree
2. ***transport*** of carbohydrate and boron to the flower via the phloem and xylem
3. ***utilisation*** of carbohydrate and boron by the flower

Related projects being reported at this conference include:

- Avocado tree growth cycles – seasonal partitioning
- Pollination – to confirm that pollen transfer was not limiting fruit set
- Transpiration during avocado flowering – role of xylem transport

Project team

Plant & Food Research

Grant Thorp	Mt Albert
Peter Minchin	Te Puke
Sam Ong Eng	Te Puke
Andrew Barnett	Te Puke
Mike Clearwater	Te Puke
Bill Snelgar	Te Puke
Helen Boldingh	Ruakura
Nick Gould	Ruakura
Mark Goodwin	Ruakura
Lisa Evans	Ruakura
Jem Burden	Mt Albert

Avocado Industry Council

Jonathan Dixon
Henry Pak
Toni Elmsley
Bart Hoftsee
Cindy Cotterel

University of California

Dr Mary Lu Arpaia (avocado carbohydrates)
Dr Patrick Brown (boron transport)

University of Malaga (Spain)

Dr Inaki Hormaza (starch and fruit set)

Why are carbohydrates important?

Carbohydrates are the major products of photosynthesis

- Structural carbohydrates are found within cell walls and provide the structural support for plant growth
- Non-structural carbohydrates provide the energy for plant growth

Major “non-structural” carbohydrates in avocado are:

- **Starch** (reserves)
- **Sucrose, glucose, fructose** (6-carbon sugars)
- **D-mannoheptulose, perseitol** (7-carbon sugars)

The 7-carbon sugars appear to play an important role in overall tree physiology (Mary Lu Arpaia, University of California). Their availability and/or utilisation could be a limiting step in achieving successful fruit set

Boron transport in plants

Boron is important for pollination and fruit set

It is generally accepted that boron is not mobile within plants and that once boron accumulates in a plant tissue it can not be remobilised to other plant tissues

However, in some plants (eg apple) boron is known to complex with sugar-alcohols, eg sorbitol, resulting in transport of a sorbitol-boron-sorbitol complex in the phloem from leaves to flowers (Patrick Brown, University of California)

What about perseitol in avocado? It is a sugar alcohol. Does perseitol have a role in facilitating the transport of boron from leaves to flowers in avocado?

