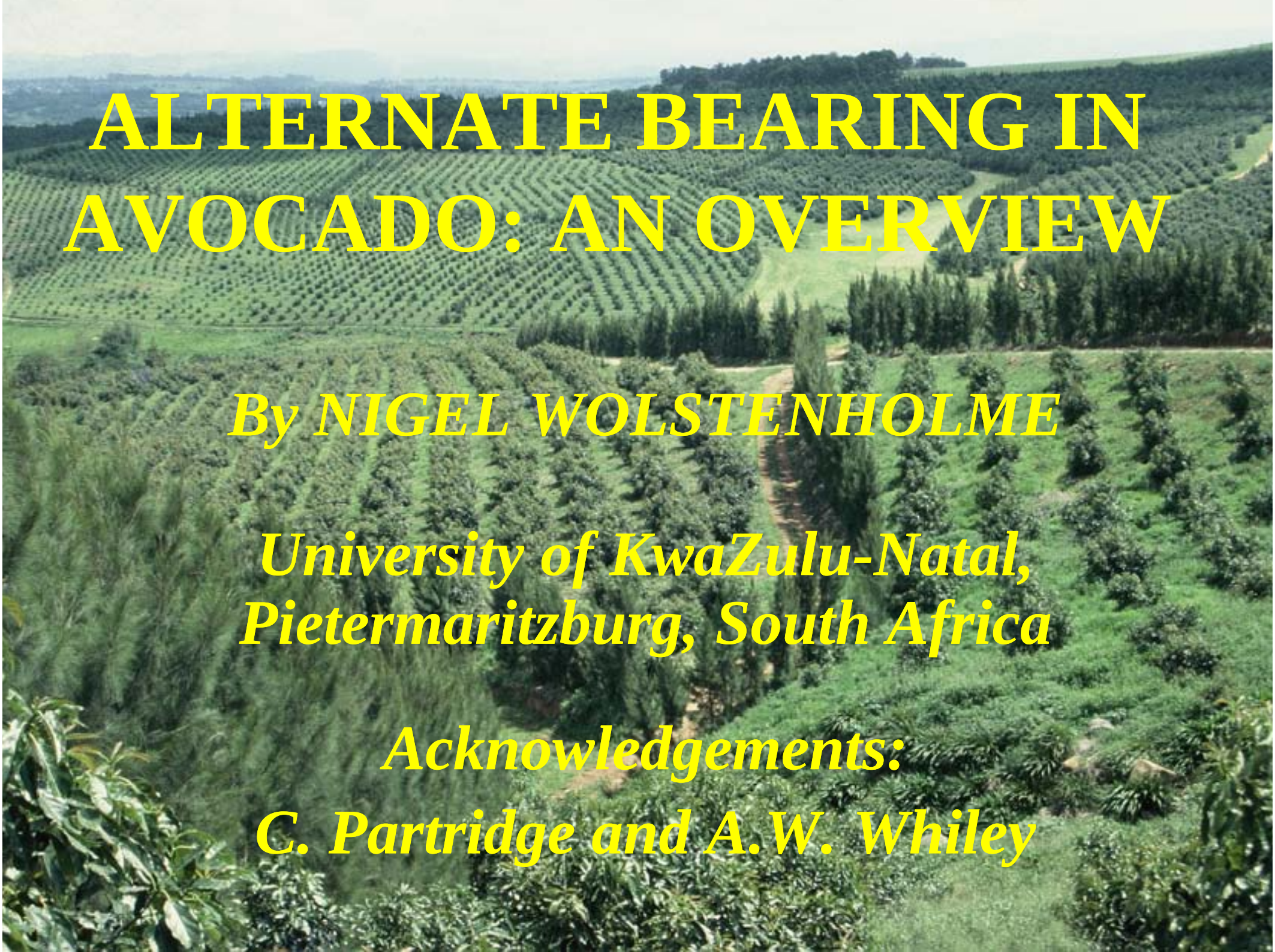

ALTERNATE BEARING IN AVOCADO: AN OVERVIEW

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Acknowledgements:
C. Partridge and A.W. Whiley

ALTERNATE (AND IRREGULAR) BEARING

- Are encoded in avocado genes through evolution
- A management and marketing problem nationally, regionally, in orchard blocks and even in a tree
- Once entrained, can only be reduced (in most situations)
- A full package of interventions necessary

DEVELOPMENT AND ENTRAINMENT OF A.B.

- Less pronounced in young trees
- Usually precipitated by first abnormal crop (heavy or light)
  - Frost or heatwaves (>33°C max) at or soon after fruit set
  - Min <10°C for several nights
  - Cyclones, severe storms, hail
  - Diseases, pests

Overbearing in a young ‘Fuerte’ tree caused by partial graft incompatibility leading to root stress. Note absence of summer flush (photographed in May). Very poor prospects for bearing in the following season.

