Potential and Limits of Pesticide Free Apple Growing by a Self-Regulating Orchard Set-Up: Project Presentation and First Experiences

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Abstract

Different research groups have already proven that flowering plants in orchards can enhance beneficial arthropods. Even within the tree rows different beneficials can be supported by selected plant species. In most experimental work done to stabilize the apple production system only single interaction effects were tested. However until now, no research group has quantified the additive effects of multiple measures on system-biodiversity and on the production economy.

Our experiment combines all known measures of indirect pest and disease control measures in a near-to practical production model orchard without the use of any pesticide (not even organic ones). The orchard is split in 4 blocks: in two of them bio-control measures e.g. application of Granulosis Virus against codling moth (C. Pomonella) are applied; in the other two blocks no bio-control is applied. Standard commercial organic and integrated orchards with the disease-susceptible cultivar Gala in the vicinity of the model orchard are assessed by the same methods and serve as reference.

Our intermediate results reveal that the self-regulating orchard developed already in the 2^nd and 3^rd leaf a clearly higher flora and fauna biodiversity compared to the reference orchards. The same happened in relation to the specific fruit beneficials e.g. the populations of aphid predators. In the self-regulating orchard they were capable to keep the aphid damages – in particular of the powdery apple aphid (D. plantaginea) - on trees and fruits under a commercially relevant level although the initial abundance of aphid colonies in spring was by far over the common threshold value. It is planned to continue the experiment until 2016.

Keywords: sustainable, apple, production, biodiversity, self-regulation

Experimental sites and set-up

The experimental orchards were planted in Nov. 2006 and are situated north-west of Switzerland (canton Aargau). Mean annual rainfall is 900 mm; mean annual temperature is 8.6 deg. C. The soils are medium to heavy brown soils with 18 % (Remigen and Lupfig) and 49% (Frick) of clay.

The acreage of the self-regulating orchard in Frick (Fig. 1) and the standard commercial reference orchards in Remigen and Lupfig is, with more than one hectare per site, relatively big in order to avoid edge effects that could influence the measurements in the central assessment plots. The twice per site replicated plots where the agronomic and ecological assessments are taken are situated in the centre of each orchard, have an acreage of 20 x 20 m (14 trees in 5 rows in Frick) and a distance to the edge of the tree rows or to the other assessment block of at least 8.4 m, up to 20 m.

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The parameters assessed comprise:

- Agronomic data such as yield (per quality class), tree growth, damages/losses by pests, diseases and physiological disorders; tree nutrition and soil fertility parameters; economical assessment for labour, input use and income and calculations of the profitability of the different systems.
- Biological assessments: Abundance of flora and fauna species. In particular pests and beneficials for fruit production, but also specific ecological indicator species.

In the self-regulating orchard in Frick 16 different and in standard orchards normally not found measures to increase the self-regulating potential against diseases and pests have been installed:

1) Soil sanitation with a 2-year lasting grass clover mixture before planting
2) Improvement of the structure of the topsoil by application of ripe compost into the tree strips 1 month before planting in Nov. 2006
3) Use of scab-resistant cultivars (Ariwa and Topaz)
4) Topaz grafted on interstem to avoid phytophtora disease
5) Use of rootstock Supporter II as a proven better rootstock in the establishing phase under organic conditions
6) Cultivars are planted in alternating rows to avoid/slow-down the spreading of eventual cultivar-specific diseases and pests
7) Tree density is approx. Only 50 % (1'666 trees per ha) of the usual commercial orchards in order to achieve a better light and air penetration into the tree canopies, though to prevent diseases.
8) For the pruning, shoot formation and crop regulation of the trees also the so called spur-extinction method after Lauri is applied in order to achieve a good aeration of the inner parts of the trees.
9) At all 4 edges of the orchard hedges were planted to provide a habitat for beneficial arthropods. The bush species planted were chosen according to their proven (by scientific publications mentioned in the reference list) capacity to be favourable for the well being of fruit-beneficial arthropods. In total 19 indigenous species are used. The width of the hedge is at least 3 m.
10) The centre row of the orchard, instead of a fruit tree row, we planted an additional beneficial-increasing hedge; however in this case, with cultivated species that produce eatable fruits (hazelnut, red elderberry, cornel cherry, blackberry, rosa-species for rose hip and service berry (*Amelanchier ovalis))*
11) Each hedge has two adjacent strips of min. 2 m width of extensively managed wild-flower mixtures. Towards the inner side it is a Salvia-mixture, mown 3 times a year (also for vole control). Towards the outer side it is a tall-forb mixture mown only once a year or every 2 years
12) In the alley ways a commercial species-rich mixture of ecotypes found in the prairies of the Jura Mountains has been sawn. These ecotypes of flowering dicotyledons support much better moving and mulching than the standard types of the same species.

13) The tree strips, to control the weed competition for water and nutrients, are not tilled over the whole surface but managed as “Sandwich-System”: A central stripe of 0.3-0.50 m width with flowering cover plants (e.g. *Hieracium pilosella* or *Potentilla reptans*) is established; meanwhile only the 2 outer adjacent strips of 0.4-0.5 m width each are tilled with the “SANDI” device, a specifically developed disc-plough. This system allows both, soft soil management, and an additional surface with flowering plants providing habitat for beneficials.

14) Artificial habitats for predators have been installed: birdhouses of different makes to attract different beneficial bird species e.g. tits, cages to attract bats for codling moth control, cages for weasels for mouse control, cages for overwintering of the green lacewing; we even dug a fox hole hoping him to help us with vole control.

