Increasing whole tree yield by spraying pollen: are there trade-offs?

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AL14004: Pollination as a controlling factor in almond yield

Pollination in almonds

- Pollination by insects is a critical requirement for almond production
- Standard practice involves managed honeybee hives (6.5 hives per ha)
- Experiments conducted 2011-2013 indicated that standard pollination practice is likely to lead to under pollination in many orchards
- Hive arrangement important
- Pollen survey showed less bee activity far from hives (>300m)

Cunningham 2014 & Cunningham et al. 2016

Hypothetical resource trade-offs at the tree-level

If pollination by bees isn't limiting…

Presentation today

- Little is known about how pollination interacts with other resource constraints to determine quantity and quality of nuts
- Hand pollination of flowers increases nut set relative to a controls using standard pollination practice
- But does this scale-up to whole tree yield?

What I will cover today:

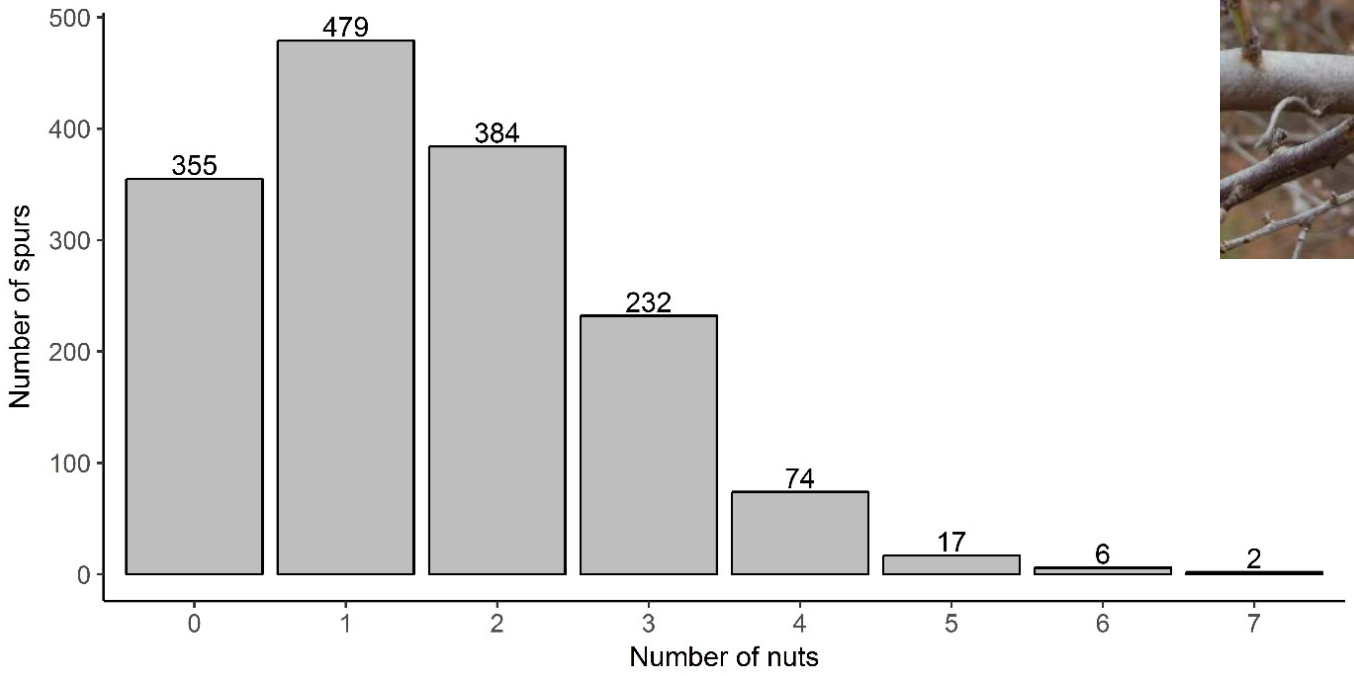
1. Does resource availability such as light and leaf area influence flowering and fruiting at spur level?