Alternate bearing can even occur on a single tree

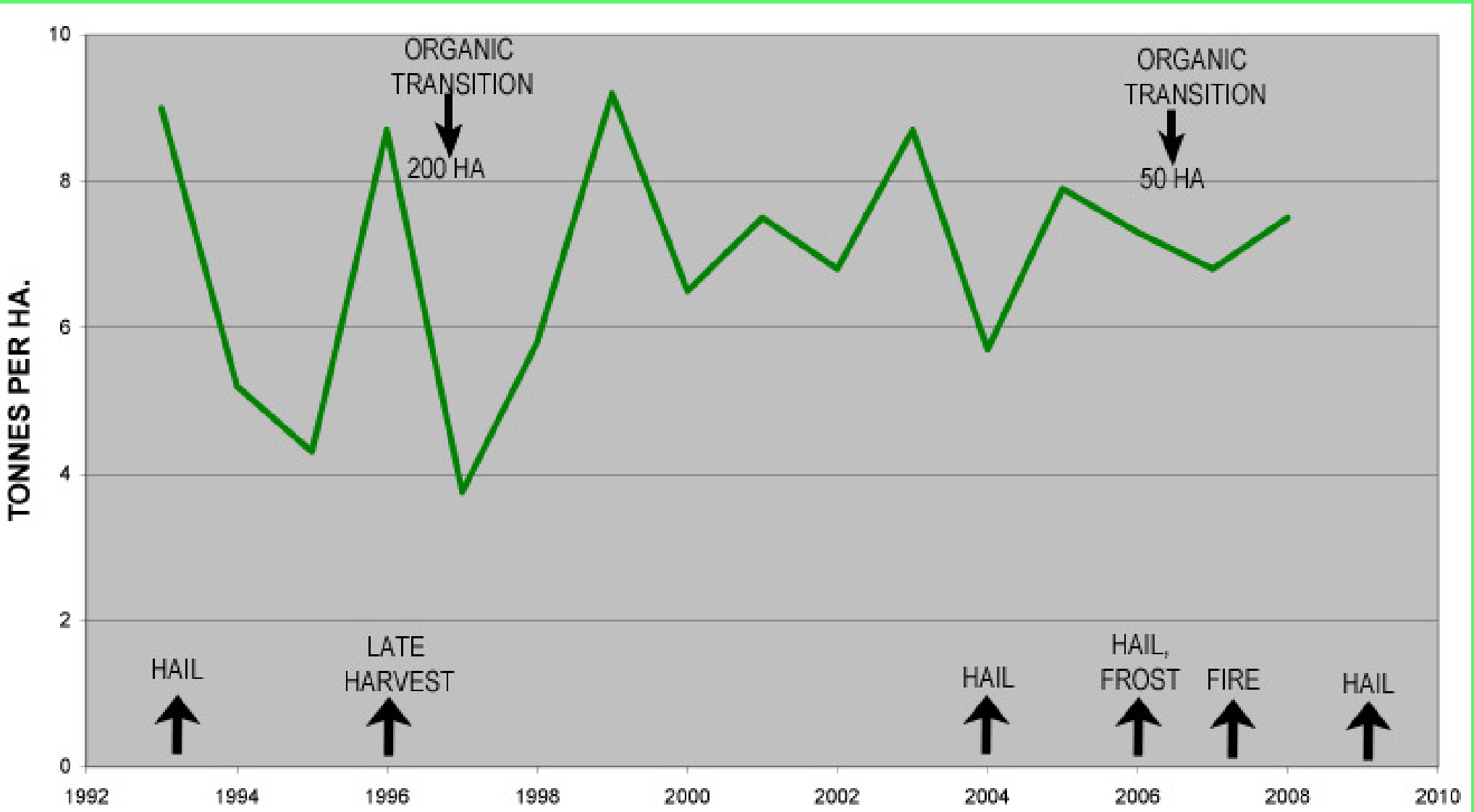
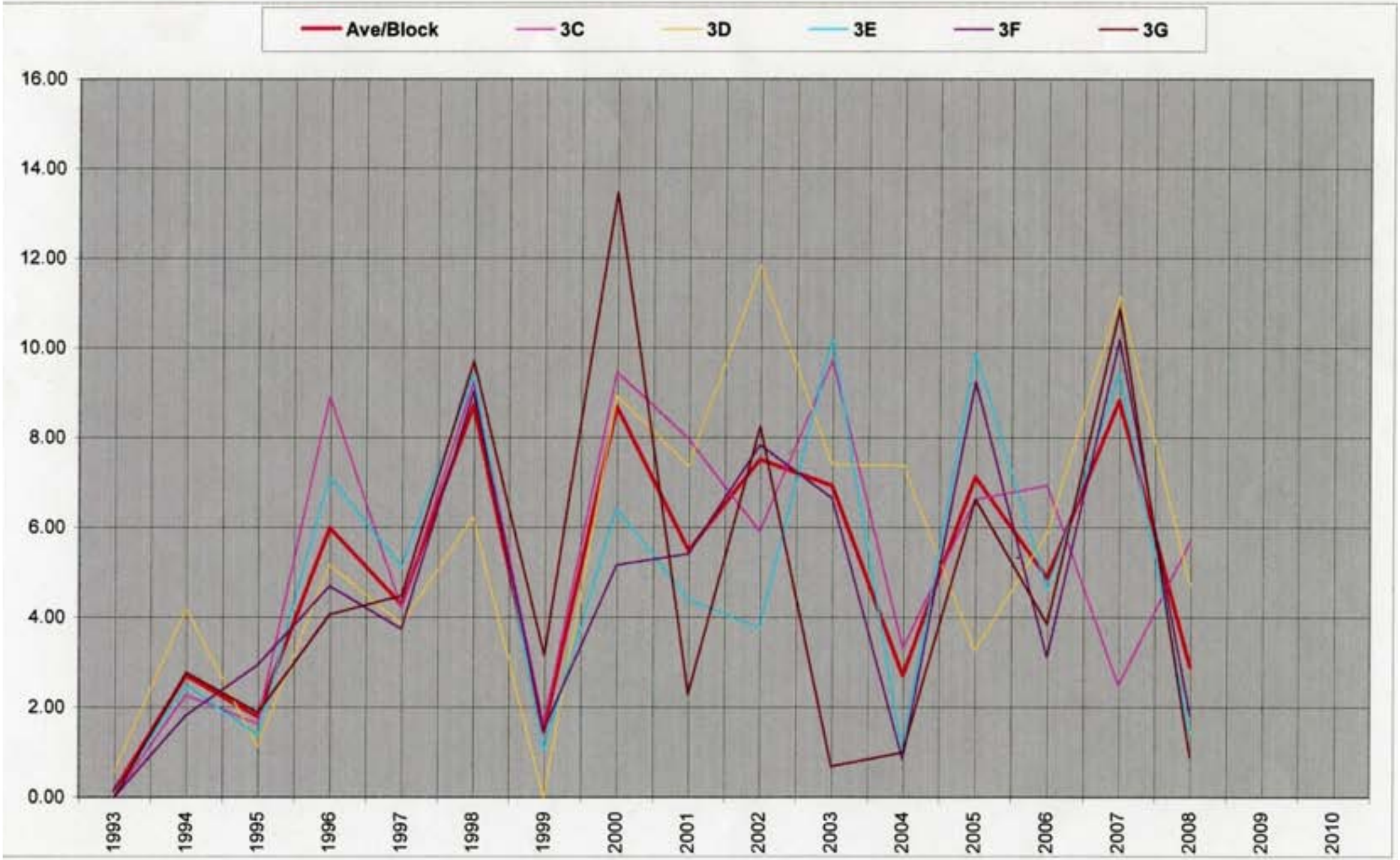