15) To support the development of flowering dicotyledons the alleyways and the wild flower stripes are not mulched but extensively and from row to row alternately mown. The mown material is taken out of the orchard and composted.

16) The trees are fertilized without commercial fertilizers on basis of this compost. The idea behind is a self-sustaining or autarkic tree nutrition system.

The 1 ha large orchard, planted in November 2006 in Frick-Switzerland, is subdivided into 4 blocks. In 2 replication blocks only system design measures are taken to keep pests and diseases below threshold values. In the other 2 blocks bio-control measures are applied.

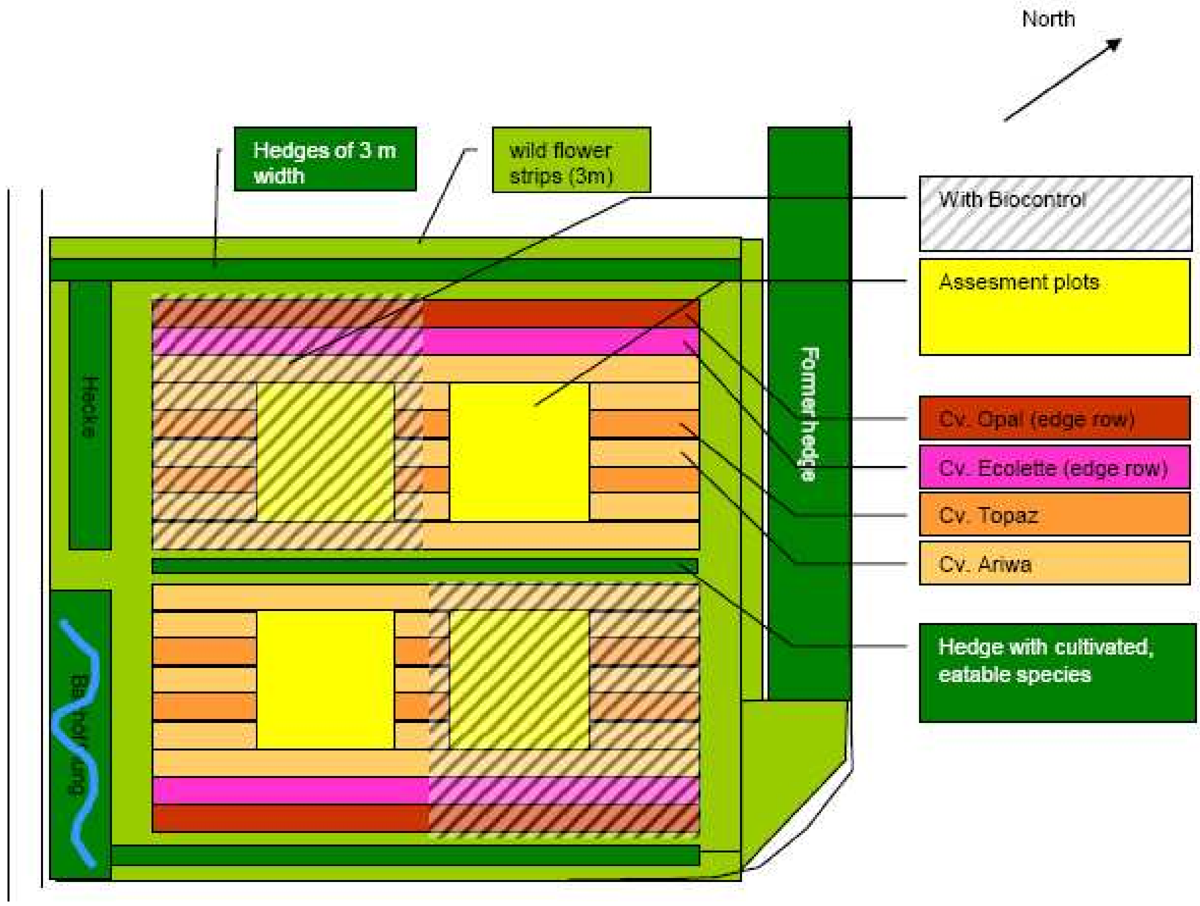

Figure 1: Plan of the self-regulating orchard established at Frick in 2006. Total acreage is 1 ha. Details see text.

Preliminary results and experiences from the establishing phase

- In the 2nd and 3rd leaf of the self regulating orchard (2008 and 2009) the abundance of beneficial arthropods such as C. Carnea, forficulidae and H. Axyridis was already significantly higher than in the reference orchards with cv. Gala.
- The elevated population of beneficial, e.g. aphid predators, succeeded to keep the aphid damage (in particular of D. plantaginea) under the threshold value. This is remarkable because the initial colonies of D. plantaginea at spring were by a factor 5 over the threshold value.
- Also the number of indifferent species, in particular spiders - as sensitive ecological indicator species - was clearly higher in the self-regulating orchard.
- The differences between the bio-control and the control plots were not significant yet. For reasons we still have to find out, even in the bio-control plots the damages of different moths (mainly *C. Pomonella* and *P. Rhediella)* is too high (up to 15%).
- With the first harvest in the self-regulating orchard, picked in 2009, we had a good yield of 4 kg/tree without significant differences between the treatments or the cultivars. When the trees are fully cropping in the coming years the continuously assessed economical data can be evaluated.
- However, in this very warm and humid year, the incidence and severity by sooty blotch disease (*Schizotyrium pomi*) on the fruits at harvest was unacceptably high with both cultivars (18% average severity with Ariwa and 38% with Topaz). In order to be able keeping the concept of a pesticide-free orchard, it has become very challenging to find a more efficient indirect or at least bio-control method against the sooty blotch disease.

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