2. Does whole tree application of pollen translate into higher yield of nuts (trade-offs)?

3. Can we make more profit if we improve pollination (economic analysis)?

Spurs

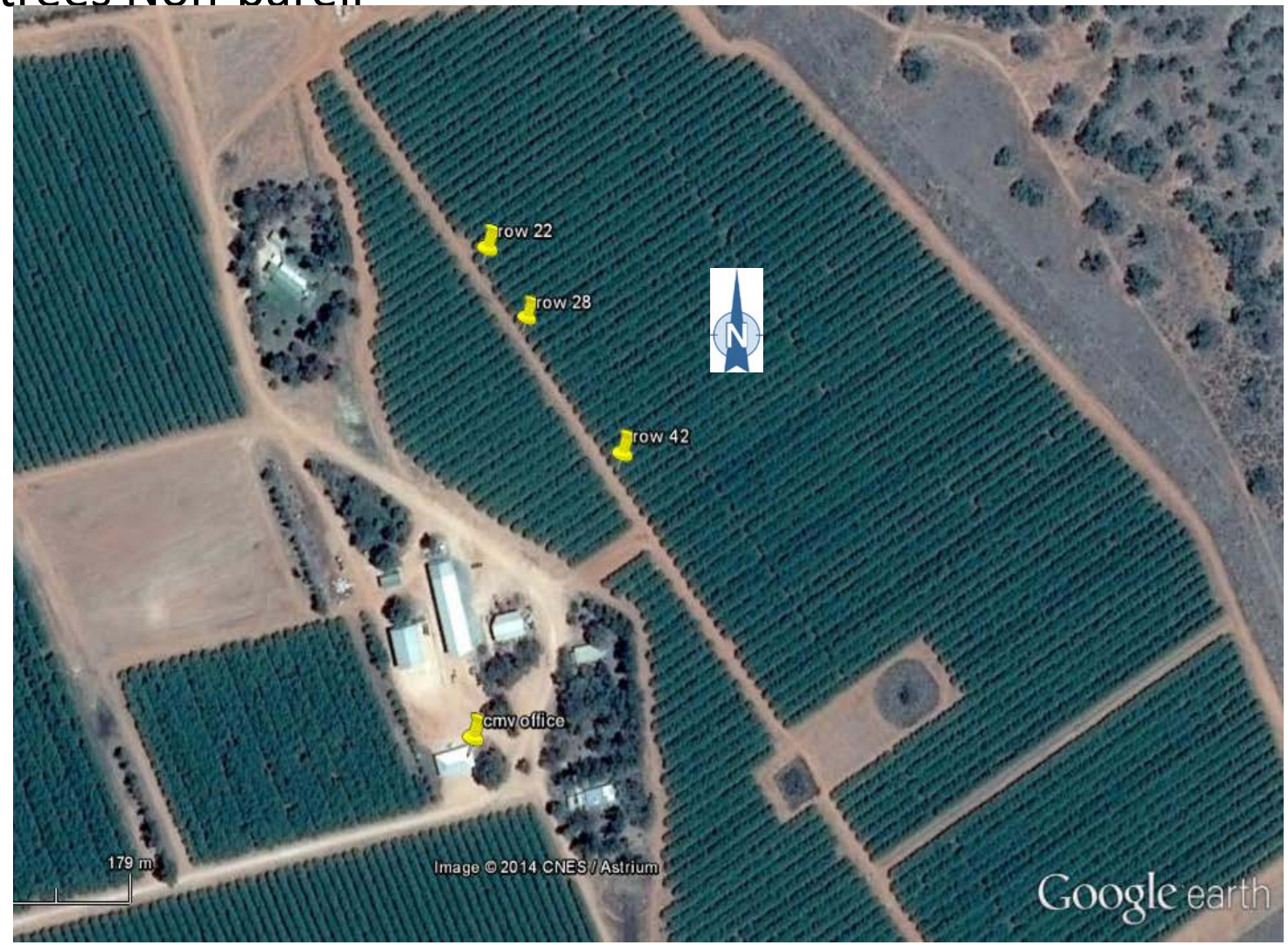
- Spurs are fruit-bearing shoots coming off a branch
- Spurs produce 1-15 flowers (most 2-5)
- Most spurs (78%) produce one or more nuts



Study site

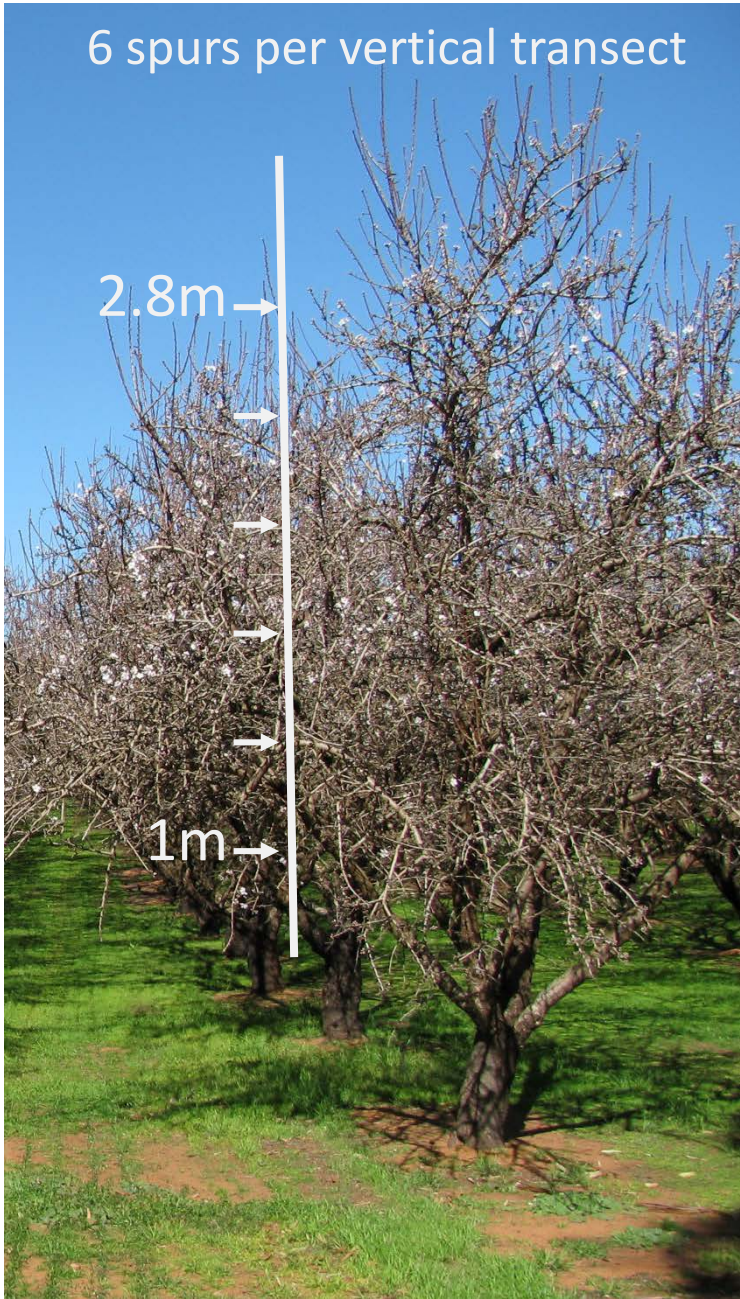
CMV orchard at Lindsay Point, Victoria.