FIG. AV. ESTATE YIELD 250 HA., ALL CULTIVARS, ALL AGES


Ave/Block
3C
3D
3E
3F
3G
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

Some grower production data to illustrate Irregular Bearing

Year	T/ha	
1998	10.5	
1999	9.4	
2000	21.7	
2001	14.5	
2002	26.2	
2003	4	(despite good flowering)
2004	0.1	(despite heavy flowering)
2005	27.6	
2006	7.6	
2007	31.5	
2008	5.4	
2009	33.7	(estimated)

C. Partridge

ALTERNATE BEARING INDEX (ABI)

$$ABI = \frac{(\text{yield, year 1} - \text{yield, year 2})}{(\text{yield, year 1} + \text{yield, year 2})}$$

Values from O (no A.B.) to 1 (complete A.B.)

In California research orchards, ABI ranged from 0.57 to 0.92 (Lovatt, 1997)

As a percentage (x100) $\rightarrow$ 57 – 92%

SCIENTIFIC LITERATURE ON AVOCADO A.B. IS:

- Scare
- Co-incidental

REPORTED AS A RESPONSE TO TRIALS

- Cultivar, rootstock
- Canopy management
- Cultural practices etc.

CAUSES OF A.B.

The literature emphasizes two main theories:

- Depletion of starch (CHO) reserves by heavy ‘on’ crop; recovery during ‘off’ year.
- Seed-produced gibberellins reduce flower induction in nearby vegetative buds.

