

INTRODUCTION OF SHEEP IN COMMERCIAL CIDER ORCHARDS

Sheep and orchards: a promising association for more sustainable cider apple production



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SUMMARY

Can we combine two existing production systems into one, thereby improving the sustainability of both? This is what this study tried to answer by examining the introduction of Shropshire sheep in the cider orchards. What are the drawbacks and the advantages linked to this method?

To answer this question a literature review was conducted, interviews were held and a field visit to France was organised to discover the French practices.

Finally, we concluded that it is possible to have sheep grazing in the orchards. Shropshire sheep do not de-bark the trees, they keep the grass down and they provide a new income stream. Spraying against apple scab is still necessary, particularly on more susceptible varieties. However, it is important to note that use of this technique implies some changes to orchard management.

BACKGROUND

Over the past two years, Heineken UK and the cider industry have aimed to understand what the key sustainability issues are for cider orchards and how best tackle them. An initial scoping study for orchard research and development was carried-out by Bulmer Foundation and BioDiversity International, which highlighted key areas for improvement, identified high priority research objectives and identified chief stakeholders to include in the process (Newman, 2008).

Preliminary research looked at the state of orcharding in practice (a snap-short of orcharding techniques *prior art* in 2009), including a review of best practice, alternative practice and the latest innovations and research (Durrant and Durrant, 2009). A separate but related study looked at orchard nutrient cycles (Durrant, 2009a). A set of indicators and metrics for orchard sustainability were designed and then consulted on with core stakeholders (Durrant 2009b).

From the preliminary research, ten 'cultural' (i.e. non-chemical) management techniques with the potential to increase the 'sustainability' of orchards were identified by Heineken and presented to a group of volunteer growers. Growers voted on their favourite ones and the top four were trialled in 2010, in association with Heineken UK. Several others have since

been identified and are planned for trial in 2011 as part of a new initiative, HONE¹ (Herefordshire Orchards Network of Excellence).

One of the proposed trials for 2011 is 'Sheep grazing on orchards'. Shropshire Sheep have been identified as the most likely breed for the trial and several growers in France who graze sheep on their orchards have been located so that we can learn from their experiences.

INTRODUCTION

With impending restrictions on the use of some agrichemicals in the next few years and the environmental impact of some chemical products on the soil, it has become clear that finding alternative methods to manage agriculture is desirable. The price of fuel does not allow farmers to use agricultural machinery as many times as they would like. The challenge is to find something to reduce the use of chemical inputs, to diminish the use of petrol and be more sensitive to the environment, particularly the soil as its fertility is vital. The sheep is well-known to be a good mower and their introduction may constitute a new income on the farm. Moreover, over-wintering apple scab may be reduced if sheep eat fallen leaves in autumn.

Are there any scientific articles which deal with the introduction of sheep in tree plantations? What are the practices involved? What are the opinions of the cider industry? How are the sheep managed? These are some of the many questions I will tend to in this report. To do so, a literature review was conducted, people were interviewed and a field visit to France was carried out.

REVIEW

What is the science ?

The reasons why we choose to study sheep grazing on orchards are diverse. Firstly, in the orchards, alleys constitute a big area which is not used. But it is necessary to withstand harvest engines. Secondly, animals which grazed between trees confer several benefits. Furthermore, sheep have already proved that they were efficient in tree plantations. Below is quoted science studies which are related to this subject.

- **Effects of agroforestry on farm biodiversity in the UK**

¹ Herefordshire Orchards Network of Excellence is a new project **part funded by the European Union (EAFRD) and Defra through the VITAL Herefordshire LEADER programme. For more information contact e.v.durrant@gmail.com**

Professor Paul J. Burgess is the Programme Leader for the Land Management programme at Cranfield University. He has recently been involved in the FarmSAFE 2006 project focusing on the ecology and economics of silvoarable agroforestry in Europe, as well as the effects of poplar agroforestry on farm profitability and biodiversity. The review suggests that the introduction of silvopastoral (trees and pasture) systems can lead to an increase in the diversity of invertebrates and perhaps birds on grassland farms (Burgess, 1999).

- **Reduce herbicide use in rubber plantations**

Here is another example of the benefits of sheep grazing. Y. K. Chee and Ahmad Faiz (1990) reviewed weed control methods and showed that the complementary use of grazing sheep reduces the overall costs of weed control.

This review shows that integration of sheep under rubber plantations can have environmental benefits; in particular, sheep reduced the necessity for chemical herbicides and resulted in less bare ground in the orchard, thus reduced soil erosion. Some tree damages have been noticed but they don't specify which breed was used (Chee and Faiz, [ca 1990]).