Focal trees Non-pareil



1. Spur Selection

- Each year spurs at different heights on 12 trees were tagged and followed throughout the season.
- Transect location was selected to equally represent each part of the tree (North, South, East, West).
- In the first year light measurements were collected (Licor light sensor).



1. Hand Pollination of Spurs

- Open flowers were hand pollinated by applying pollen from the anthers of freshly picked flowers from Peerless trees.
- Peerless trees have the highest level of pollen compatibility with Non-pareil.
- Repeated daily as new flowers opened until all flowers were hand pollinated.
- As close to 100% pollination as possible (at the spur level).

1. Marking spurs

36 trees (3 treatments) 12 spurs per tree = >400 spurs

1. Flower, leaf, light and fruit assessments.

- All spurs surveyed for the number of flowers produced, numbers of nuts, weight of nuts.

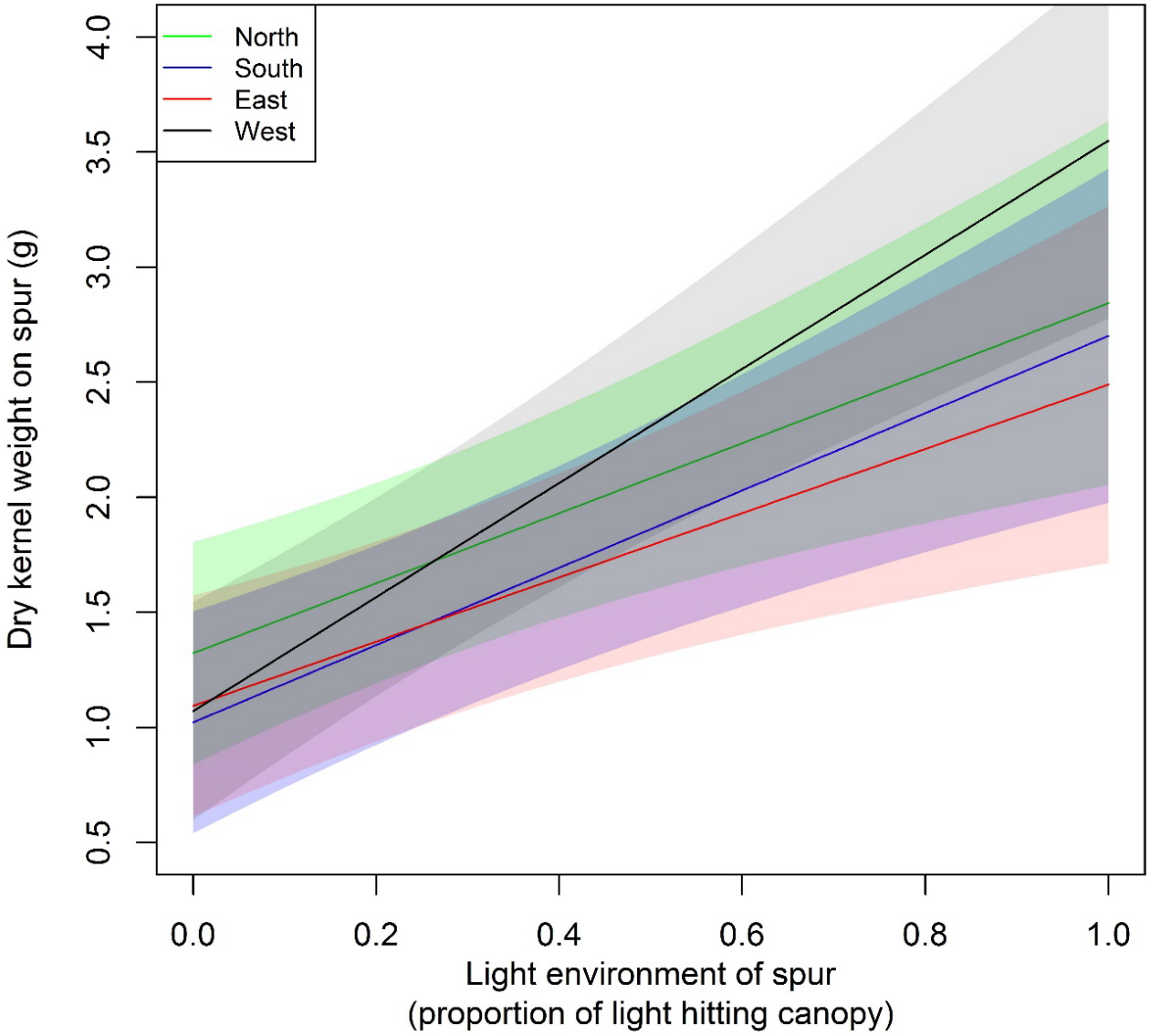
- Statistical model developed (Monks & Taylor in this experimental block) which estimates the expected light environment as a function of spur height in the tree.