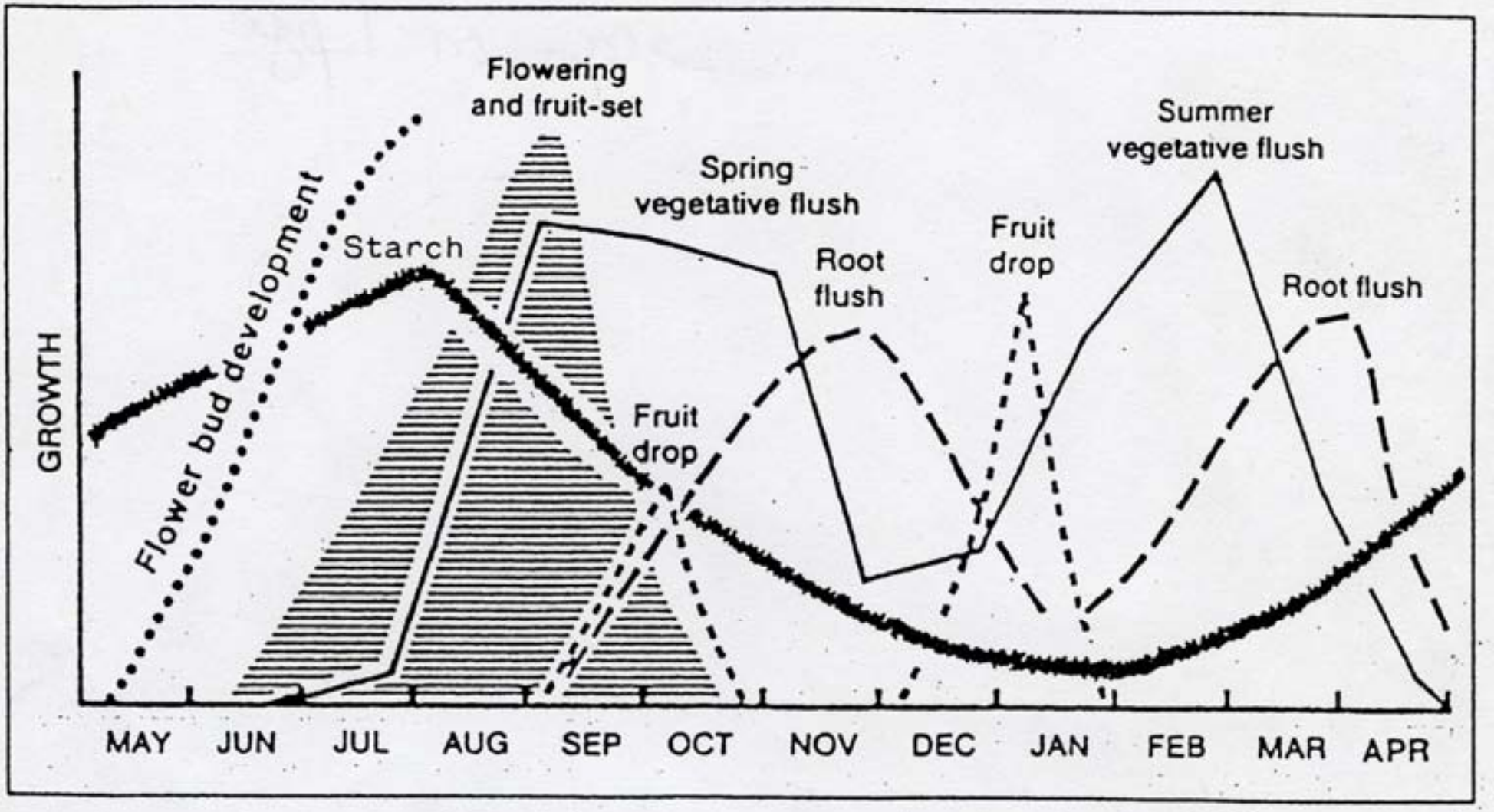


Fig 1 The total growth cycle of cv Fuerte showing the relationship between vegetative and reproductive growth and reserve starch in the trunks of trees (Whiley & Wolstenholme 1990).

