



Lessons learnt - Agroforestry for organic and free-range egg production in the Netherlands

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Contents

1	Context.....	2
2	Background	2
3	Apples in organic egg production	3
4	Cherries in free-range broiler production.....	6
5	Biomass willows in organic egg production.....	7
6	<i>Miscanthus</i> in organic egg production.....	9
7	Walnut trees in organic egg production	10
8	Tree nursery in free range egg production	11
9	Main lessons	12
10	Acknowledgements.....	14
11	References	14



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1 Context

The AGFORWARD research project (January 2014-December 2017), funded by the European Commission, is promoting agroforestry practices in Europe that will advance sustainable rural development. The project has four objectives:

1. to understand the context and extent of agroforestry in Europe,
2. to identify, develop and field-test innovations (through participatory research) to improve the benefits and viability of agroforestry systems in Europe,
3. to evaluate innovative agroforestry designs and practices at a field-, farm- and landscape scale, and
4. to promote the wider adoption of appropriate agroforestry systems in Europe through policy development and dissemination.

This report contributes to Objective 2 in that it focuses on the field-testing of an innovation within the “agroforestry for livestock systems” participative research and development network. This report contributes to Deliverable 5.14: Lessons learned from innovations in agroforestry systems.

2 Background

A free-range area contributes to the welfare of laying hens. Studies that looked at the relation between the use of a free-range area and the degree of feather pecking damage (stress related behaviour), found that if a higher proportion of a flock uses the free range area, then significantly less feather pecking damage is seen (Bestman and Wagenaar 2003; Green et al. 2000; Mahboub et al. 2004; Nicol et al. 2003; Lambton et al. 2010; Bestman et al. 2017). A higher proportion of hens using the free range area can be achieved by providing shelter (Zeltner and Hirt 2003; Bestman and Wagenaar 2003). This can be artificial structures or natural, for example with trees or bushes. Bright et al. (2016) found a relation between tree cover and injurious feather-pecking: less feather pecking was seen in case of more tree cover. This can be explained by more hens going out in case of more tree cover. Moreover, if there is no such shelter, then especially in flocks of more than 1,000 hens, only a small minority of the hens will go outside.

Besides an advantage for animal welfare, a higher degree of woody cover in the free-range area seems to be related to less avian influenza risk birds in the free range area (Bestman et al. 2017). Another benefit of (tree) cover is a better distribution of hens across the range area, which may reduce the risk of parasitic contamination (Bray and Lancaster 1992). Finally, a better distribution of hens may prevent local accumulation of nitrogen and phosphate (Dekker et al. 2012). Thus, outdoor areas with (tree) cover contribute not only to the welfare, but also to the health of free-range hens and may also have environmental benefits.



Figure 1. Free-range area planted with *Miscanthus*, 1.5 year after planting

In the Netherlands the mean size of an organic egg farm is 11,000 hens¹ with 4.4 ha free range area. A mean conventional free-range farm is 24,000 hens with 9.6 ha free range area (PPE 2013). Providing cover on such large surfaces is expensive. Therefore, within the *Trees for Chickens* project (2012-2015)², farmers investigated means of establishing plantations where it is somehow possible to get revenues from the range plantation.

In the *Trees for Chickens* project, fruit trees, biomass willows and miscanthus (Figure 1) were tested on commercial farms. They were planted in the period between March and May 2013. Within *Trees for Chickens* the performance of these range plantations was then monitored until spring 2015, the plantations then being two years old. Within AGFORWARD the performance of these and other existing range plantations have been monitored upto spring 2017, the plantations being up to seven years old. Together the results from both projects give a good impression of what can be expected on the short and medium term. This lessons learned report summarizes experiences with the following range plantations:

1. Apples in organic egg production
2. Cherries in free range broiler production
3. Biomass willows in organic egg production
4. *Miscanthus* in organic egg production
5. Walnut trees in organic egg production
6. Tree nursery in free range egg production

3 Apples in organic egg production

The costs of establishing a commercial orchard can be up to 36,000 euros per hectare. This is only affordable if the plantation is managed professionally and produces enough good quality harvest. Pedersen et al. (2002) investigated the effects of broilers on pest insects in apple and pear orchards and found a reduction in pest insects, although not enough to see a higher yield or a better fruit quality. Generally, there is limited experience with growing professional fruit in poultry free-range

¹ Divided into compartments of maximum 3000 hens.