Thus, a breed which does not debark trees and can also reduce weed control cost is sought. This breed may be the Shropshire sheep.

- **Outcome of Shropshire Sheep's action**

Shropshires have been successfully grazed in Christmas tree plantations as a tool for weed control in Denmark, Ireland, Germany, the United States, Switzerland and Austria.

In 2004, Vincent Houis, project manager of 'Sapin de Noël-Agriculture' at the Natural Regional Park of Morvan in France, undertook a trial to study and understand how to use Shropshire sheep in Christmas tree plantations.). He adds that it is a satisfactory method from an environmental point of view, but quite hard from a technical one. He explains that the difficulty lies in finding the right balance between number of sheep per hectare and keep the grass down. Indeed, we need to provide good grass for lamb growth, but it should not compete heavily with the growth of trees.

This study confirms that Shropshire sheep do not debark the tree if good grazing management is applied and animals are healthy. Moreover, this breed is very robust. They do not need concentrated food. They are calm and kind. And so, there are no soil issues (Houis, 2007).

This method allows having two crops on one acre. For any further information see appendix 1.

- **Research Centre for Fruit Growing at Lake Constance in Germany**

After the success of Shropshire sheep in Christmas tree plantations, the Research Centre for Fruit Growing in Germany started a formal trial to establish the suitability of Shropshire for use in commercial fruit tree cultures (SSBA, 2008).

This trial set out to establish (i) whether the sheep could be used for effective grass and weed control without damaging the trees, and (ii) if they could play a role in removing scab-contaminated leaves from the ground in autumn. This trial was conducted in a typical modern commercial fruit tree culture where trees are small and have low branches (between 0.6m and 0.8m from the ground). Trees were planted close together at 0.8m to 1.5m between trees and 3.2m to 3.5m between rows.

The conclusions of this study are the following: Shropshire sheep are docile and easy to manage and they keep grass very tidy and short except for nettles. However, whilst the relative attractiveness of tree foliage corresponded to the size of the sheep, it was largely out of reach as the sheep do not rise on their hind legs. To minimize tree damage, regulated management of the surrounding pasture is necessary. It is also required to co-ordinate spraying and sheep grazing. Unfortunately, it was impossible to tell if Shropshire sheep will also eaten fallen leaves because of the wet weather at the time of the study.

All these studies suggest that sheep grazing has positive effects on the environment and on tree plantations (increase of biodiversity, reduce the use of herbicide, weed control, no damage to the tree), but it is not simple to use them.

Some persons who were intrigued by this new 'environmentally-friendly' tool have decided to test it. Here is their testimony.

What is the practice ?

The Shropshire Sheep breeders' Association (SSBA) released a book in 2008, *Two Crops from One Acre*, to describe where Shropshires were already used. Below are some extracts of people who testified in this book (p3-15-19-28)

Graham Allan is a Scottish shepherd who is managing sheep in conifer plantations. The compatibility of Shropshires and conifers was first identified more than 20 years ago by him. Mr. Graham has exported this concept to Great Britain, Germany and France. According to his experience, the Shropshire breed of sheep is most suitable for weed control in tree plantations.

Raimund Khol is a German grower and he introduced his first Shropshire sheep in his Christmas tree plantation in 1993. In his opinion, Shropshire sheep have a positive effect on the density of ground-cover vegetation and cause less damage than mechanical weed control around small tree seedlings. The advantages of Shropshire sheep are; a) their applicability for vegetation/weed control in orchards and Christmas tree plantations; b) their easy care characteristics (easy lambing, motherliness, calmness); c) their robustness; d) their good meat quality, and; e) their ability to fatten lambs only with grass.

Adrian Morgan is a British Christmas tree grower. He planted his first Christmas tree in 1997. At the beginning only six Shropshire sheep were grazing in his plantations. Now, he runs two

flocks. For the first four years, the comparative costs of weed control by sheep and the conventional chemical method is likely to be similar (conventional treatment cost of employing a spray contractor to apply herbicide 3 or 4 times per year). But then, the additional costs of Shropshires in trees are minimal and likely to afford significant savings when compared with chemical weed control. Time spent in shepherding has to be provided for free!

According to the persons who are using Shropshire, they all agree to confirm that Shropshire Sheep are doing an excellent job in Christmas tree plantations. The use of herbicide isn't required anymore and they attract people during marketing activities. Nonetheless, this method is not that easy. Indeed, it uses living being and so, some knowledge is required to properly manage them. The number of sheep per hectare depends on different factors. They require extra food during winter, trace element and salt must be provided and they need basic cares (vaccination, dewormer, shearing...). Yet, they are also used in vineyards and plum orchards.

Michel Heyberger is a French grower who has Christmas tree plantations, orchards and vineyards. As he has no experience of keeping sheep, he teams with a shepherd to have sheep grazing in his plantations.