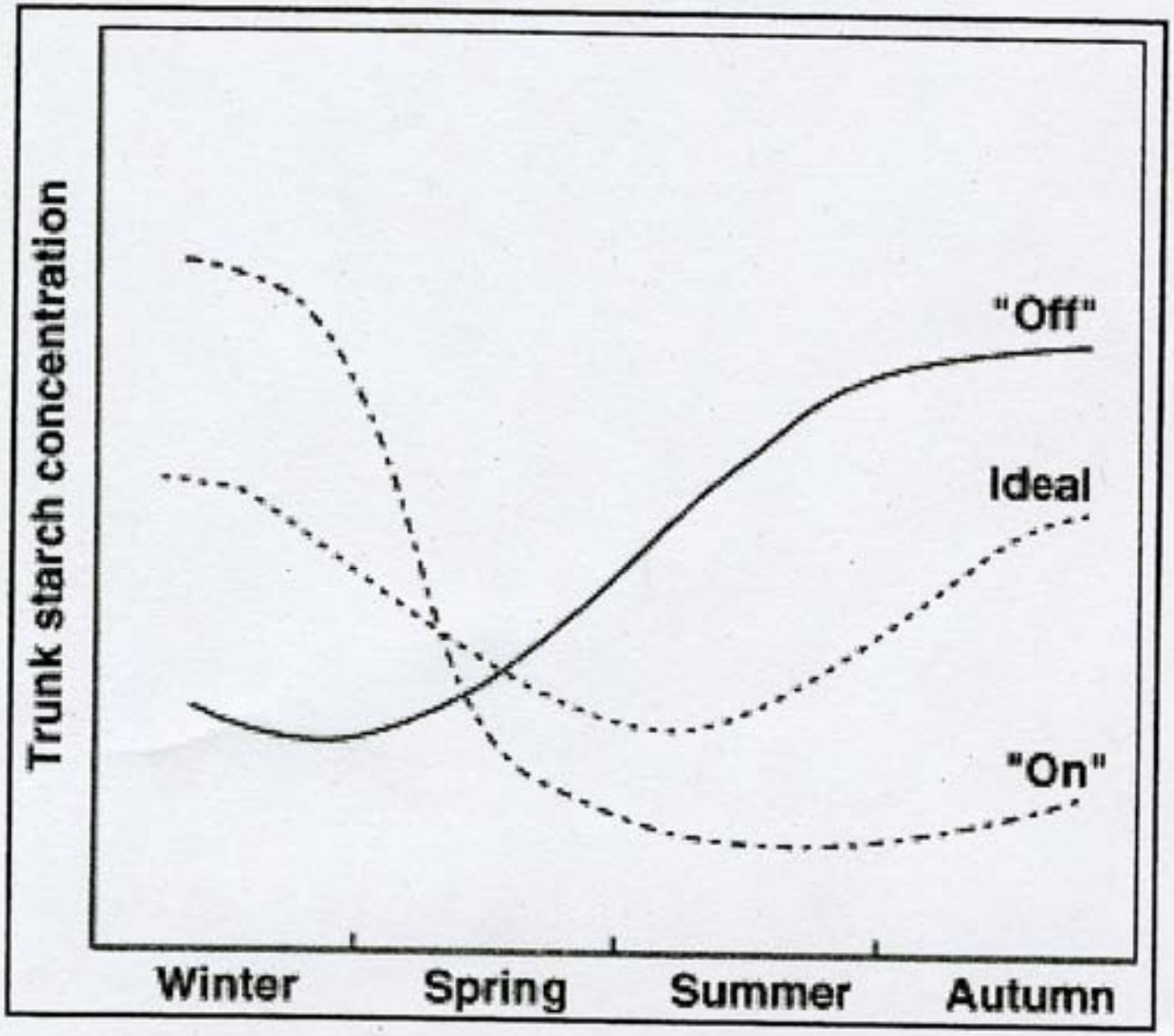
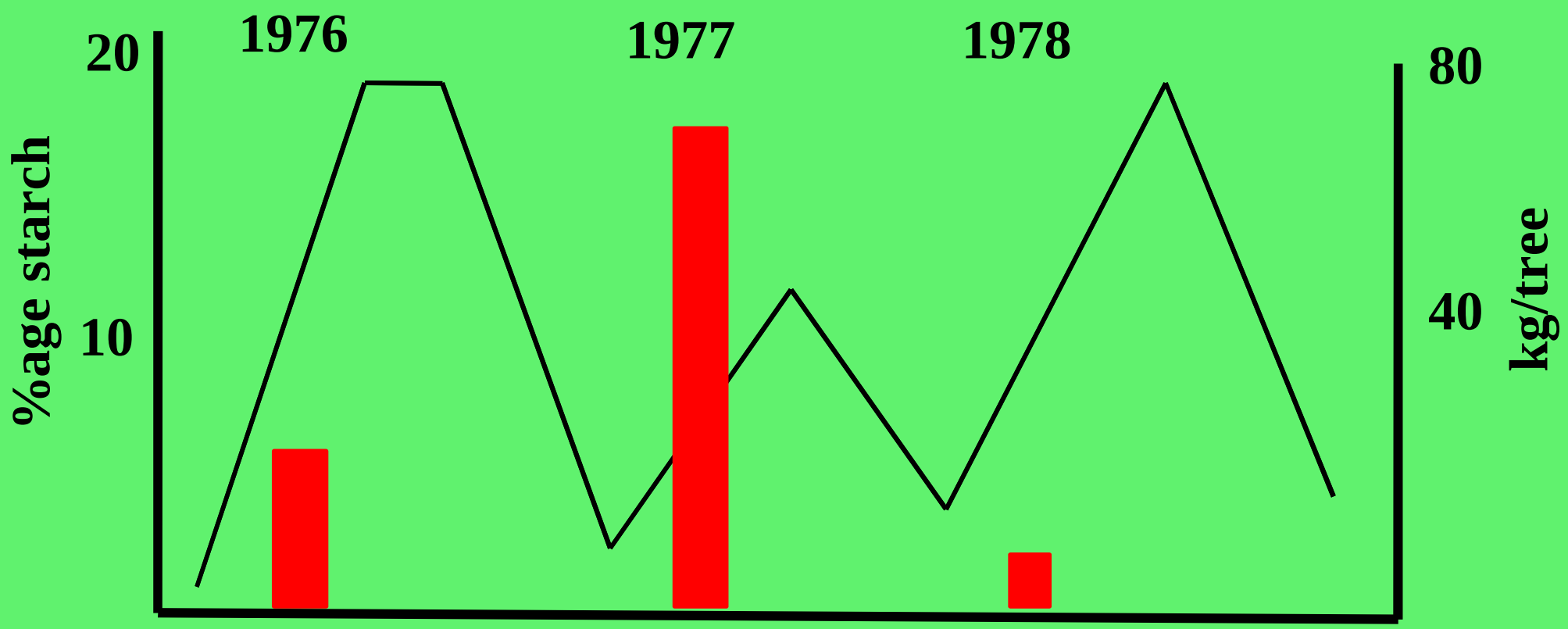