*light = 0.2688*x - 0.4058,*

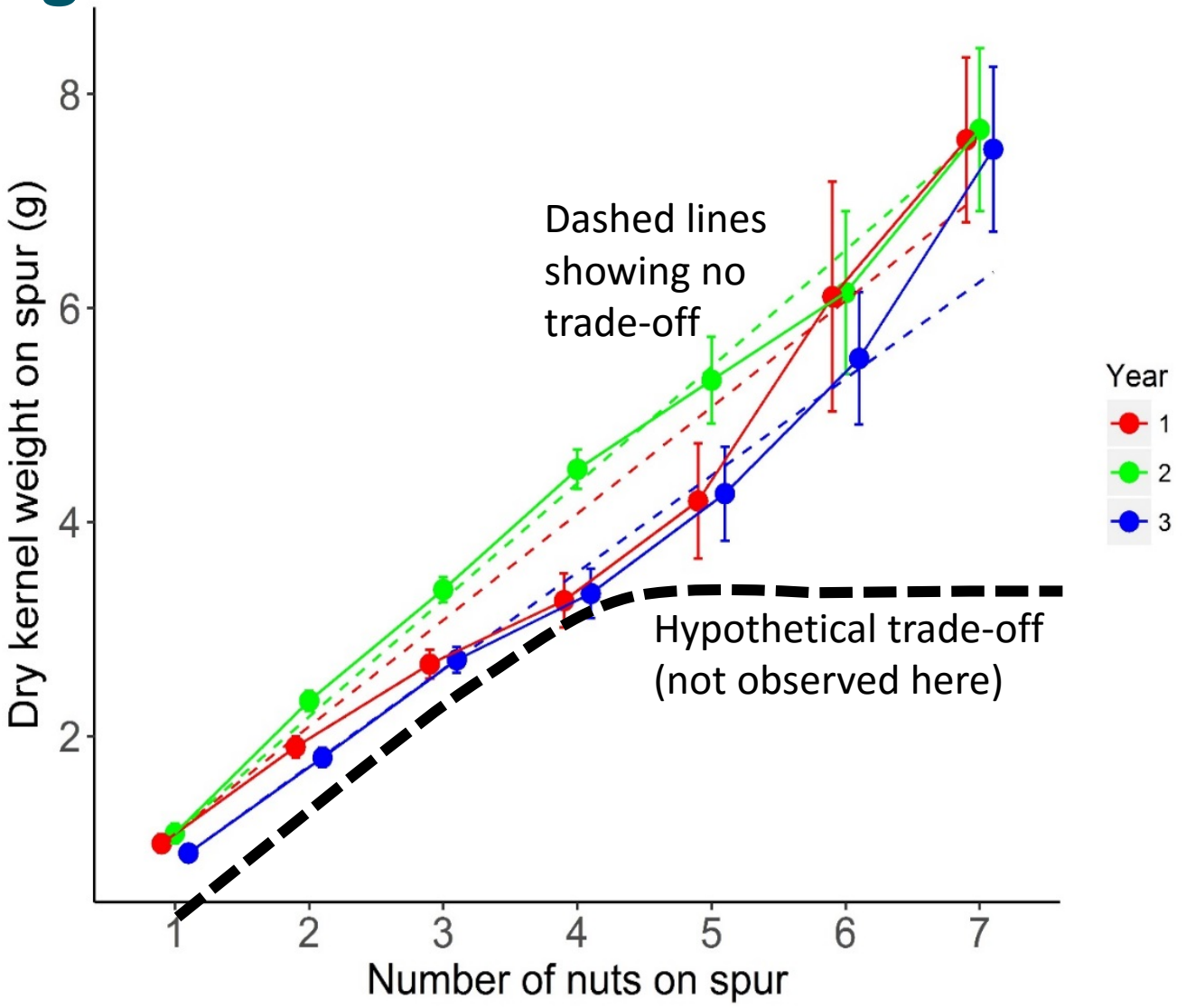
where x is spur height above the ground in meters