In his orchards, Shropshires keep down herbage without causing damage to the trees and they eat all rotten fruit. This helps to reduce parasitical pressures.

In his vineyards, they are also doing an excellent job. They clear the herbage from areas between the rows of vines after grape harvest. Shropshires eat the leaves in autumn but do not touch the branches or the woody stems. Furthermore, the manure produced is an added bonus.

Benoit Gille is a French shepherd who runs a 250 sheep flock. He is working in collaboration with growers. His flock grazes in 62 ha of plum orchards and 25 ha of cider orchards. In his opinion, sheep, trees and grass are the perfect balance. Trees provide a shelter to the sheep, sheep control weed and grass to avoid competition with the tree, and grass provides food for the sheep. This technique requires observing animals to detect weakness or disease and observing the orchard as a pasture to feed sheep. It is about watching orchards through a new eye because sheep interact with the soil and trees. For further information see appendix 2.

As far as I know, nobody has been disappointed by using pure Shropshire sheep. They are doing an excellent job to control weeds without eating the bark. They are docile and easy to manage. However, we must keep in mind that this method requires patience and time; time to know the flock and time to learn how to manage them in order to keep the grass down and to avoid damage to trees. Yet, Mr. Diquelou who is a French grower in Brittany, noticed that his pure Shropshire sheep were eating the trees. He grows apple cider orchards. There are 400 trees/ha and he is an organic farmer. He did not give minerals and salt to his sheep, it may be the reason why they started to eat the bark to find trace elements they needed. Furthermore, he told me that the soil was very acidic and even his trees had trouble to grow.

Sheep will eat the bark if their diet is not balanced and if they cannot find what they need somewhere else. Then, Mr. Diquelou sold his flock to another grower who later had no problems with the flock. The sheep have stopped eating the bark. A balanced diet for the sheep is a key factor in keeping trees safe.

Another breed is well-known to keep grass down amongst the vineyards, without eating the vines. This breed is the Olde English Babydoll (cf. appendix 3), but as far as I know there is no flock identified in the UK. According to the website mylittlesheep.com, it is very expensive to import them and not always possible.

In Devon, Mrs Trace, one of a contractor of Bulmer's, lets her Poll Dorset sheep grazing in her bush cider orchards. They only graze from December to April. They make a good income and they destroyed fallen leaves which help to reduce apple scab. Furthermore, they improve soil structure. For more information see Appendix 5.

Today, some people are using alternative methods to reduce their impacts on the environment, using sheep as lawn mower is one of them. But, this is the choice of only individual growers. This study aims to make this alternative method known by a larger number of persons. Thus, viewpoint of the cider industry is fundamental.

INVESTIGATION

Cider industry inputs

Interviews with five key individuals in the cider industry (all of whom work with orchards) were carried-out as part of the research. Here are summaries of their opinions:

Chris Fairs, Grower Advisor for Heineken UK Ltd, Heineken Office, 02/12/10. During interview Chris Fairs expressed the following concerns:

- The combination of spraying and grazing: the compatibility of a typical commercial or even a reduced/reducing spray programme with the need to exclude sheep for prolonged periods after application is questionable. During the exclusion period, the sheep would need access to another field (unsprayed orchard or grass field).
- Water supply: particularly at certain times of the year, when sheep might require more water - also the possibility of contaminating water troughs when spraying.
- Containment of sheep with fence: for the following reasons; a) to prevent sheep from escaping, and, b) to prevent the theft of animals from isolated orchards. For practical purposes, there is the potential need to re-divide/reorganise orchard layout.

- Supply high quality grass: orchard grass mixtures are neither very nutritious nor productive, being chosen to reduce mowing costs and provide a dense, durable surface for harvesting and other mechanical orchard operations.

John Thatcher, JOB TITLE.... telephone interview, 20/10/10. In his opinion, having sheep in orchards is only suited to standard orchards. The risk of contamination with *crypto sporidium* for example could be a publicity risk (health issues). Furthermore, John Thatchers has some economic concerns as the lamb market is not ... (need another word here, prolific does not make sense).

Liz Copas is the National Association of Cider Makers' Orchardling Advisor and Field Trial Officer, email interview, 20/09/10. In her opinion, sheep grazing is not appropriate in bush orchards because sheep would damage the trees and eat the bark. Moreover, animals would need to be excluded for at least 56 days prior to harvest to avoid contamination from their faeces.

Bob Chaplin, the Fruit and Orchardling Manager at Gaymers, email interview, 29/09/10. His main concern would be the faecal contamination issue, and as a result the significant risk to pomace.