Alternate bearing in ‘Hass’ avocado: possible role of carbohydrates and boron

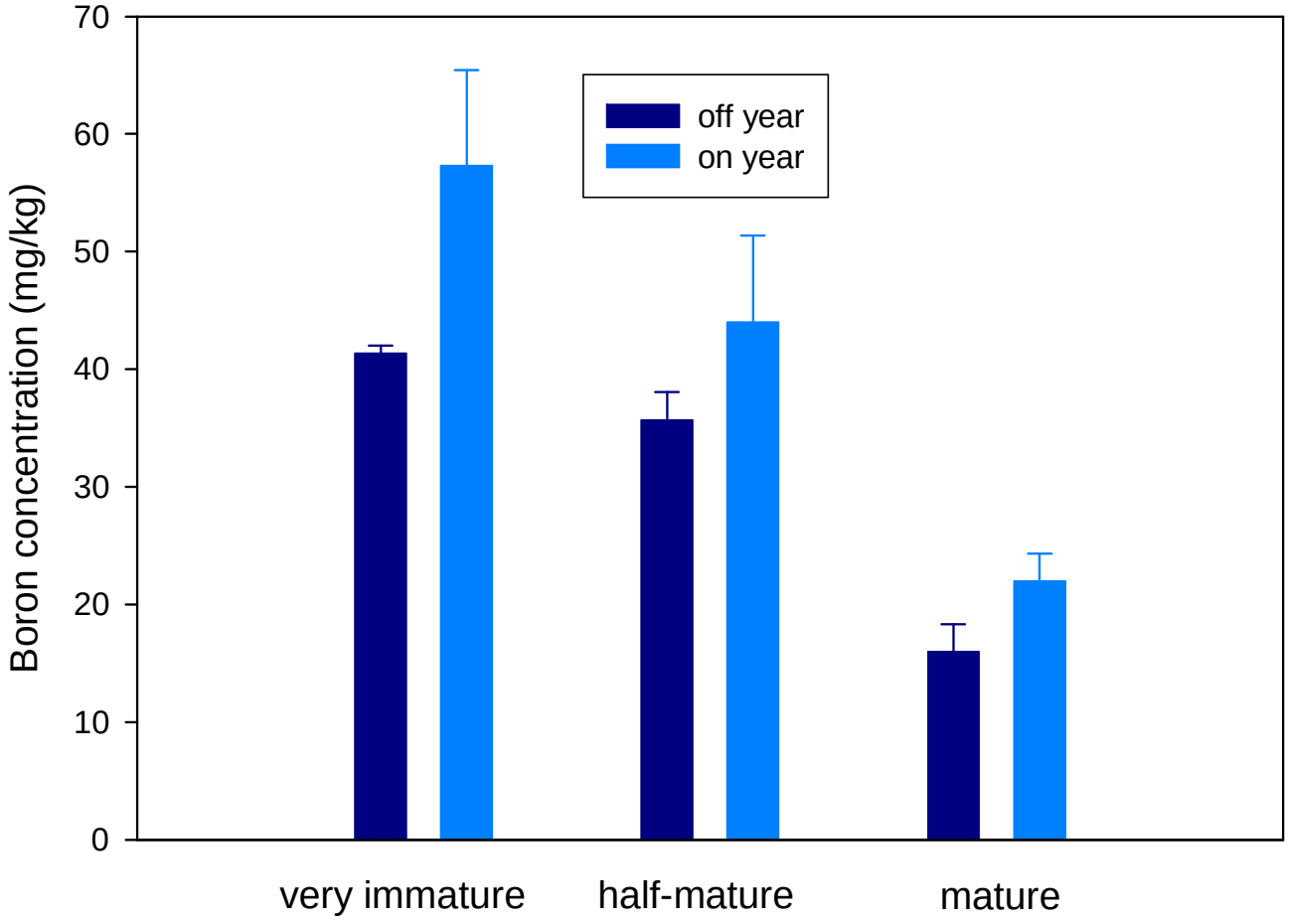
Our hypothesis is that the seasonal accumulation and utilisation of 7-carbon sugars, in combination with a possible role in facilitating boron (B) transport, is a major regulatory process critical to achieving successful fruit set in avocado.

Key experiments in Year 1:

1. Demonstrate that boron follows the same transport pathway as carbohydrates, from leaves to flowers
2. Compare carbohydrates and boron in ON and OFF cropping trees
3. Confirm that treatments which increase carbohydrate content of flowers also increase boron content, and thus increase fruit yields

Boron concentration in leaves

If boron is transported in the xylem then it would accumulate in the old leaves as these leaves have transpired the most water. In avocado, boron concentration decreased with leaf age. This suggests that boron does not accumulate in the leaves but is being exported.