and light is proportion of incoming PAR

1. Result: Spurs with more light produce more nuts



1. Result: Minimal trade-off in terms of nut number and weight



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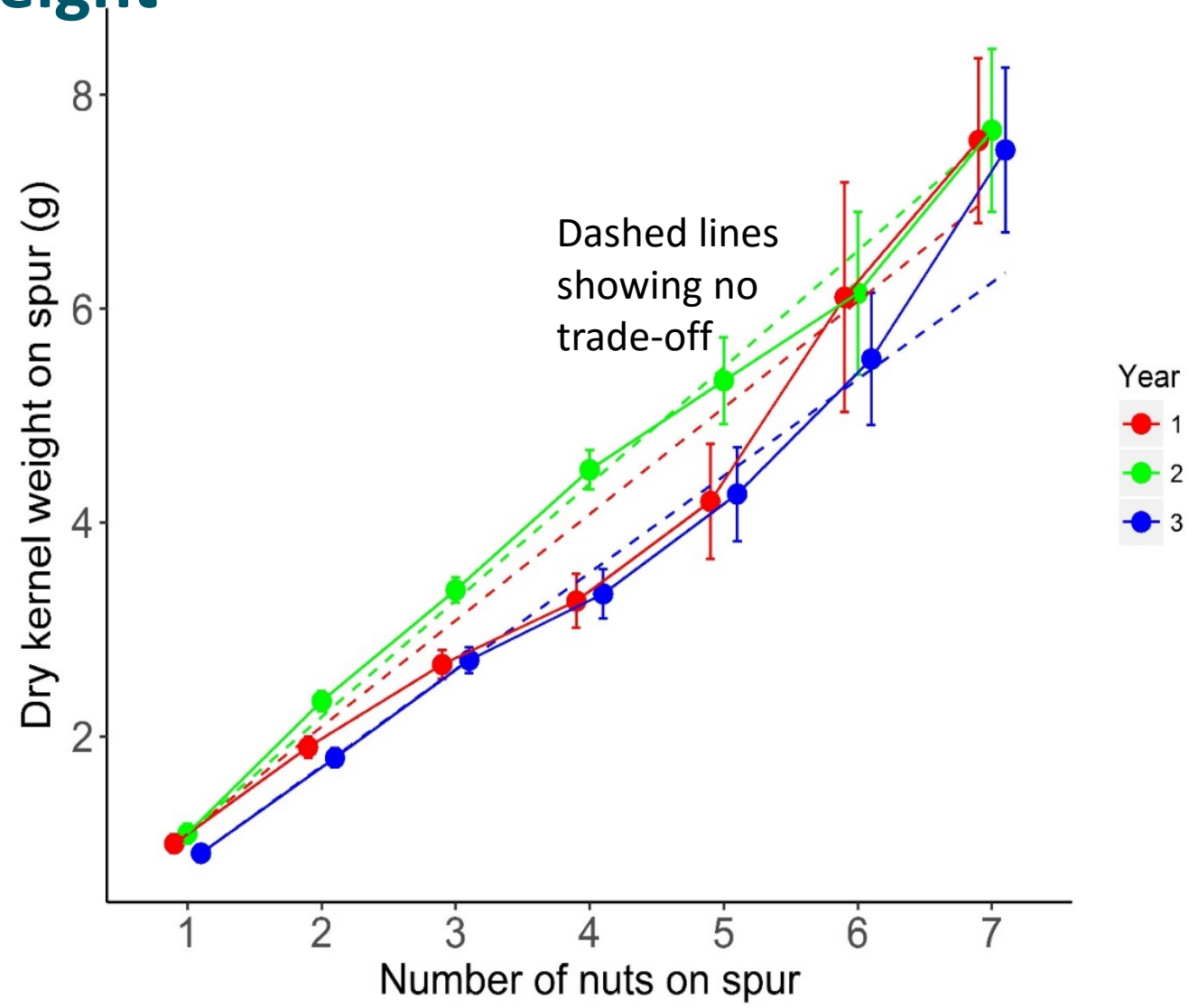


Presentation today

1. Does resource availability such as light and leaf area influence flowering and fruiting at spur level? (Yes, positive relationship)

2. Does whole tree application of pollen translate into higher yield of nuts?

3. Can we make more profit if we improve pollination (economic analysis)?

2. Whole-tree pollen application

- Applied pollen in suspension to 12 (yr1), 24 (yr2), 12 (yr3) trees per year, compared to control trees with standard pollination by bees.

- First spray when trees were at 45-65% flowering, second spray at 90-100% flowering.

- Pollen solution included Boron to help maintain pollen viability, control trees in years 2, 3 were sprayed with Boron solution but no pollen.