Ross Cider is a family business in the cider industry, email interview, 11/10/10. Mike Johnson, owner, is interested in grazing sheep on his orchards. They are aware that they need to balance time and costs as having sheep is time consuming and they do not always reach a good value at market. On the other hand, they think that sheep could reduce the time it takes to mow the orchard floor.

Summary:

The two main concerns raised by the interviewees in the cider industry are the faecal contamination issue and the economic issue and the rearrangement of orchards (water, fence, tree protection).

Nonetheless, in France, some growers are using Shropshire sheep. Let's see how they attend to these problems.

Case Studies

The researcher visited three growers in France who are using Shropshire sheep on their bush apple orchards (December, 2010). Two of the farmers were already sheep breeders and the other became a shepherd as the result of a passion for animals. A researcher at the Institut Francais des Productions Cidricoles (IFPC), Natalie Dupont, was also interviewed, as well as Jean-Charles Cardon from the Chambre d'Agriculture de la Manche (c.f. appendix 4).

Growers shared their experience of keeping Shropshire sheep. Here are their stories.

Hervé Duclos (c.f. appendix 6)

Hervé Duclos produces his own Cider and Calvados. He is working with his wife and two others employees.

At the origin, he was a sheep breeder and then he planted orchards. He started his orchard from scratch and so, he decided to raise sheep until his cider orchards produced an income. Six years ago, he started to let his sheep grazing in the orchards. To begin with, the sheep were grazed for one month, then one month and a half during the spring. Today, sheep are in the orchards from March to December. He bought Texel sheep initially, which did not seem to eat the bark. However, Duclos had many problems with the lambs and it took a long time to fatten them so the costs were quite high. Consequently, he decided to find another breed more suitable for this job and he bought Shropshire sheep in 2008.

His wish has always been to work with less chemical inputs and more 'organic inputs. To fight against scab uses sulphur. He possesses a weather station which forecasts when he needs to spray. In 2010 he sprayed three times on all varieties and four times more on the more susceptible varieties. He has ten varieties split into sixteen hectares of standard and bush orchards.

He uses one organic insecticide once a year and one specific herbicide against the nettles. He has to mow once or twice a year. As fertilizer, he is using chicken manure.

He installed fences all around his orchards and separated the farm into paddocks with an electric fence to allow a rotation. When lambs are weaned, they go into the bush orchards because they cause less damage to the leaves than old ewes. According to Duclos, ewes like green leaves.

According to Duclos, the Shropshire ewes are very good mothers. The lambing takes place inside. He gives the sheep one wormer each month from May to September and trims their feet once a year. Shearing ewes once a year just before lambing has a positive effect on the ewes (making them easier to watch and easier to lamb).

The yield is 20 metric tonnes per hectare, but the aim for Duclos is not to produce the highest yield possible as they use them for cider and calvados on site. The sale of sheep widely compensates his costs incurred by keeping sheep (fence, water, extra-food for the winter). He sells meat directly to the consumer so makes a good profit from the meat.

His is very delighted by what sheep bring to his orchards; apples are better conserved and the soil is better. Moreover, he is very happy to work with sheep.

Thierry Briand (c.f. appendix 7)

Thierry Briand works on his farm with his mother and his brother. They have dairy cows, cereals, cider orchards and Shropshire sheep. He owns eight hectares of cider orchards and

his orchard counts 800 trees per hectare. The yield is thirty tonnes per hectare on average, which he sells to a local cider-maker.

Their wish was to stop the herbicide strip and so, in 2003, they decided to replant a grass cover under the trees. The grass mix is 60% perennial ryegrass and 40% red fescue; there are just a few legumes (clover). To upkeep the grass, they invested in a specific mower, but the work was tedious and expensive. Still, having grass under the tree was conserved the apples.

After some research in 2008, they imported 40 Shropshire sheep; a breed which does not eat the bark. They installed 2 km of fence all around the orchard and separated it into different plots, thanks to a moveable fence, in order to create a grazing rotation. He trained a dog to protect the flock from thieves and predators such as foxes or stray dogs. He excludes sheep one month prior to harvest to avoid faecal contamination of apples collected from the orchard floor.

Now, Thierry Briand needs to mow only once a year (sometimes twice, depending on the quantity of forage available) to eliminate nettles. He also makes a good income by selling his lambs for the meat, or to other growers interested in this concept of an ecological mower.

They do not spray a lot: one insecticide per year against apple blossom weevil, one fungicide (containing copper), very few fertilizers and no herbicides. They spray against scab in the middle of December, usually sheep are inside because grass has become sparse and ewes are soon to lamb. Apple scab is not really a problem for him but the exact reason remains vague. It might be a combination of different elements. What he is certain of is that his sheep maintain the soil very well and may accelerate decomposition of leaves.

