Basics of biennial bearing and how to deal with it

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Theory of alternate bearing

- The physiology and management of natural variability in flowering and fruit set and its relationship to crop load and yield has been discussed for thousands of years.
- Initially, the reduced flower initiation rate was explained by sink–source interactions between fruit and developing buds with fruit attracting more carbohydrates and leaving new buds in the nutrient deficit.
- It was found that plant hormones and hormone-like acting compounds as cytokinin, adenine (promoters) and different gibberellins (inhibitors) are strongly involved in the flower bud induction.
- Proteome analysis revealed that particular sugar forms might play an important role in flower bud induction and initiation.

Theory of alternate bearing

- The picture of flower bud induction mechanisms in apple is far from complete.
- Despite achievements in genomics, even the newest genome versions still cannot provide sufficient information about promotors and repressors of flowering.
- It is still unclear what is the initial trigger for floral meristem formation and how the fruit may inhibit flower development in the adjacent spur buds.

Proper light conditions inside the canopy.

- Training systems
- Pruning
- Reflective mulches

Optimal balance between vegetative and reproductive growth.

- Pruning
- Training
- Rootstock
- Nutrition
- Irrigation
- …

Crop load management

One recommendation simply does not exists

Factors affecting crop load level

- tree health status,
- tree age,
- growth vigour,
- canopy volume,
- rootstock, rootstock - cultivar combination,
- orchard management practice,
- pruning and training,
- cultivar genetics,
- climate

Tree growth vigour

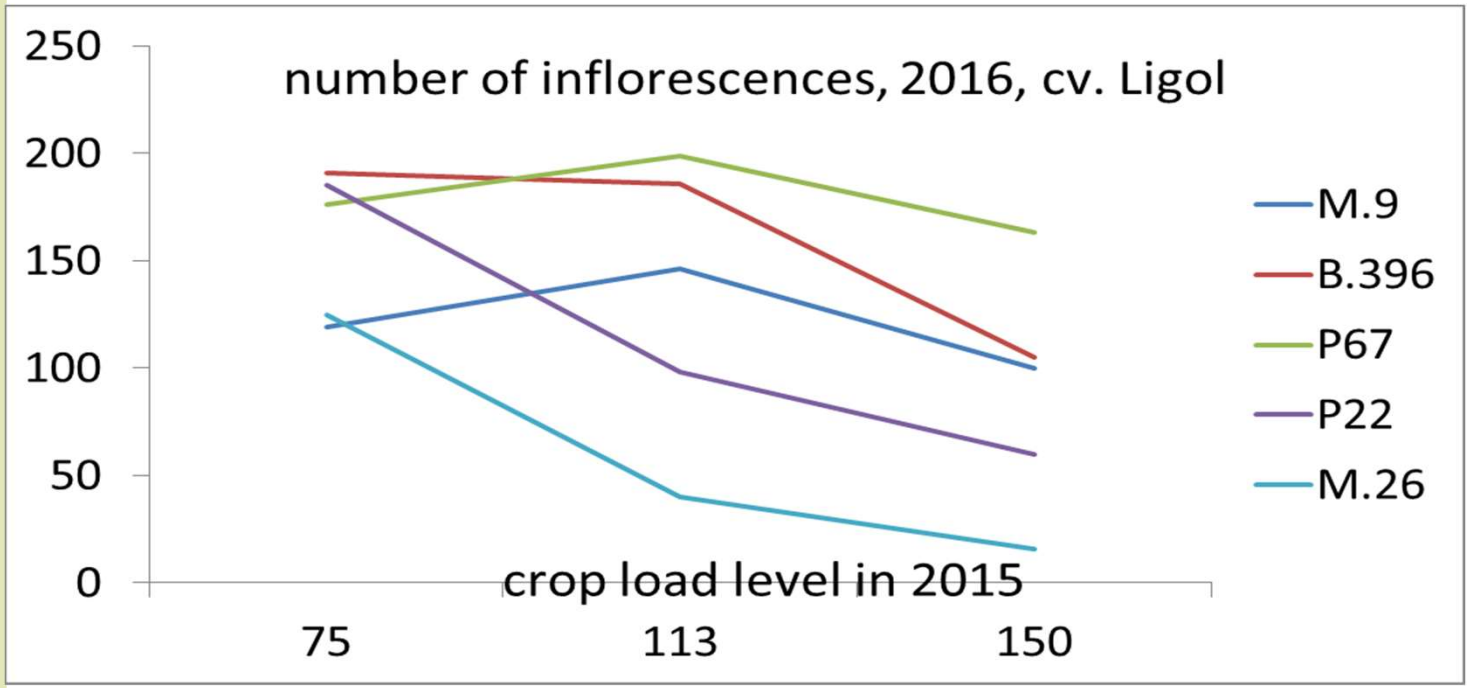
Enough leaves to support fruit growth and enhance flower bud differentiation