² <http://www.louisbolck.org/sustainable-agriculture/animal-welfare-2/trees-for-outdoor-chickens>

areas. More information on different aspects of the combination apples and egg production is published in Bestman (2015).



Figure 2. Apple orchard in free-range area, 2.5 years after planting

In 2015 Timmermans and Bestman (2016) investigated the following questions on two organic poultry farms with a professionally planted and managed apple orchard:

1. Are there any differences in tree health in relation to the distance to the hen house?
2. Are there any differences in fruit quality in relation to the distance to the hen house?

The further away the trees are located from the hen house (or more precise: the pop-holes) the fewer hens are expected to be around those trees and the smaller will be the expected effect of the hens on those trees. For details about the farms, research methods and results, see Timmermans and Bestman (2016)³. On Farm 1 there was a delay in the management of the orchard. This confirms that for fruit farming other skills are needed than for poultry farming. Farm 2 showed that during the first years the harvest can be good.

If fruit is grown in a poultry free-range area, compared to an orchard without hens, a number of measures is needed to compensate for the effect of the poultry. Close to the hen house soil management and drainage are necessary. Because conditions close to the hen house are not optimal for fruit production, it makes no sense to plant expensive fruit trees there. Cheaper and robust trees or other species would be more sufficient. Although it was not investigated, hens could as well have advantages for the trees: less soil management (depending on the distance to the hen house) and less weed control necessary, less harmful insects to be expected and perhaps there is a higher number of fruits and less deceleration may be needed. Anyway, fruit and poultry do combine well, at least during the first years after establishment of the orchard (Figure 2).

However, the experience in organic fruit farming is that apple scab slowly increases over the years. Perhaps hens can be of use in the case of scab, because if the leaves disappear during winter (eaten

³ <http://www.louisbolk.org/downloads/3132.pdf>

by the hens), then the risk of scab may decrease. Continued monitoring will show how diseases will develop. Thereby possible differences between breeds should be taken into account.

In 2016 Timmermans and Bestman (2017) on the same two farms investigated the following research questions:

1. Are there differences in tree health (growth and leaf quality) in relation to the distance to the hen house?
2. Are there differences in the amount and quality of apples in relation to the distance to the hen house?
3. Is there a relation between the amount of leaves on the ground in spring and the amount of apples infected with scab?
4. Are there differences between apple varieties?

For details about the farms, research methods and results, see Timmermans and Bestman (2017)⁴. Because of the initial bad drainage and limited management on Farm 1 it was not possible to draw any conclusions on the impact of hens. On Farm 2 on the contrary, it seemed that organic professional fruit production is very well possible in a professional poultry free-range area. As far as any unambiguous trends could be seen on Farm 2, higher trees and more growth were seen further away from the hen house, there was more insect damage to fruit further away from the hen house, and there was scab further away compared to no scab closer to the hen house. Less dead leaves were found in spring close to the hen house compared to further away. Based on our findings we advise closer to the hen house to plant cheaper, more robust tree species or to try fruit trees with vigorous rootstocks that promote growth. We advise to plant bigger trees in a free-range area anyway. Moreover, because of the soil condition tractors should not ride through the free-range area itself; the soil suffers already because of the hens.

In summary our experiences of the combination of apples and egg production are:

- The combination of apples and egg production is very possible: good harvests can be achieved.
- The combination perhaps works better on organic farms, since conventional orchards depend on chemical protection.
- Start with bigger trees compared to a situation without hens.
- Professional fruit trees (which require high investments) need professional management to be economically viable. If the necessary skills are not available on the farm, this should be organized somehow (see Bestman (2015) for examples).
- A positive effect of trees on hens is that more hens go out, spend more time outside and disperse on a larger surface, compared to a situation without trees.
- A negative effect of hens on the trees is soil degradation close to the hen house.
- Possible positive effects of hens on the trees are less soil management needed (depending on distance to the hen house), less weed control needed, less harmful insects, and fewer leaves in winter that serve as a refuge for apple scab.