Thus, whilst the aim of bringing sheep onto his orchard was to remove the herbicide strip and reduce fertilizer applications, it also has the added benefits of a new income stream and less mowing (so less fuel consumption).

Thierry Briand is well-satisfied with his sheep. Now, the farm has a more stable income as he has diversified. It reduces labour time on farm and it is good for his health and the environment.

Jean-Yves Fillatre (c.f. appendix 8)

Jean-Yves Fillatre, settled in 1987, today owns 8 hectares of organic eating apple orchards in Brittany.

His objective has always been to own animals and let them graze the orchards. The aim was to maintain a grass cover, to reactivate microbial flora and break parasitic cycles.

His orchard is planted at a density of 1500 trees per hectare. He has 30 varieties altogether but 5 varieties represent 95% of the orchard. He produces about 25 tonnes per hectare on average and markets in retail, wholesale or directly to the customers.

He introduced 25 Shropshire sheep in 2005, or 3 ewes per hectare. He added 30 geese and hens. He thinks that having different animal species reduces disease because these animals

have different parasites on their body. He only treats sheep with a wormer when they need it.

Since introducing the animals, he only mows once a year, which is necessary to control nettles which none of the animals eat. He uses a very low dose of copper (copper is dangerous for sheep, 15g/ha) and he says that it is very difficult to find leaves at the end of February - this might reduce over-wintering scab.

As fertiliser, he stopped adding nitrogenous chemical fertiliser and is now using feather flour. No damages are caused by codling moth or apple sawfly. He strongly believes that animals help to reduce insect populations. He uses two vegetable insecticides before bloom and does not use any herbicide.

Having animals on his orchards necessitated some management changes. He installed an electric fence all around the orchard. Electric fencing requires maintenance of under-lying vegetation, although this is 5 times less time-consuming than mowing 6 times a year. Animals keep grass short and tidy and so, it reduces frost risk.

Sheep also need a shelter from the rain and some hay and minerals to balance their diet. Mr. Fillatre is not a breeder but his passion and his willpower to have animals on his farm make this combination work. The most labour-intensive period is lambing in the spring. Ewes lamb outside so lambs are sensitive to predators such as fox and stray dogs.

Whilst his purpose was not to create a new income (the presence of the sheep on the farm was enough for Fillatre to invest), he occasionally sells lambs to the butchers occasionally to regulate the flock size.

Having sheep is 'not a big deal' in his opinion. Shropshire sheep are very easy to rear. Ewes are good mothers and they are robust.

In a nutshell, the presence of animals on the farm brings a balance between trees, soil and animals and Jean-Yves Fillatre is very pleased with the result.

Summary of case studies

Combination of sheep and orchards only works if the grower wants it to work. He must have knowledge about sheep or the will to learn about them. It also helps if the grower has a strong environmental conscience as the environment is one of the largest beneficiaries of the system.

These people showed us that it is possible to derive a respectable income from an orchard with sheep. The advantages of the method are numerous; and range from human health benefits to environmental and economic ones.

Nonetheless, having sheep in commercial orchards requires personal investment, time to learn animal behaviour and necessitates some changes to orchard management. The next section explains how these changes can be made.

Results

Transformations to consider in the orchard and the explanation of husbandry are described below.

1. Orchard management

Co-ordinate spraying and grazing

A bush orchard is an intensive crop; it requires the use of chemical treatments (Garthwaite and al, 2008) and is therefore not an appropriate place for grazing animals. However, with modifications the alleys could be a great source of land for grazing. For example, in standard orchards there are already some livestock which safely graze between the trees (Coulon and al, 2005). Why does it work so well? There are several reasons:

In standard orchards, the tree density is low, 100 trees/ha compared to 660 trees/ha for a bush orchard. This creates much space for the sheep, and provides a good air flow which helps to reduce disease spread and contamination. Furthermore, trees are older than in bush orchards, and so, there are holes in trunks in which birds can live. Birds are natural predators for insects and help to regulate insect population.

In the same way, the biodiversity is high and as a result, the balance between pests and predators is respected and the pest issues are less a problem. It is naturally solved. The presence of hedge around the orchards is another biodiversity source. It creates a new habitat for predators. Moreover, there is permanent grassland which limits soil erosion.

Thanks to these elements, less chemicals input are used in standard orchards, thus there is no risk for any animals.