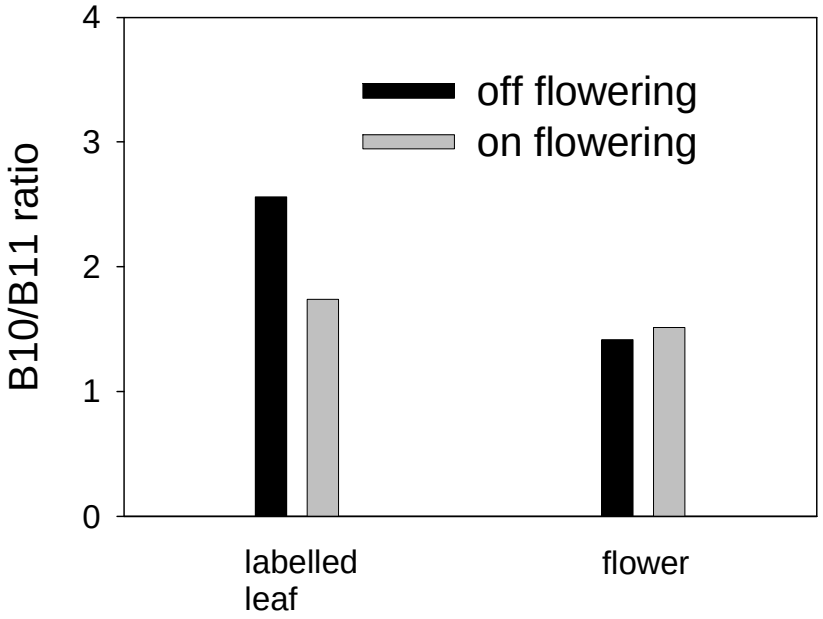


Boron transport

Boron isotope (B10) applied to leaves before flowering, then analysed at mid-bloom (24 October) in leaf and floral tissues. These studies confirmed the transport of boron from leaves to flowers (via the phloem)

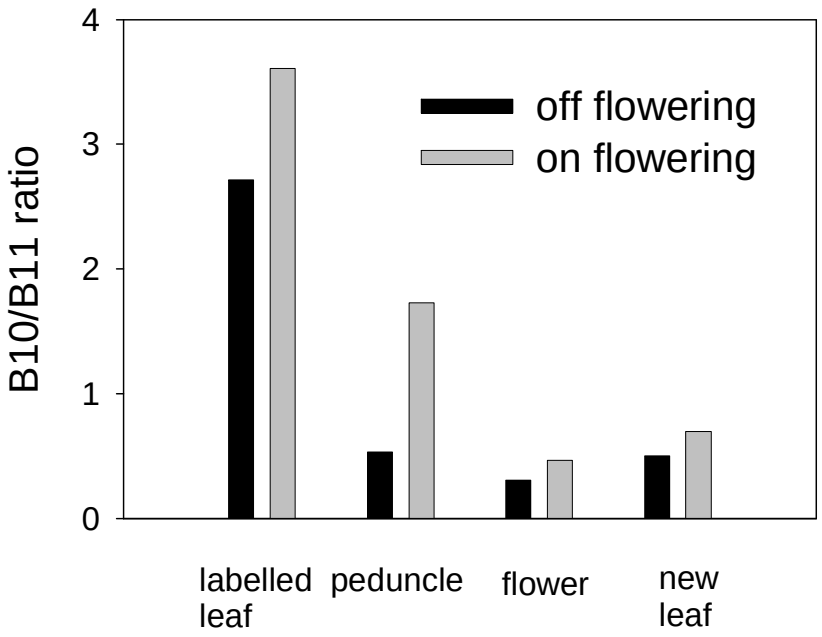
4 September

(50 days before mid-bloom)

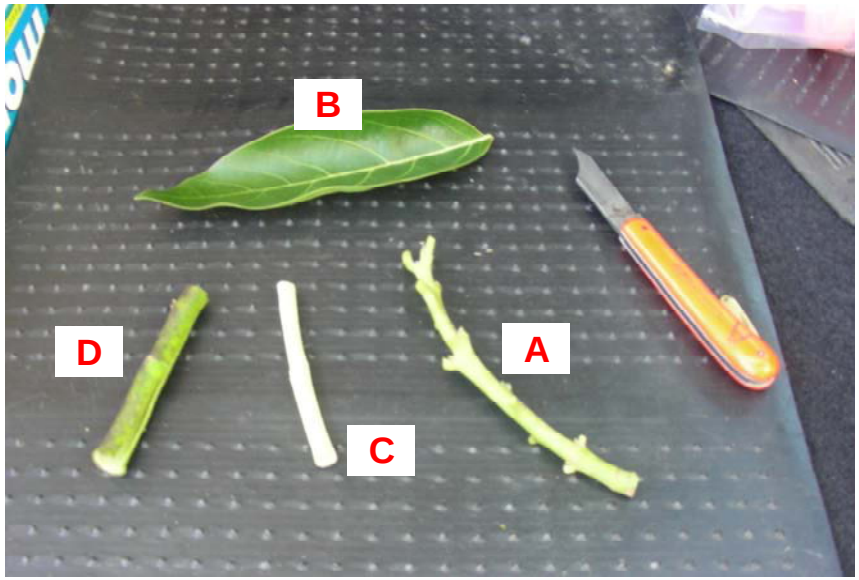


8 October

(16 days before mid-bloom)