⁴ <http://www.louisbolk.org/downloads/3237.pdf>

- If high hygiene standards are required, consider juice or cider production (which requires pasteurization) instead of production of ready-to-eat hand fruit (Figure 3).
- Only a few farms practice this combination and experiences are based on young orchards. From an economic point of view, an orchard should produce for about 20 years. Continued investigations are needed to confirm whether the combination is viable on the long term.



Figure 3. Contact between poultry manure and fruit for human consumption, such as can happen when fruit crates are left unattended, should be avoided.

4 Cherries in free-range broiler production

The farm description below is based on Poelsma (2014) and Bestman (2015). The farmer was interviewed as an agroforestry case study and was subject of several visits within AGFORWARD. This farm is the only one in the Netherlands that combines professional free-range broiler production with professional cherry production (figure 4). The farmer keeps 20,000 free-range broilers and has a cherry orchard in the free-range area, consisting of 550 trees of 15 varieties. The 0.5 hectare orchard was established in 2005, while the parcel was turned into a chicken free range area in 2010. There is also a campsite on the farm with 25 sites. The cherries are being sold in the farm shop and in shops in the neighborhood. The chickens are being kept in two departments. At the age of four weeks they move from the rearing to the fattening department, where they have outdoor access during the last four weeks of their life. In 56 days the JA757-broilers reach a live-weight of 2.3 kg. A typical chicken density indoors is 11 chickens per m², outside they typically have 1 m² each. Mean mortality is less than 2 %, antibiotics are used rarely. Most of the chickens are sold to one trader and a small number is culled on-farm and sold in the farm shop.



Figure 4. Cherry orchard in free-range area of a broiler farm

Experiences of the combination of cherries and broilers:

- Chicken welfare: in the orchard they show natural behaviour like dust bathing and looking for insects to eat.
- The different enterprises (campsite, cherries and chickens) on the farm reinforce each other. Although the chickens are the main enterprise, all three provide income for the farmer. The camping guests buy products.
- An advantage of broilers (or rearing hens) compared to laying hens is the regular 'poultry-free period', which is less stressful for the trees.
- An important advantage of managing all activities by one party, is that the responsible person is able to balance the interests of chickens and fruit, rather than running the risk of 'digging the bottom' after negotiating with another party.
- The only disadvantage of the combination is dust on the cherries, but this is washed away.

5 Biomass willows in organic egg production

The farm description below is based on Boosten (2015); in Bestman (2015) and additional interviews by Bestman in 2016 and 2017. Biomass willows (Figure 5) can produce up to 20 tonnes of fresh biomass per hectare per year. This can be used instead of 5,500 m³ of gas. A biomass plantation can be productive for up to 20 years. In 2013, a total of 2.75 ha of biomass willows were planted in the range areas of four egg production farms: Swedish varieties selected for high production and good resistance against diseases. Per hectare 15,000 cuttings of 20-25 cm length were established with planting machines. A Swedish schedule was used: alternately 0.75 and 1.50 m between the rows, with 0.60 m distance between the cuttings within the rows. Three persons, of whom two are on the planting machine, can plant 1 hectare per day. Willows can be planted in early spring. Weeds need

to be controlled three times mechanically during the first half year, when the willows grow 1.5-2 m high. Moreover, during the first 2.5-3 months the willows need to be protected against leaf eating hens. Planting large parcels instead of strips reduces the damage by the hens. Further from the hen house less damage is seen as well. After the first season, cuttings of 1.0-1.5 m can be cut for filling up empty spaces caused by mortality. The original plan was for mechanical harvesting every 2-4 years in the period November to March. However, because the harvesting machines were too heavy for the soil, the farmer decided to let a gardener cut the branches and use them for constructing decorative garden fences. In case of harvest every four years, 80 tonnes of fresh biomass at a time is expected. The wood chips can be sold 'fresh' to tradesmen or 'dried' and after drying under a roof or special cloth (20-30 % water content) to owners of industrial woodstoves. See Boosten (2015) in Bestman (2015) for calculations of costs and benefits in Euros.