2. Collecting pollen

2. Spray technique

2. Harvest

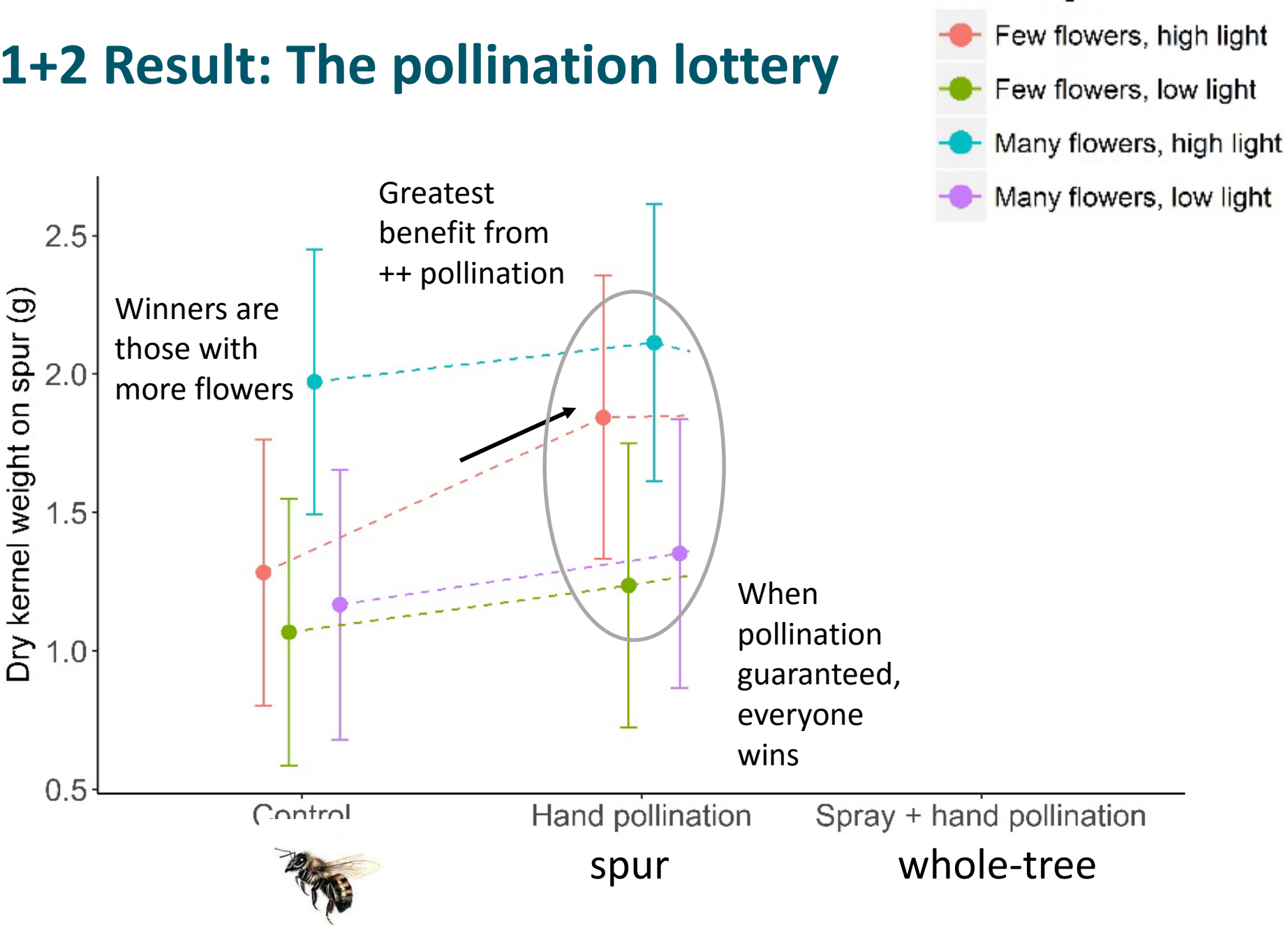
- Almonds from each tree were harvested separately for comparison of whole tree yield.
- Fruit collection area on the ground was delineated by the point halfway between trial and non-trial trees.
- Gross weight was recorded.

2. Result: Whole tree yield increased, but variable between years

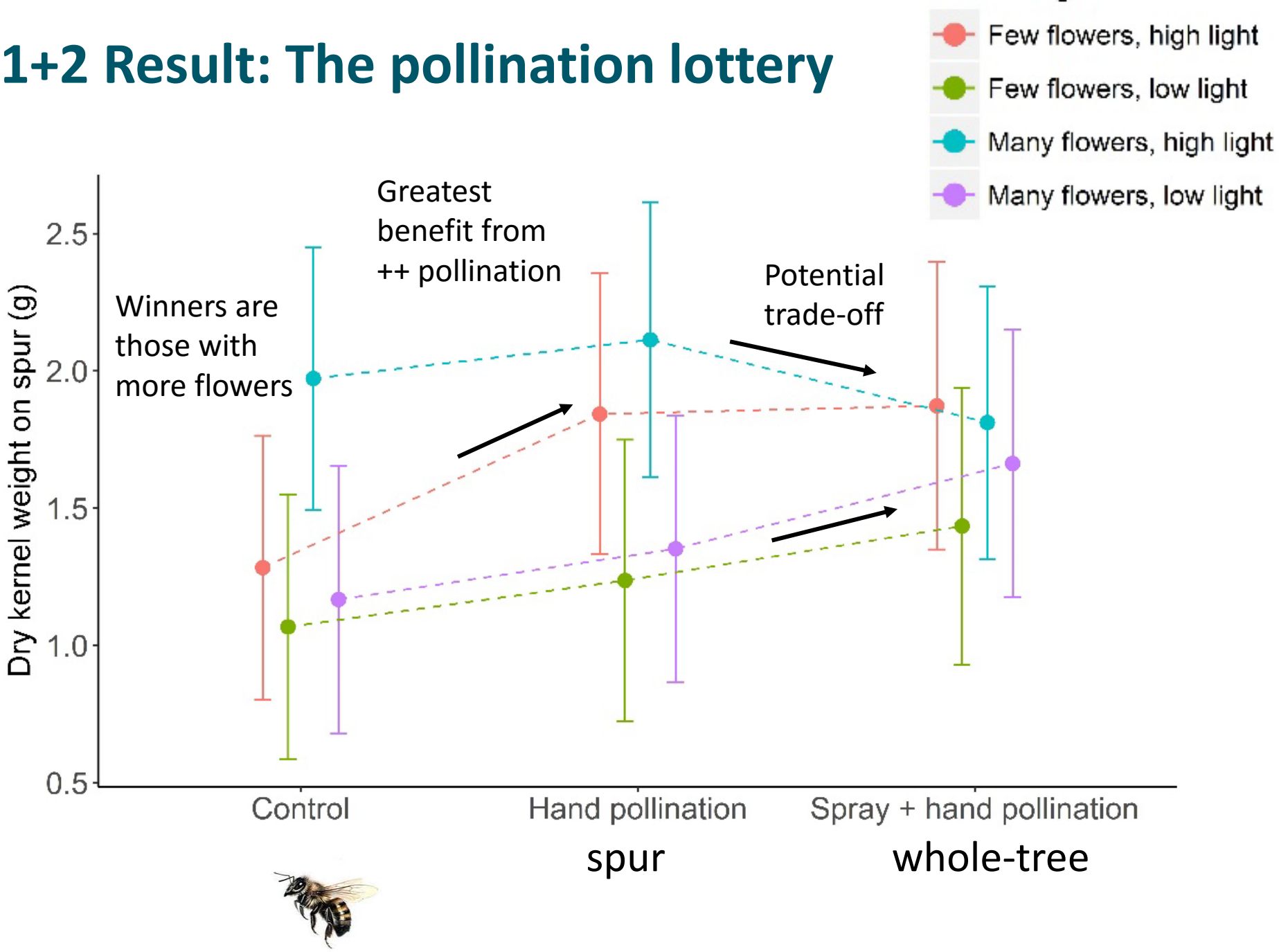
				Median yield (fresh weight kg)		
Experiment	Year	Block	Control method	Sprayed with pollen	Control	% difference
A	1	Upper	No spray	59	51	16
B	2	Upper	No spray	41	37	10
C	2	Lower	Boron solution	54	49	10
D	3	Upper	Boron solution	21	19	10