Carbohydrates in ON and OFF flowering trees



starch

sucrose

glucose

fructose

D-mannoheptulose

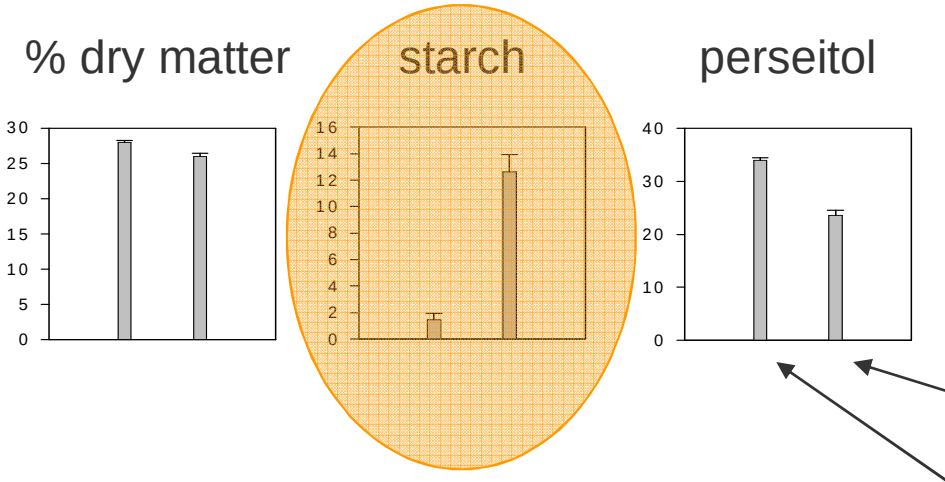
perseitol

(boron)