Indeed, co-ordinated spraying and grazing is one of the hardest things to do but also one of the most important things to do because:

- Chemicals products are toxic for men and so for sheep. As a result, we would need to wait before letting sheep graze (Curriden, 2006). As we regularly spray we would need to often exclude sheep and then it wouldn't become any profitable. However, we don't have to let sheep grazing all the year. It could just be during some intervals of the year and then we would have been less trouble with sprays.
- We can believe that presence of sheep would reduce/eliminate herbicide use (cf. What is the science)

- We can hope that sheep reduce apple scab by accelerate the process of leave destruction (cf. Case study)
- What's more is that ewes are sensitive to copper (V.Houis, B.Gille, 2010)

What we need to find-out is how to reduce chemical inputs in bush orchards without diminishing the yield. Currently some trials are carried-out to determine which treatment is the best to fight apple scab (garlic tree wash and tackling over-wintering scab leaves). Sheep grazing in orchards is not THE solution which would solve every problem. It is one of the solutions. But before adding sheep in orchards, we need to readjust commercial orchard management.

Another change should be made. It concerns the height of branches.

Canopy line

The canopy line in bush orchards is characteristically very low (under 1 m), which may be a problem for sheep grazing as green leaves are palatable for them. But, if we prune the last branches up to a canopy line of 1.2 or 1.3 m above the ground then it will negate the problem. Such a practice will involve reducing the yield a little. In France, growers cut the branches up to 1.10 m. It creates an air flow in the orchards and reduces disease pressure.

Diminishing the yield doesn't mean to lose money. Indeed, sheep can help to reduce chemical inputs. Consequently, the lower treatment cost would compensate the yield lost.

2. Disease control

Apple Scab

Fungicides and insecticides used to control the main pests and diseases make up the largest economic input to the orchard; the typical regime for Bulmer's orchards is 6-8 fungicide applications per year plus 1-2 insecticide applications (Durrant and Durrant, 2009). In France, growers who use Shropshire sheep apply in average 1-7 sprays per year. Most of the time they use organic products. Moreover, analysis of one representative orchard known as 'Sheep Cross' showed that 65% of the spray costs were for fungicide and 92% of fungicide use was primarily for control of apple scab (Newman, 2008). That's why, it seems important to find another way to reduce apple scab. One trial aims at reducing scab infection from the previous season's leaf litter. Two methods are considered: shred leaves on orchard floor and spray with 5% urea or collect leaves after leaf fall. These methods aim to destruct fallen leave. In fact, growers noticed acceleration in the decomposition of the fallen leaves. No trials have proved sheep impact on this observation.

An explanation could be the following: it is well-known that the most important function of soil micro organism is the decomposition of various kinds of organic matter present in the soil (See: <http://www.microbiologyprocedure.com/soil-microbiology/decomposition-of-organic-matter-insoil.htm>) and contaminated leave belong to this category. The increase of soil micro-organism would help to accelerate the decomposition of leave and then reduce spread of over-wintering scab. Sheep presence would bring manure (fertilizer) and urine (nitrogen). As a result, there would be an increase of the number of micro-organisms and thus, an acceleration of the process of decomposition of leaves. In addition, the standing of sheep on leaves would improve leaves decomposition.

Codling Moth

Codling moth is one of the main insect pests of apple trees (Durrant and Durrant, 2009). One of the solutions set out is to eliminate contaminated fruit (Dupont and al, 2009). According to growers' experience, sheep eat fallen apple and so reduce codling moth. But, no scientific study has proved this point yet.

For the growers with Shropshire sheep codling moth is not a big issue. 2/3 growers are using one insecticide per year. Jean-Yves Fillatre is using sexual confusion and there are no observable damages.

Having animals in the orchards seems to create a balance between trees and soil and fauna. And the global impact is very beneficial. But how do they manage their flock?

3. Grazing management

Which one may safely graze?

Ewes and lamb can safely graze around the orchards. We can also allow rams to graze but we must provide to them old trunks or strakes because rams love to rub their head.

Number of sheep per hectare

It depends on the existing vegetation. The existing vegetation depends on the season and the condition weather. In France, the average is 5 ewes / ha. Jean-Yves Fillatre is using only 3 ewes/ ha whereas Hervé Duclos is using 6 ewes / ha. But Mr.Fillatre had to add geese to keep the grass short because 3 ewes / ha was not enough.

Contain and sheep protection

To contain sheep and to protect them from predators or thieves, we need to install an electric fence (Brantly, 2005). But an electric fence implies to upkeep the grass and weed under it. On the other hand, not having an electric fence is a risk for predators (humans or animals) and you would need a dog to protect the flock.

To separate your field into paddock you can use moveable electric fence in order to move them in the same time when you move the flock from a paddock to another. Or if you choose a permanent pasture you don't need your fence to be moveable (c.f.6).