The results indicate that the whole tree spraying effect is primarily from pollen rather than boron, because the benefit in experiments A and B (no boron control) is similar to C and D (control includes boron).

1+2 Result: The pollination lottery



1+2 Result: The pollination lottery



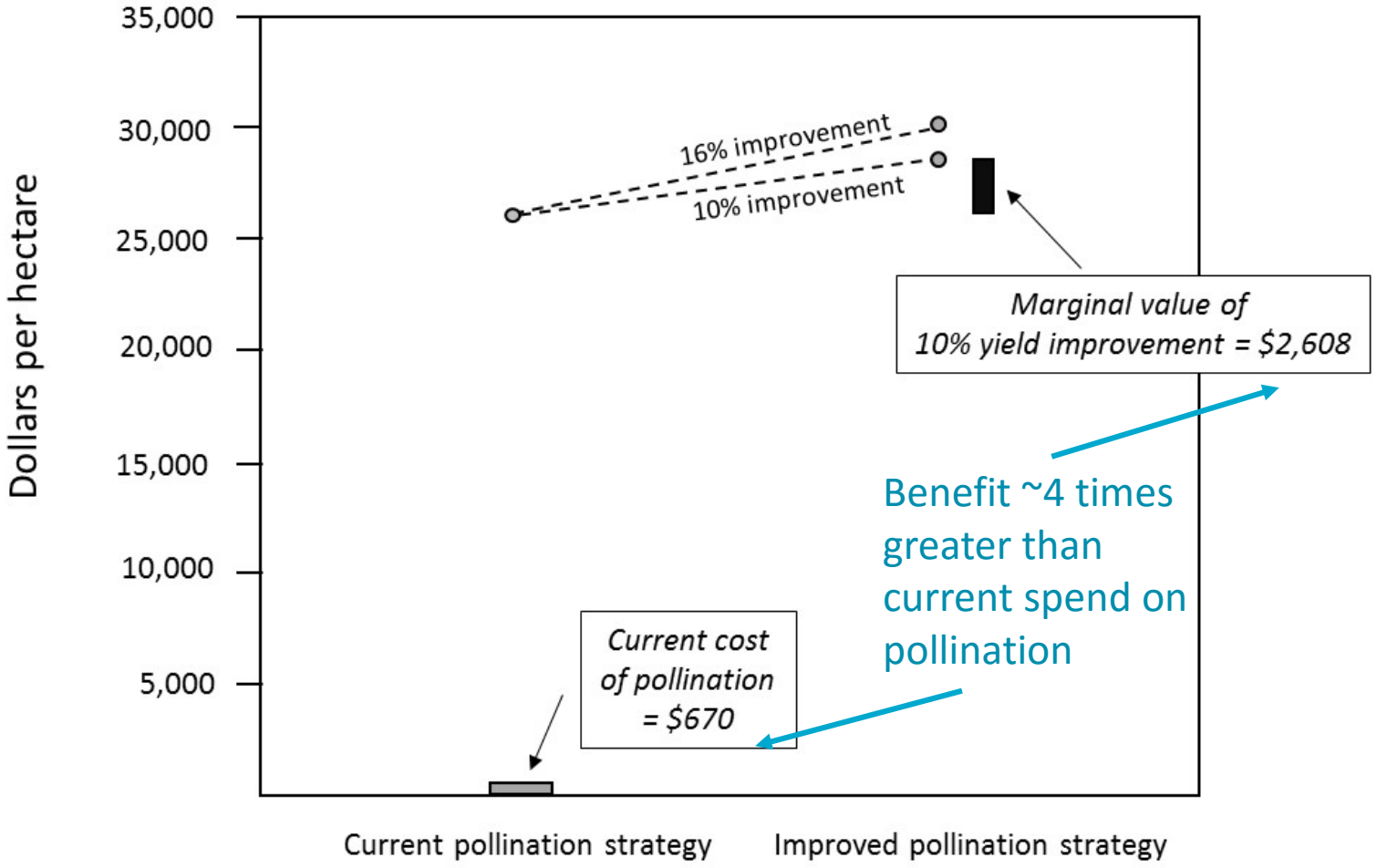
Presentation today

1. Does resource availability such as light and leaf area influence flowering and fruiting at spur level? (Yes, positive relationship)

2. Does whole tree application of pollen translate into higher yield of nuts? (Yes, minimal trade-offs observed)

3. Can we make more profit if we improve pollination (economic analysis)?

3. Result: Yes, this can potentially translate into increased profit



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Recommendations

- Our research shows that there is not necessarily strong trade-offs in nut quality. If you give trees ample pollination they will give you more nuts.
- Maximising flower production is the foundation for boosting nut production under current pollination practices.
- Orchard management strategies that decrease self shading will lead to greater nut production when combined with ample pollination.
- Strategies to further boost pollination by more effective use of managed bee hives should be explored further.

Next steps

Short-term

- Optimising research methods for whole-tree spraying.
  - Address variability across years
  - Scaling-up, increasing replication
- How to get more pollination from managed bee hives.