ON bearing → OFF flowering

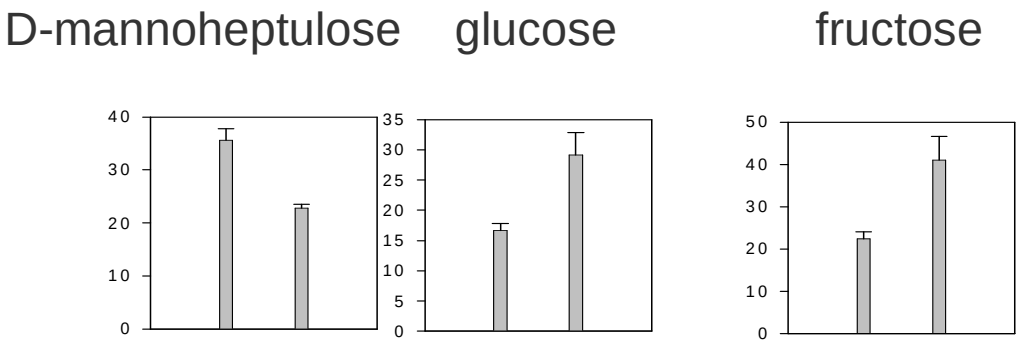
OFF bearing → ON flowering

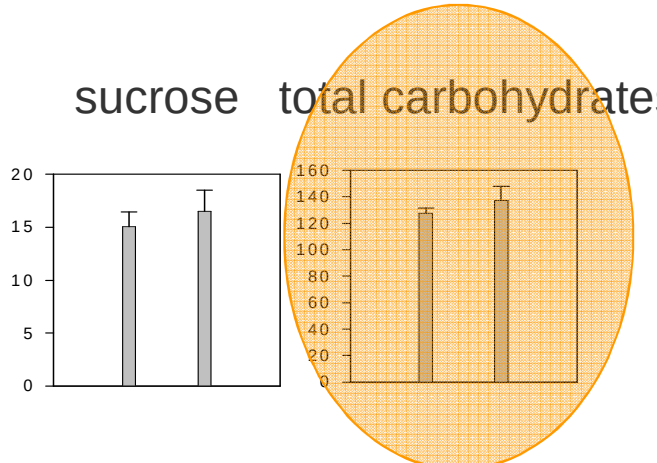
Avocado flower carbohydrates



ON flowering

OFF flowering





Avocado flower carbohydrates

- Total carbohydrates are the same in flowers from ON and OFF bearing trees
- Flowers on trees with a heavy crop load (few flowers) have low levels of starch
- Flowers on trees with a low crop load (many flowers) have high levels of starch

Agrees with work of Inaki Hormaza in Spain which indicates that flowers with high levels of starch are more likely to set fruit than flowers with low starch content

Can we increase the carbohydrate content of flowers?

Branch girdling studies

Thank you to Ron and Chris Bailey

Branch girdling study

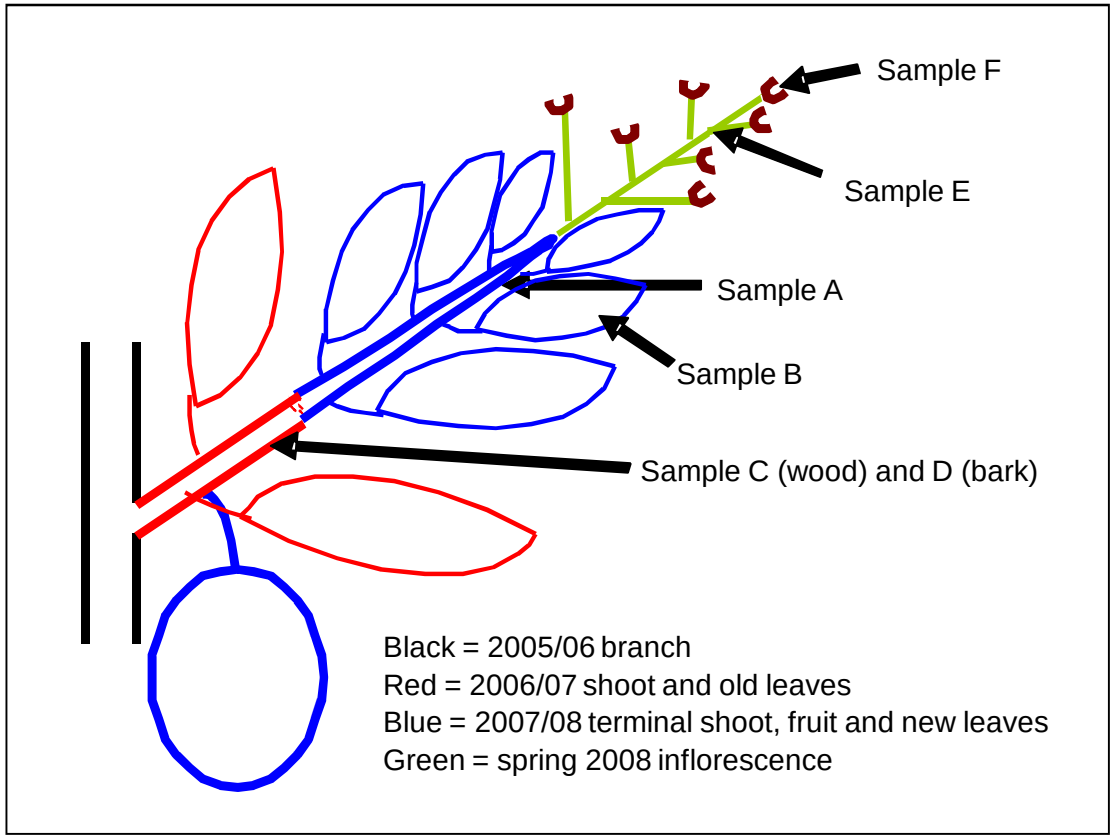
Paired branches (2-year-old growth units), one pair per tree