Sheep diet

a. Orchard cover

The most popular grass varieties are: Chewings Fescue, Red Fescue and Brown-top Bent (Fairs, 2010). Generally, the ground cover in orchard doesn't entirely suit to feed sheep requirement. We must add legumes (Gille, 2010).

b. Food preference of sheep

Sheep need a varied diet.

Sheep preferred to graze on legumes first, followed by grasses species (Paquay, 2004)

c. Feed

To avoid tree damages, a mix of salt and mineral must be available during the whole year (SSBA, 2008). During the winter, it seems to be necessary to add some hay or silage.

According to the growers' experience, sheep eat rotten and wormer fallen fruit. We must be careful; too much sugar may be dangerous for the sheep. B.Gille has found a method to avoid this problem: if specific mix of browse is available thus sheep could eat as many fruit as possible. This specific mix of browse will be labelled in the spring 2011. On the other hand, sheep know how to regulate its own diet, and none of the growers we have met had a problem with that.

Water source

Water is essential to life. This is the reason why water must be provided in each paddock. To avoid gathering problem or tree damages, water must be located in a strategic place (Brantly, 2005). Water may be contained in movable tank. Although water is essential, it seems that sheep find the water they need in the plant they eat. According to French growers' view, water is not a difficulty.

Permanent or rotational grazing system

How to well-managed grazing management? This question is one of the most difficult to answer but one of the most prominent.

Two growers practice a rotation grazing. It allows to control forage quantity and provide a fresh pasture to the sheep and so diminish parasitic pressure and to avoid over-grazing. This technique presupposes to separate the orchard into different plots. They move sheep from a paddock to another when they have cleaned it up. Jean-Yves Fillatre has decided to let his

sheep freely grazing and he doesn't complain about disease or over-grazing. We should keep in mind that he has only 3 ewes/ha.

However, Benoit Gille strongly believes that it is possible to let sheep freely grazing around the orchards without any problems. But to reach this point the orchards must be balanced. A balanced orchard means that the grass composition is adapted to the trees and the sheep, and the soil is balanced (good proportion of N, P and K), and trees are healthy.

Now, we have a better idea how to deal with sheep grazing. We need to consider how to take care of them.

4. Husbandry management

Vaccination

There is no compulsory vaccine for sheep in England. The most common used is for *clostridium perfringens* type C and D and the tetanus (CD-T) (Schoenian, 2004). Ewes are vaccinated prior to lamb and then 6 weeks of age lambs are vaccinated.

Yet, Benoit Gille who is a supporter of non chemical treatments thinks it is possible to have a healthy flock with no vaccine. In order to succeed in this practice, we must provide diverse diet and trace element. The assumption is that if sheep is balanced, he would be less likely to get sick.

For example to struggle against intestinal parasites, you can add tanniferous plant in sheep diet. As a matter of fact, some studies have shown that tanniferous forage plants can have beneficial effects on ruminant productivity and health (improved protein supply, bloat safety and anti-parasitic properties) (Suter and Hertzberg, 2007).

Shear

Sheep are usually sheared once a year (depends on the breed). It could be done prior to lambing or early in the spring.

Disease

Sheep can be subjected to different disease. The most commons are quoted below

- a. Diarrhoeal infection

In livestock, diarrhea is called scours. There are many causes of diarrhea: bacterial, viral, parasites, and diet.

- b. Intestinal or pulmonary parasites

It is very hard to avoid intestinal parasites but we can diminish the infection. We can use dewormer several times per year. However, dewormer loses their effectiveness (Wells, 1999) and we need to find other way to protect sheep from them. In the article written by Ann Wells she explains how decrease internal parasite:

- nutrition : tanniferous plant/ phosphorus
 - pasture management: allow pasture to rest and soil life to function well; not allow animal to graze below 1 inch
 - soil organisms: earthworms eat egg and larvae and destruction of manure
 - deworming at the right time
 - deworming alternative: garlic
- c. Wound and injury

Sheep can suffer from injuries and wounds. The best way to make sure they quickly recover is to provide a good feed (high quality) and make sure they don't miss anything (Gille, 2010)

d. Hoof infection

To avoid hoof infection, we must trim hoof and give foot bath (Hale and al, 2010), but according to the growers' experience Shropshire don't have many hoof issues.

Hard period

All this information comes from this website: Sheep101.Info. 2010.

<http://www.sheep101.info/raisingsheep1.html> . 2010

a. Breeding time

Rams are put in with ewes for breeding: 1 ram for 30 to 50 ewes.

Rams are switched around after the first and the second heat cycles in case some ewes don't become pregnant after being mated by the first rams.

Most ewes will get pregnant within the first 17 days of the breeding seasons

b. Birth time

Gestation lasts 142 to 152 days. During the last month of pregnancy, ewes will need extra feed.

c. Weaning

Between 60 and 90 days of age lambs are weaned.