Rootstock and crop load effect on bearing stability

Stable yield at 35 t/ha level was achieved on M.9, B.396 and P 67 rootstocks regulating crop load at 113 fruits/tree level.

To achieve desirable return bloom keeping 150 fruits/tree (50+ t/ha) was possible only on P 67 rootstock.

Growing on M.26 or P 22 crop load should be decreased till 75 fruits/tree level in order to avoid biennial bearing.



(Kviklys et al. 2020. Frontiers in Plant Sci.; Kviklys et al., 2018. ActaHortic.)

Cultivar genetics

Three types of cultivars:

- biennial bearing (Elstar, Summerred, Fryd, Eden etc),
- regular bearing (Rubinola, Gravenstein, Gala etc),
- intermediate, which is easier to maintain in regular fruiting mode (Aroma, Rubinstep etc).

Different crop load management strategies for every type of cultivar

Eden and Fryd

Extremely high set.

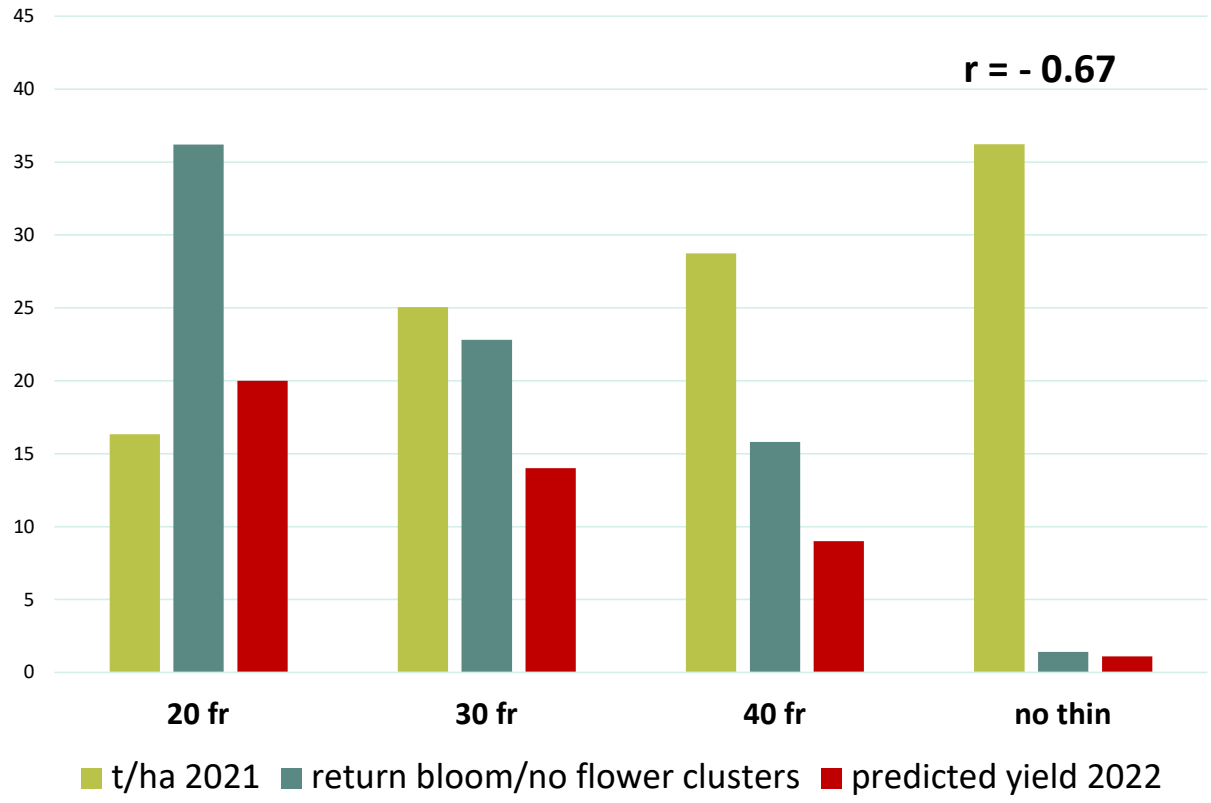
Strong fruitlets

No self thinning

Eden return bloom in 2022, after different crop load levels in 2021

- Thinning at 20 fruits/tree or 5 fruits cm^2 TCSA gave 16 t/ha yields in 2021 and trees were able for 20 t/ha yield 2022.
- Thinning at 30 fruits/tree or 6,5 fruits cm^2 TCSA gave 25 t/ha yields in 2021 and trees were able for 14 t/ha yield 2022.
- Thinning at 40 fruits/tree or 8,4 fruits cm^2 TCSA gave 29 t/ha yields in 2021 and diminish yield 2022 till 9 t/ha
- **Strategy for Eden. Optimal crop load 3rd year 20 fruits (5 fruits cm^2 TCSA)**

cv. **Eden**: yield 2021 and **return bloom** and predicted yield 2022.