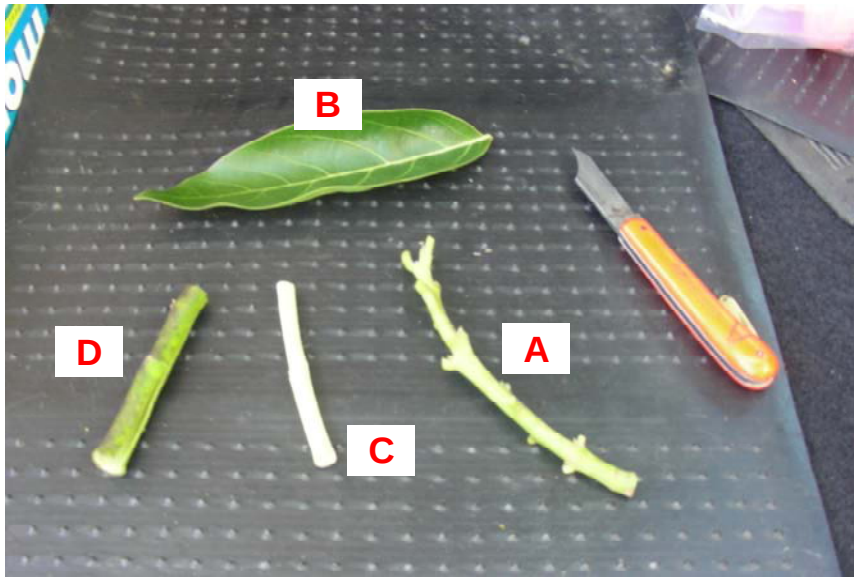
Treatments applied to one branch from each pair in April 2008

Treatment (n = 18 trees)	Basal Diameter (mm)	Length primary axis (m)
Girdle	60.0	2.4
No Girdle	62.1	2.4

Even mix of ON and OFF bearing trees (average 107 and 68 kg/tree)

Tissue sampling





Leaves

		ON Bearing		OFF Bearing		
		Intact	Girdled	Intact	Girdled	*Significance* [1]
Starch	April (autumn)	16.4	18.2	17.5	11.5	NS
	October (mid-bloom)	7.5	17.4	8.8	31.1	(*)
Perseitol	April (autumn)	25.2	25.2	25.5	26.2	NS
	October (mid-bloom)	13.9	13.3	15.4	12.5	NS
Boron	April (autumn)	39.0	35.1	36.8	40.8	NS
	October (mid-bloom)	25.6	20.3	28.6	22.5	(*)