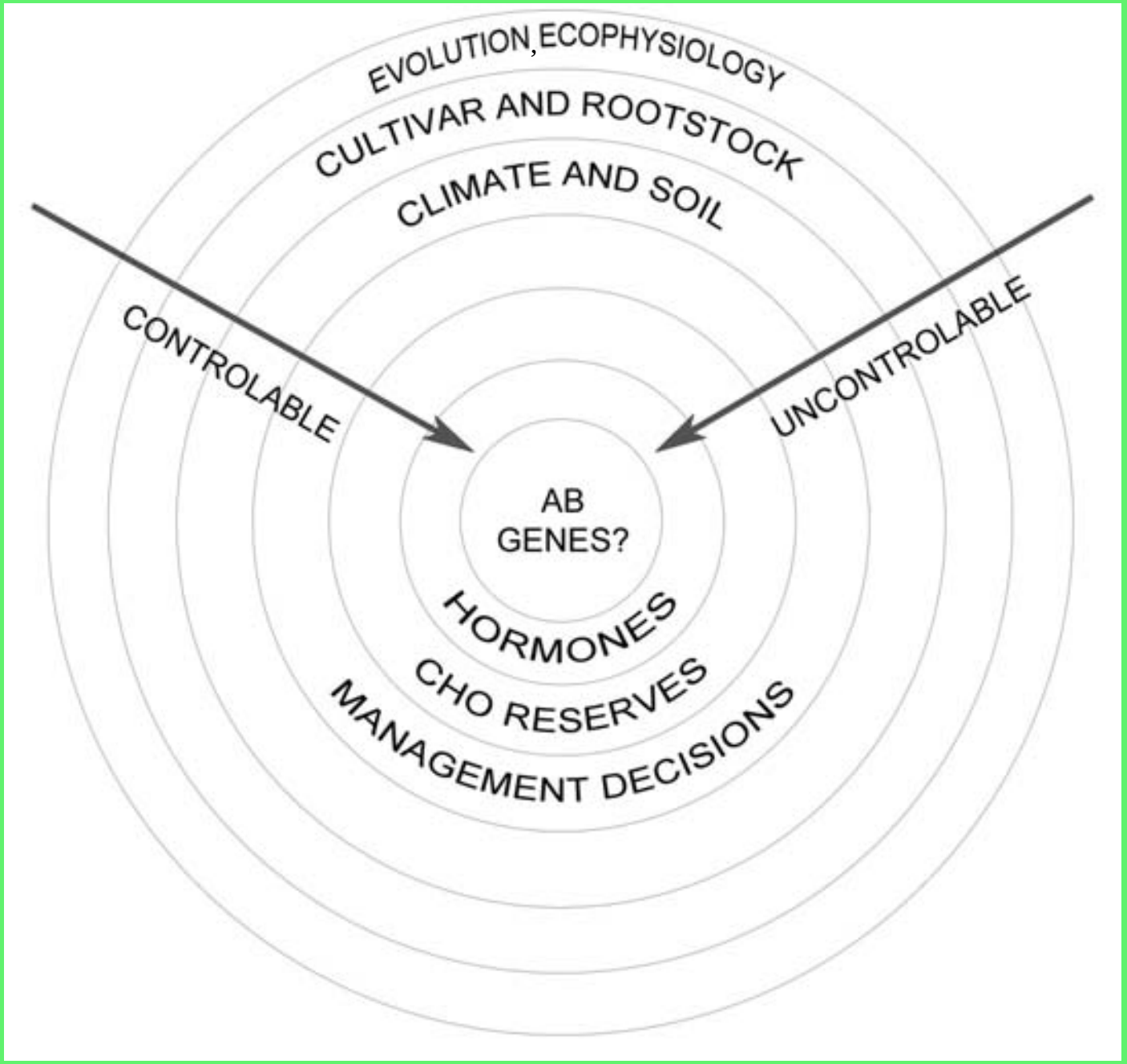