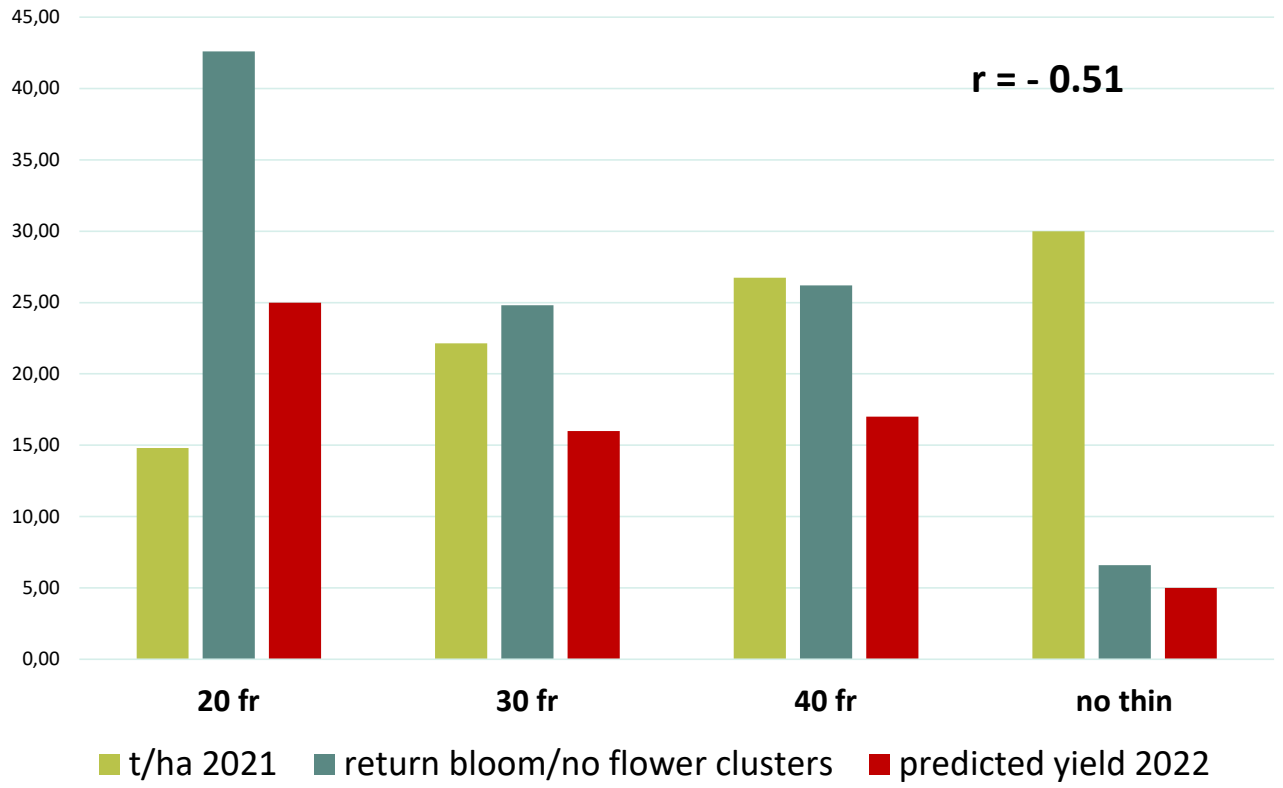

Fr. 8
20 fruits/tree


FRYD
40 fruits/tree


Fr. 7
Not thinned

- Fryd was less sensitive to higher crop levels: thinning at 30 or 40 fruits per tree or 6,5 or 8,5 fruits cm^2 TCSA gave 22 – 26 t/ha yields in 2021 and trees were able for 16-18 t/ha yield 2022.
- Thinning at 20 fruits/tree or 5 fruits cm^2 TCSA gave 15 t/ha yields in 2021 and trees were able for 20 t/ha yield 2022.
- **Strategy for FRYD.** (Calculated) **Optimal crop load 3rd year 25 fruits (5.5 – 6 fruits cm^2 TCSA).** Yield – 18-20 t/ha, return yield – 20-22 t/ha (4th year).

cv. **Fryd**: yield 2021 and **return bloom** and predicted yield 2022.



Tool, developed by INRA France, gives a number of fruit per branch diameter

The young apple thinning gauge developed by Cornell, US, gives a number of fruit per trunk cross-sectional area

Stages of crop load management

- Pruning (dormant)
  - reduces competition for carbohydrates and nutrients, eliminates the source of plant hormones which inhibit flowering for the next season
- Pruning of spurs at pink bud stage
  - Sets target fruit number, enhance spring uptake of nutrients, thus resulting in better fruit set.
- Thinning
  - current commercial practice using chemical thinning does not produce reliable and predictable outcomes.
  - ‘’spray and pray’’
  - but plant growth regulators (NAA, ethephon) can promote return bloom
  - hand thinning

Thinning time effect on return bloom

Hand thinning after June drop normally has a positive effect on fruit size but is too late to stimulate flower bud development.

The earlier the target number of fruits per tree is achieved, the stronger the stimulation of flower bud development and bloom in the next season.

Some tips

- Remember, that we always are growing two crops of fruit on our trees: the crop that will bear fruit this year, and the juvenile buds that will develop into next year crop.
- Keep the balance of vegetative vs. reproductive growth in our trees
- Regulate crop load right from the beginning. If let young trees to overcrop it is much harder to avoid biannual bearing in later years

Some tips

- All measures what we do to increase light penetration and carbohydrate reserves, and/or reduce tree vigour should promote flowering and fruiting in the following year.
- On the other hand, if we grow vigorous trees with dense shaded canopies, and if we over-irrigate or over-fertilize trees by nitrogen, the risk of inhibition of floral initiation and the risk of biennial bearing pattern increases.

Concluding remarks

- Managing of crop load is one of most important tasks of apple growers.
- It lets to achieve a balance between proper yield of optimum fruit quality in the current season and good return bloom in the next year.
- For each cultivar and orchard there is an optimum number of fruits per tree.
- Optimized crop loads according to cultivar, tree training, and orchard management system in a particular environment leads to the best financial returns.