- Future orchard layout to maximise pollination. What benefit can we expect from insect pollination with self-fertile trees in orchards.

Long-term

- What are the opportunities for artificial pollination systems that facilitate whole tree pollination?

Thank you for listening!

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Hort Innovation
Strategic levy investment

ALMOND FUND

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- Nutwood orchards kindly allowed us to borrow their Hydra-lift for spraying trees.
- Danny Le Feuvre allowed us to collect pollen from his bee hives

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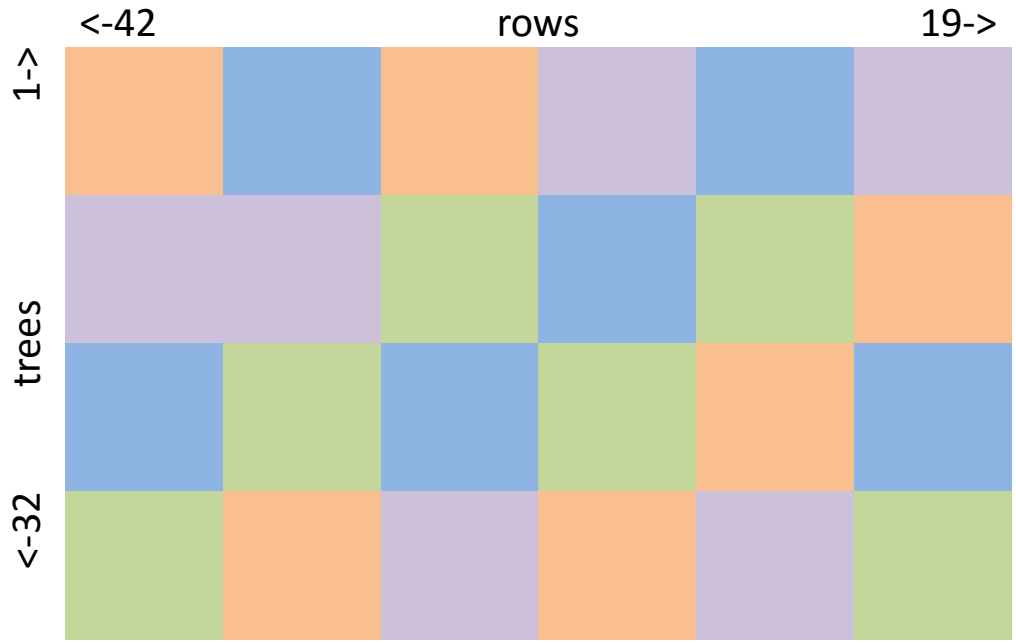
CSIRO

Non Pareil	Carmel	Non Pareil	Montere y
x	x	x	x
x	x	HP	x
HPS	x	OP	x
x	x	x	x
x	x	OP	x
HPS	x	OP	x
x	x	HP	x
x	x	x	x

Layout of trees in each experimental block of the main experiment. Each cell contains one tree. X marks trees that are present but not assigned to any treatment. HPS denotes trees with spurs hand pollinated and also a whole-tree pollen spray. HP trees had spurs hand pollinated, but no pollen spray. OP trees were open-pollinated according to normal orchard practice, with no pollen spray or hand pollination.



The layout of the main experiment, with each replicated block in the trial represented by a different colour, arranged in six replicates aligned with rows. Blue is normal orchard management, Green is normal water reduced N, Purple is reduced water, normal N, Orange is reduced water and N (See Monks and Taylor project for design details).

How do leaf area and light environment effect flower number at spur level?