Fig. 19 Seasonal starch reserves in trunk wood of avocado trees in "on", "off" and "ideal" bearing seasons (diagrammatic)

Carbohydrate/Yield Relationships in Avocados



Source: Scholefield *et al.*, 1985



HIERARCHY OF FACTORS AFFECTING A.B.

CLONAL ROOTSTOCK EFFECTS ON A.B.

Mickelbart *et al.* (2007)

10 year study of Hass on 10 rootstocks in S. California:

- Phytophthora-free soils
- Soil salinity not a problem
- Berms to improve soil drainage
- Spacing 6.1 x 6.1m

RESULTS

- Trees showed A.B. on all rootstocks (RS)
- A.B. worst on ‘Topa Topa’ and ‘Toro Canyon’ RS
- Lowest ABI on ‘G755A, B and C’ RS (but lowest yields – no longer recommended)
- ‘Duke 7’ RS gave highest canopy efficiency (kg fruit per m^3 canopy)

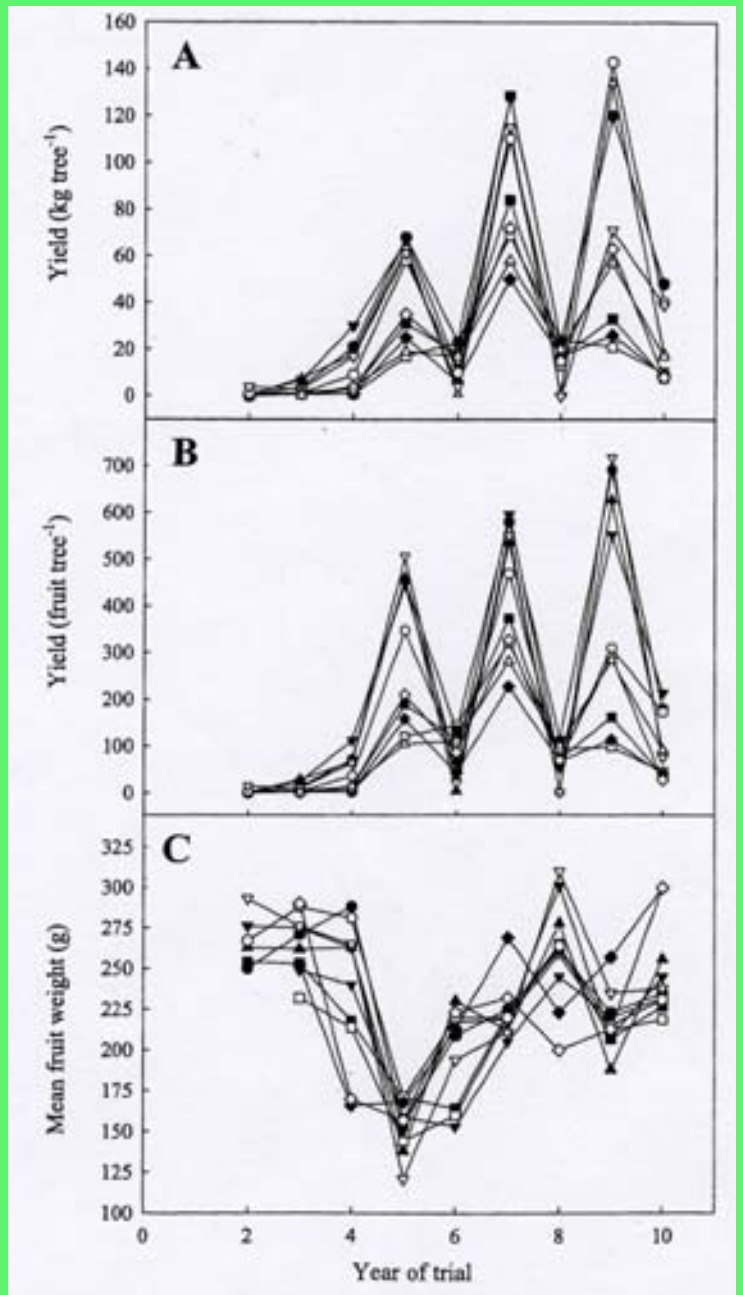


FIG. 1
Yield in fruit weight per tree (Panel A), yield in fruit number per tree (Panel B), and mean fruit weight (Panel C) of 'Hass' avocado trees growing on ten clonal rootstocks ['Borchard' (●), 'D9' (○), 'Duke 7' (▼), G1033 (△), G755A (■), G755B (□), 'G755C' (◆), 'Thomas' (◇), 'Topa Topa' (▲), or 'Toro Canyon' (▽)] 2 – 10 years after planting at the University of California South Coast Research and Education Center.

Mickelbart et al. (2007)

CALIFORNIA RESEARCH

Salazar-Garcia *et al*. (1988; 1998)

- ‘On’ year: 13% of shoots flowered next season
- ‘Off’ year: 46% flowered next season
- Spring veg. shoots (ex indeterminate flowering shoots) didn’t flush in the ‘on’ year if carrying fruits
- Heavy crop reduces no. and intensity of flushes
- Overwhelmingly indeterm. flowering shoots

MEXICAN RESEARCH

Salazar-Garcia *et al*. (2006)

In a subhumid, semi warm borderline tropical highland climate:

- One (main) winter flush and 3 minor summer flushes
- Stable flowering intensity of **all** flushes
- Good veg.: reproductive balance maintained
- Sufficient fruiting sites for return bloom
- A.B. reduced

WARM, HUMID SUBTROPICS

- Too few peripheral fruiting shoots at start of ‘off’ season
- Reduced flowering intensity at start of ‘off’ season
- This is the ultimate horticultural cause of A.B.

Garner and Lovatt (2008): no significant difference in % fruit set in ‘on’ and ‘off’ years in California.

Reduced crop in ‘off’ year therefore due to:

- Fewer potential fruiting shoots
- Reduced flowering intensity
- **Not** poor fruit set (in the absence of climatic upsets)

CAUSES OF ‘OFF’ SEASON REDUCED FLOWERING

- Excessive previous ‘on’ crop
- Greater drawdown of CHO reserves
- Reduced summer flush previous ‘on’ season
- Reduced root flushes previous ‘on’ season
- Reduced leaf replacement / renewal
- Fruit / seed gibberellins reducing floral induction previous ‘on’ season?