Figure 5. Free-range area with 2.5 years old biomass willows

Experiences with the combination of willows and egg production:

- Because the carrying capacity of the soil seemed to be low, the original idea of mechanical harvest, cutting the branches into short pieces and using it as fuel in an industrial woodstove used for heating calf milk on the same farm, had to be given up. The branches are now harvested manually and used for weaving decorative garden fences by another party.
- The farmer says after the first growing season, his willow plantation does not require much work, compared to an apple orchard which he also manages on his farm.
- The willow plantation is very effective in attracting the hens to the range area: 75 % of the hens are seen outside.
- Despite things developing in a different way to the initial plans; the farmer says he can recommend establishing a willow plantation to other poultry farmers.

6 *Miscanthus* in organic egg production

Miscanthus, also called elephant grass, is a grass, but its appearance, management and application has similarities to biomass willows. In the *Trees for Chickens* project it was regarded as a promising crop and therefore chosen by some farmers to test in their free-range area. Within AGFORWARD the farmers' experience with crop has been updated. After planting, *Miscanthus* should remain productive for up to 20 years. It provides shelter during summer and winter (Figure 6). It can be harvested yearly with a maize harvest machine and be used as litter in animal husbandry, cow feed, as fuel in industrial stoves or pressed to create building material. In April 2013 in three free-range areas 3.5 ha *Miscanthus* was planted with a planting machine manned by four persons. Before planting, the soil was prepared by tilling or ploughing. In 2.5-3.0 hours one hectare was planted with 12,000 tubers: 0.75 m between the rhizomes within a row and 1 m between the rows. During the first season per hectare 60 hours of weed control was necessary, in the second season this reduced to 30 hours and after that no weed control was needed. During the first months, the young plants had to be protected from the hens. The first harvest, which took place in the second year, was limited and left on the parcels in order to suppress weed growth. The plants developed rapidly and the second harvest (3 years after planting) was much bigger (6 tonnes/ha) than the farms could use themselves. The 3rd harvest was 14 tons/ha and the 4th was 16 tonnes/ha. See Bestman (2015) for costs and benefits in Euros.

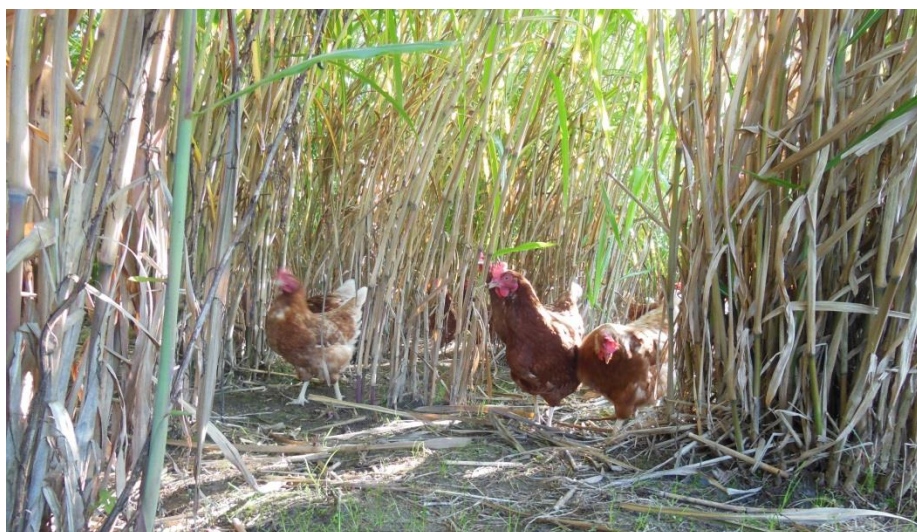


Figure 6. Inside the *Miscanthus* hens (originating from forest birds) feel very comfortable.