To learn how to take care of living being take time. Still, this investment could be very profitable for the future.

DISCUSSION

Faecal contamination

Concerning faecal contamination, many studies affirm that E.Coli is destroyed during the pasteurization (McLellan and Splittstoesser, 1996). On the other hand, there is a potential risk with unpasteurized cider and so, with pomace. The solution would be to exclude sheep prior to harvest. Nobody agrees on the duration of exclusion prior to harvest and the decomposition speed of sheep manure depends of the microbial soil life and moisture. Besides to avoid contamination with Cryptosporidium, the most important thing is a proper hygiene (Fleming and Eng, 2004) and pasteurization is sufficient to destroy infectivity of oocyst (Harp and al. 1996).

In France, there are no issues about faecal contamination. They exclude sheep one month prior to harvest. According with growers' observation apples are quiet clean, they wash them if need be. Hervé Duclos uses an engine to spread the faeces and so, accelerate the degradation process. In England, most people recommend to exclude sheep 56 days prior to harvest. The time of decomposition depends on the weather, the microbial life and the number of sheep per hectare.

Orchard management

Table 1: Comparison with Bulmer's orchard management and French grower's management

	Bulmer's	French growers
Mowing	~ 8 runs / yr	1-2 runs / yr
Insecticide	1-2 sprays / yr	1-2 sprays /yr
Fungicide	7-8 sprays/ yr	1-7 sprays / yr
Herbicide	1 spray / year	0-1 spray / yr

The bigger difference concerns the mowing. But there is others advantages for keeping sheep in the orchards: overall grass. When apples fall down they are protected from degradation thanks to the grass cover. The soil is protected from the erosion. French growers recognize that at the beginning of the tree life overall grass is not the best solution.

Financial issues

As regards economic issues we need to consider the benefits bring by sheep grazing in term of spray reduced and fuel and the environment beneficial.

There are two ways to use sheep in an orchard: to own a flock, to let other sheep grazed in the orchard. If you choose to own your flock the expense to set out would be higher than if you just let sheep grazing in your orchards. However, at the end, it could be very prolific to have his or her own flock thanks to the sale of meat. You must keep in mind, it is a new job and it will require patience and a certain capacity with animals. They will need to be checked every day. Moreover, the advantages confer by sheep in the orchards would be more important if they are grazing whole year in the orchard.

In addition, using natural products and sheep may interfere with the yield but a good cider depends on the quality of the apple, not on the quantity. We need to consider what impact it will have on Heineken’s production if the yield is reduced.

In term of costs, they are entirely compensated by the income and they even make a profit with sheep.

To sum up, here are the cost and income make thanks to the sheep:

COST	INCOME	GAINS
Buy the flock	Sale of meat	less sprays
Overall grass	Sale of lamb	Less erosion
Fence		Less time
Water		Better environment
Feed		
Shearing		
Hoof trimming		
vaccinations		

Market

Concerning public image, Hervé Duclos told us that the customers are very pleased to buy cider where sheep were grazing and they do not complain about the sheep, on the contrary they love seeing sheep and trees together.

Whilst the sheep market is not particularly lucrative, all of the growers are making a profit from keeping sheep. Selling of the meat more than compensates the costs of keeping sheep.

Management:

There are two ways to have sheep in orchards:

1. having his or her own flocks, or
2. working in collaboration with a shepherd.

In France, both ways exist and are successful. But the first one requires having some knowledge with sheep. In France, out of the five growers who imported Shropshire sheep from the UK three years ago, only two succeed because the others were not breeders or did not take the time to learn about sheep care. For further information see appendix 8.

Tree damage

Sheep do not eat the bark but they seem to like the green leaves.

Disease

Apple scab is not a big problem for these growers, the cause of which is unknown. However, sheep eat low foliage, increasing air flow in the orchard, which could help to reduce apple scab, as could the quickened decomposition of leaves which is aided by sheep hooves and faeces.

Insects such as codling moth, apple blossom weevil or apple sawfly are well held back.

Biodiversity

According to scientific review and the experience of growers, having sheep in orchards is good for biodiversity.

Spray

French growers have not stopped spraying but they try to change the practices. They are learning every day and their orchards are still evolving.

RECOMMENDATIONS

The following recommendations have been made as a result of the research presented herewith;

Further research:

- An experimental field trial to determine the impact of sheep on codling moth populations in an orchard
- An experimental field trial to determine the impact of sheep on apple scab
- An experimental field trial with sheep and geese combined, observing changes in orchard ecology and management needs, i.e. mowing, spraying, etc,
- A laboratory experiment to elucidate any real risks of faecal contamination
- Determine the financial gain and cost of having sheep in a orchard

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