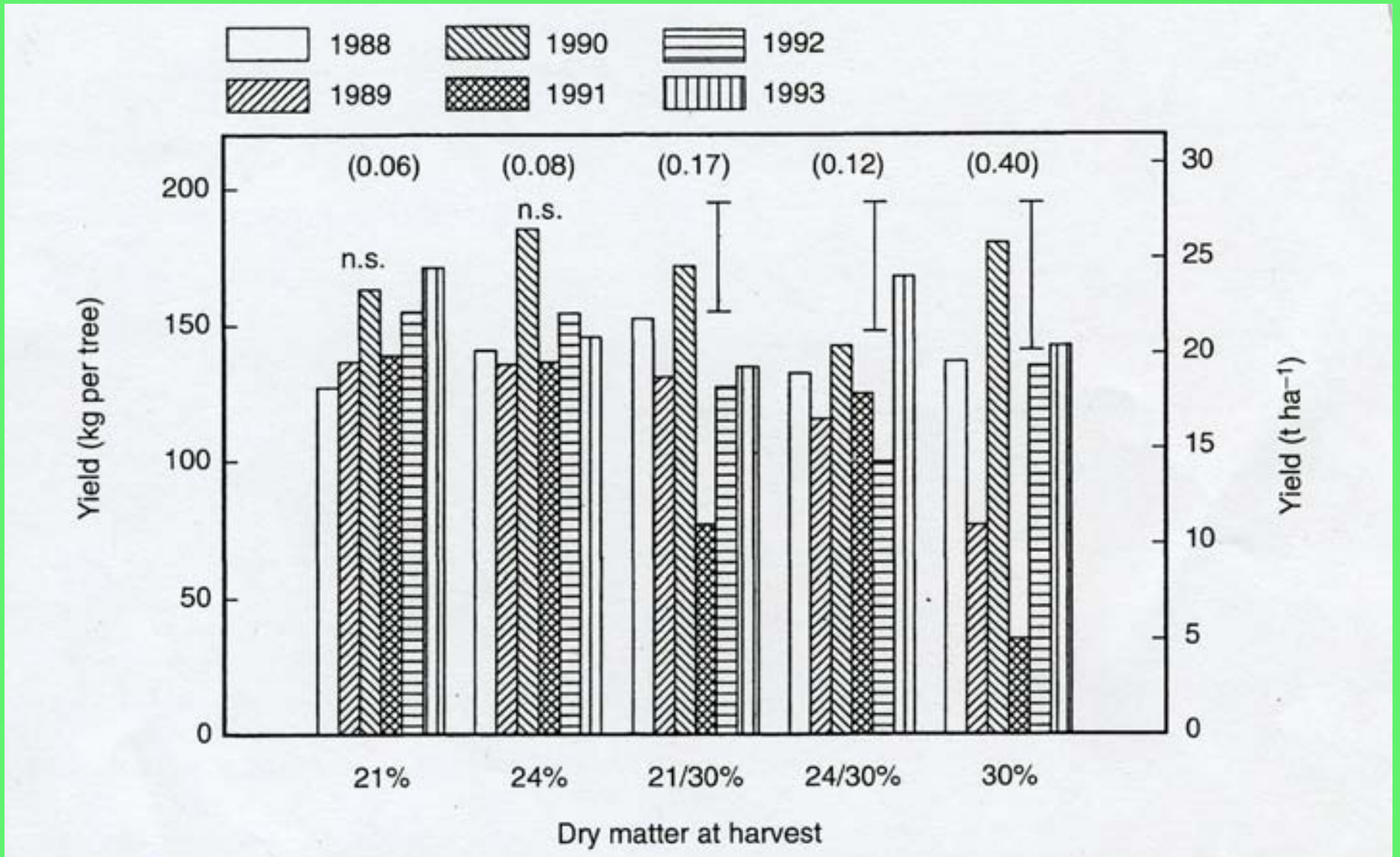


Fig. Effect of time of harvest on the sustainability of yield of 'Fuerte' avocado trees growing in south-east Queensland over 6 consecutive years. *I* values (alternate bearing index) for each harvest time based on dry matter values are given in parentheses. Columns are mean values ($n = 6$) and vertical bars indicate LSDs ($P \leq 0.05$) determined by ANOVA. (Reprinted from Whiley *et al.* (1996a), with permission of Elsevier Science (1996©).)

PRUNING AND A.B.

A major management intervention to reduce A.B.

- Reduce amplitude of ‘on’ and ‘off’ crops
- Vegetative: reproductive balance improved
- Encourage shoot flushing in ‘on’ year
- Techniques still being researched

GIRDLING AND A.B.

- Ancient horticultural tool to reduce vigour and improve fruiting
- Only use on healthy, vigorous trees
- Timing and size of cut critical
- Trunk vs branch girdling / scoring
- Use with caution – root starvation, leaf yellowing, tree stress

UNICONAZOLE (SUNNY™) AND A.B.

A single 0.5% or 1.0% Sunny™ spray significantly reduces ABI in young Chilean trees

- Young ‘Hass’ trees, 0.5% mid-bloom spray, two seasons
- Well illuminated canopies
- Light annual pruning
- Soil applied urea in spring may enhance reduction of ABI and increase leaf **N** in mature trees

(Whiley, A.W., pers.comm)

NUTRITION EFFECTS ON A.B.

- Little dedicated research other than ‘best practice’ based on field trials
- More research on N **timing** (Lovatt, 2001) and **amount** to promote flushing in ‘on’ year

  But
- Danger of excessive fruit flesh N levels
  - Fruit flesh disorders
  - Especially in Pinkerton
- Different leaf optima for ‘on’ and ‘off’ seasons?

TIMING OF SOIL **N** APPLICATIONS

(Lovatt, 2001)

- California standard is 6 split applications
- A double application at floral anthesis / early fruit set significantly reduced A.B.
- This increased total **N** application from 168 to 196 kg/ha/an.
- ABI was reduced from 0.90 to 0.72
- Four year (two A.B. cycles) study on 20 year Hass on Duke 7

GA3 APPLICATION TO REDUCE FLOWERING ('ON' YEAR)

Salazar-Garcia and Lovatt (1998, 2000)

Can GA_3 sprays manipulate flowering?

100 mg/l GA_3 applied early winter before an 'on' bloom:

- Reduced no. of inflorescences
- Increased no. of vegetative shoots
- Reduced 'on' yield by 47%

Spray at ‘cauliflower’ stage:

- Indeterm. veg. shoot develops earlier
- Reduced veg: reproductive competition at fruit set
- Higher yield ‘on’ and ‘off’ years

Potential for reducing A.B.

More research – concentration, timing etc.

KEYS TO REDUCING A.B. AND I.B. IN NEW ZEALAND

- Site selection, including aspect
- Encouraging earlier shoot flush
  - Soil temperature >15°C
  - Phytophthora / flooded soils
  - Earlier harvest, especially ‘on’ crop
  - Problem of prolific fruit set
  - Nutrition, especially **N** and **K**

Assuming *Pc* is under control, **cold/inclement weather over flowering is the main cause of IB** in my opinion. So site selection, shelter, pollinizers, canopy management & bees are very important to minimise……

‘Empty’ panicles

C. Partridge

Anything that inhibits flush development contributes to AB and abnormally heavy sets are a major inhibitor of Spring flush development & starch accumulation

C. Partridge

Prune July to end September to force new growth in an expected ‘on-year’.

5. Pollinizers - Zutano, Ettinger & Bacon - ***definitely*** improve set in some seasons in NZ:-
(Observed two growers in Whangarei who *always* set some fruit, have a high % of pollinizers)

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…..I suspect heavy winter rainfall causing root damage even on good soils in NZ.

(Summer drought must also be implicated in IB & AB)

After the flood (note mounding)

C. Partridge

For tree height control, NZ needs new approaches:- ‘Flat topping’, ‘Chilean limb removal’ with PGR applications and higher density plantings are being trialled

C. Partridge

CONCLUSIONS

- Alternate / irregular bearing is normal in avocado
- Its extent is variable depending on many complex, interacting factors
- Our objective is to ameliorate the boom:bust cycle
- More intensively managed orchards
  - Smaller, more closely spaced trees
  - Pruning and girdling / scoring
  - Uniconazole growth retardant
  - Doing the basics right
- Longer term – new cultivars and rootstocks