Experiences with the combination of *Miscanthus* and egg production:

- When planted in strips of several metres wide, alternated with grass, the hens can enter the *Miscanthus* from more sides and they keep it more open by eating weed.
- Early weed control is very important. Consider how much time you want to spend on weed control and include this in you decision on how many hectares you want to plant.
- There is a high demand of labour for planting and weed control in the first growth season, but after that labour is only primarily required for harvesting.
- The crop provides shelter in summer and winter against sun and wind, creating an attractive atmosphere for the hens.

- Depending on the distance to the hen house, the *Miscanthus* should be protected against the hens after each harvest. Another possibility is not to harvest close to the hen house: the mature plants will keep the new shoots out of sight.

7 Walnut trees in organic egg production

Two Dutch organic poultry farmers have walnut trees in their free range area (Figure 7). Farm 1 has 11,500 laying hens and 30 nearly 70 years old walnut trees. A variety of cultivars is planted in order to assure their pollination. They grow from 10 m from the hen house onwards, an area intensively used by the hens who keep the soil bare. This makes nut collection easier. The nuts are collected by the customers themselves; they pay less (advantage for them) and the farmer has less work and needs less space for drying and storing (advantage for him/her). Depending on the weather in spring, this farmer sells up to 1000 kg nuts in autumn. Farm 2 has 10,000 hens and 100 young (8 years) not yet productive walnut trees of one cultivar. They were planted on a distance of 10 m x 10 m, 90-100 m from the hen house. The only significant work is pruning the lower branches. The harvest until now was too small to collect. In September 2014 a visit for poultry farmers was organized within AGFORWARD to two locations with 15-year old walnut trees (Initial Stakeholder Meeting Report Poultry in the Netherlands).



Figure 7. Walnut trees 8 years old (left) and 15 years old (right).

Experiences with the combination of walnuts and egg production:

- Because of the plant distance, an advantage of walnut trees compared to biomass willows or *Miscanthus*, is that the farmer has a good view on his/her hens under these trees.
- Walnut trees are trees planted for the long term; nuts can be harvested only from eight years and the harvest varies per year. After 50-60 years the trees can be cut and the exclusive wood being sold.
- Small scale walnut production does not lead to big revenues. To be profitable, more hectares are needed, making mechanical harvest possible.

- By planting a variety of cultivars, during a longer period in spring, pollen and flowers will be available, since every cultivar flowers at different times. If frost destroys the flowers of the first flowering cultivars, then the flowers of the later flowering cultivars can still be pollinated. Thus planting a variety of cultivars may also limit frost damage.
- Nut trees don't do well on wet soil.
- If the hens don't keep the grass under the trees short enough, then the grass should be mown shortly before the nuts fall. By doing so, a 'bag-a-nut' can be used to collect larger amounts of nuts without stooping.
- Although the nut shells are toxic, there are no experiences of hens eating them and being poisoned.
- Cleaning of the nuts can be done by spraying high pressure water on the nuts in a wooden crate or an iron basket.
- Fresh nuts are wet and should be dried in order to make them edible and suitable for storage. They can be air-dried, when stored in crates with a netting bottom in a ventilated and dry room. It can also be done with warm air, but this costs electricity.
- Food safety. Since nuts are being collected from the ground and in a free-range area they can be smeared with manure. By being transparent about the hens under the trees or letting the customers collect the nuts themselves, they can estimate the risks and either leave or wash the nuts.

8 Tree nursery in free range egg production

A Dutch commercial tree nursery wanted to reduce the costs of labor for mowing, reduce the use of fossil fuel and reduce the risk of pest insects in an environmental friendly way. He wanted to do so by keeping hens under the trees. However, he did not want to become a poultry producer, so the tree nursery made an arrangement with a poultry entrepreneur. The province, where the nursery is based, faces environmental problems because of large-scale intensive animal production and they supported the pilot because this combination might be an alternative for intensive animal production. Together the three parties started a pilot to test the combination. One hundred ready-to-lay Marans hens were housed in a mobile house on a parcel with young oak trees (Figure 8). A proportion of the trees was already harvested and sold, resulting in large open spaces. Each hen has 40 m² of outdoor area available. In total they have 400 m² surrounded by electric wire, which has not been electrified to date. This animal density is supposed to balance the manure input by the hens with the manure uptake by the trees (Bestman 2015; Niekerk and Leenstra 2016). At the moment of writing this report, the hens have been on the parcel for three months. Approximately 20 % of the hens have been eaten by foxes and birds of prey and the remaining 80 % only leave their house if the caretaker is present. Right now, the project partners are thinking how to tackle the dilemma of frightened hens and predation.