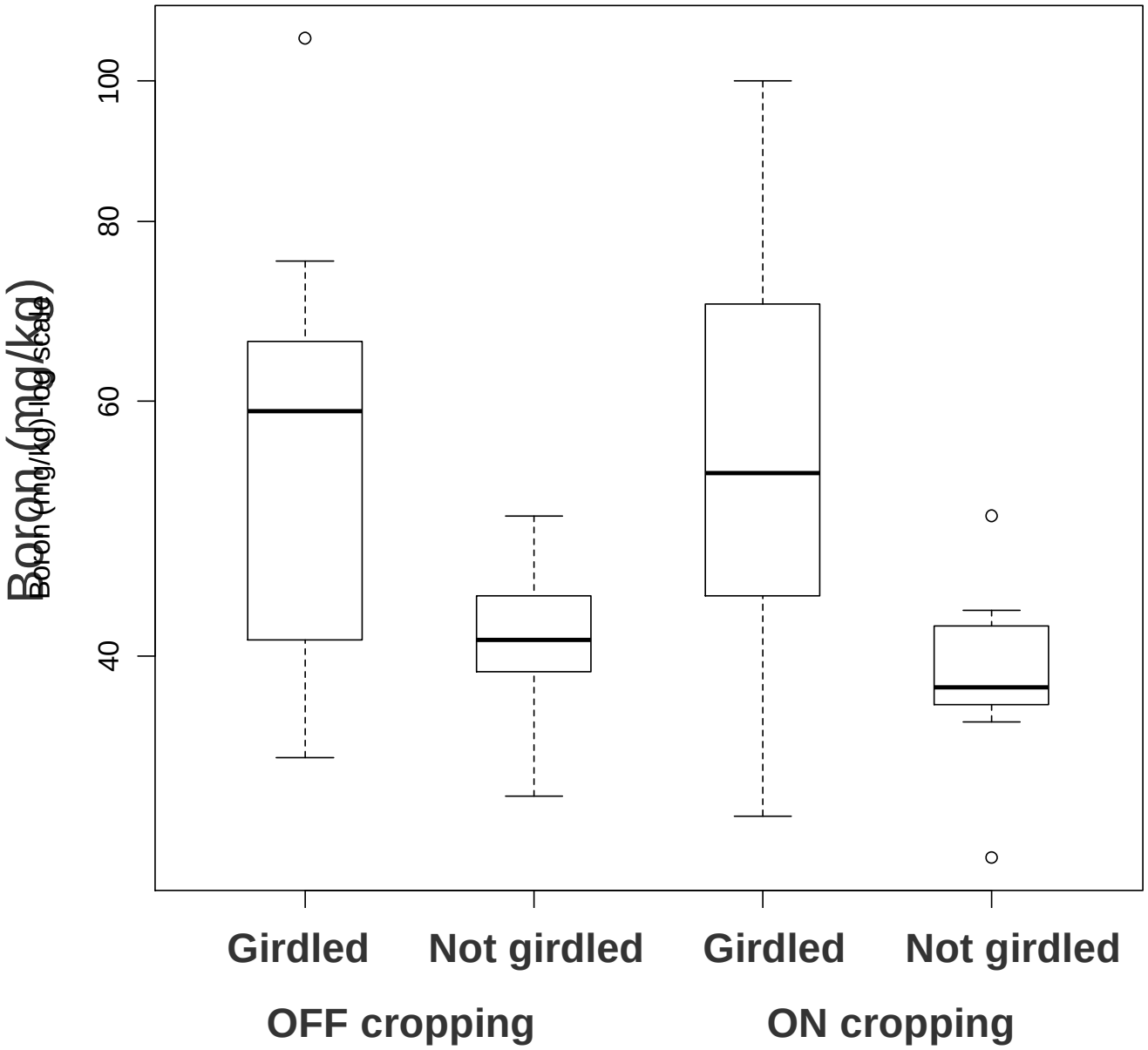
Girdling treatments applied in April 2008

Flowers

		ON Bearing		OFF Bearing		
		Intact	Girdled	Intact	Girdled	*Significance* [1]
October 2008 (mid-bloom)						
Starch	mg/g	22.4	22.7	20.5	18.8	NS
Perseitol	mg/g	17.9	17.1	19.0	18.3	NS
Boron	mg/kg	39.3	58.7	41.2	58.7	*

Girdling treatments applied in April 2008

Variable response to girdling



Summary and questions

- As expected, girdling maintained high levels of starch in leaves on girdled branches, especially in OFF cropping trees
- Boron was exported from leaves during April to October, with increased export from leaves on girdled branches – why?
- Neither girdling nor crop load affected the starch and perseitol content of flowers, but girdling did increase the boron content of flowers on both ON and OFF cropping trees – why?
- Not all branches responded to girdling – why?
- Variable response to girdling suggests opportunities to improve the efficiency of this technique and thus improve its usefulness to growers wanting to achieve more consistent yields

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Thank you

www.plantandfood.com

grant.thorp@plantandfood.co.nz