Figure 8. Young hens in partially harvested tree nursery parcel

Experiences with the combination of tree nursery and egg production:

- In order to have the hens use the range well, buy hens with outdoor experience. Keep roosters with them, since they attract the hens to go out and chase away birds of prey.
- If birds of prey are killing and scaring the hens, tighten fishing wire from pole to pole in such a way that a grid is formed consisting of 1 m² meshes. Attach camouflage nets on poles to give the hens a safe feeling.
- If foxes are a problem, use a timer for opening and closing the pop-hole door right on time to keep the hens safely inside at night and maintain an electric wire around the range area.
- In case more different stakeholders/partners are being involved, agree in advance who is responsible to deal with what kind of problem and who is going to pay for which measure or damage.

9 Main lessons

Based on studies and analyses of 10 commercial farms combining poultry and trees the following main lessons can be drawn:

- In the Netherlands, several examples (Figure 9) of combining both commercial poultry production and trees exist: egg production with apples, biomass willows, *Miscanthus*, tree nursery, walnut trees and broilers with cherries.
- These combinations have advantages for animal welfare and animal health and by using the same land for two types of food production, the total land use for food production may be reduced. Risks of this combination are the high investment costs needed in case of planting large surfaces with trees, lack of skills to manage trees, conflicting interests between the poultry and tree enterprises on the farm and fear of financial consequences of land use change from pasture to forest.
- A typical organic egg production farm in the Netherlands has 11,000 hens and needs 4.4 ha free range area. Planting such a surface with trees, requires high investments. In order to

make this profitable, revenues from the trees are needed. Thus, the trees need to be managed professionally in order to make them produce profitable amounts of harvest.

- Fruit production skills or willow production skills are different skills than poultry farming skills. They cannot always be combined in one person. So if a poultry farmer wants to start profitable tree production, he or she needs to establish somehow a partnership with a 'tree professional'.
- Keeping chickens in a professional way and managing trees in a professional way may lead to conflicting interests. For example, because of health risks such as avian influenza, a poultry farmer does not want to have other people interacting with his or her chickens. Fruit production sometimes requires immediate action in case of frost in spring or an apple disease. Sometimes chemical interventions are needed in fruit production, which are not allowed in poultry production.
- The above mentioned aspects require good agreements to be made between different partners concerning costs and benefits and about how to make choices in case of conflicting interests.



Figure 9. Vineyard in free-range area (farm not involved in AGFORWARD).

A variety of aspects related to the tree species mentioned in this report are summarized in Table 1.

Table 1. Summary of a variety of aspects concerning different tree species

	Financial investment	Protection against chickens necessary	Lifespan of plantation	Product	'Tree skills' needed	Trees allow view on chickens	Hygiene aspects
Apples	High	No	20	Apples for fresh consumption and processing	Yes	Good view	Keep manure and fruit separated
Cherries	High	No	20	Cherries for fresh consumption and processing	Yes	Good view	Keep manure and fruit separated
Biomass willows	Medium	First months after planting	20	Wood chops for burning, branches for decorative fences	Medium	Limited view	Not an issue
<i>Miscanthus</i>	Medium	First months after planting and after harvesting	20	Biomass for burning, litter for stables, cow feed	Medium	Limited view	Not an issue
Walnuts	Medium	No	60	Walnuts, quality wood	Medium	Good view	Difficult to keep manure and nuts separated
Tree nursery	High	No	8	Young to mature trees for sale	Yes	Good view	Not an issue

10 Acknowledgements

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