Ber. Inst. Landschafts- Pflanzenökologie Univ. Hohenheim Beiheft 26, S. 23-32, Stuttgart 2011

Can Streuobst be replaced by modern agroforestry systems?

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Synopsis

Agroforestry was a prominent land-use system in Europe a century ago, supported by research and development until the 1930ies. After the second World War, R&D were interrupted and agroforestry practices declined. Only two decades ago, agroforestry research started again, aiming at developing modern systems which can be managed with modern farm technology and yield products for which there is a market demand. Amongst the traditional agroforestry systems, Streuobst is still widespread – but declining – in Central Europe. Modern agroforestry should be complementary to traditional systems, requiring less subsidies and being attractive for farmers.

Keywords: research history, agroforestry experimentation, traditional orchard

Schlüsselwörter: Forschungsgeschichte, Agroforst-Experimente, Obstgärten

1 Introduction

Agroforestry systems are intercropping systems where (i) at least two plant species interact, (ii) at least one of the species is a perennial woody plant and (iii) at least one of them is used as food or fodder (SOMARRIBA 1992). Additional uses are fibre, energy, medicinal purposes, etc. Traditional orchards or Streuobst are today the most prominent traditional agroforestry systems in Central Europe (HERZOG 1998, EICHHORN 2006). They are, however, degrading due to insufficient profitability and in spite of policy measures to maintain them, e.g. by means of agri-environmental programs. In Switzerland, for example, 80% of the traditional standard fruit trees have been lost since 1951 (BFS 2001).

Agroforestry was a popular land-use practice all over Europe and since the 19th century research helped to improve the traditional systems. However, agroforestry research was interrupted in the second half of the 20th century, when agriculture was modernized and mechanized (Fig. 1). Agroforestry research only started again two decades ago. In this article we summarize the evolution of European agroforestry research, with special regard to the situation in Germany, and discuss the implications for the maintenance of Streuobst.

2 Historical agroforestry research and development

Tree based agricultural systems in Europe are reported from Roman times (LELLE & GOLD 1994). Until a century ago, many European forests were significant sources of food and were grazed with ruminants and pigs (Brownlow 1992). There actually was no distinct limit between forest and agricultural land and the input of organic matter and energy necessary to keep agriculture sustainable came from forests in the form of fodder, litter and wood (HABER 1994). ECKERT (1995) estimated that in the Neidlingen Valley (Baden-Wurttemberg, Germany) until about 1500, the forest provided three quarters of the nitrogen and 90 % of the phosphorous available for the fertilisation of fields, vineyards and gardens.

In the 18th and 19th century, intercropping on cleared forest land between rows of planted or sown forest trees was common practice in many forest districts in Austria, Belgium, France and Germany (BEIL 1839, KAPP 1984).

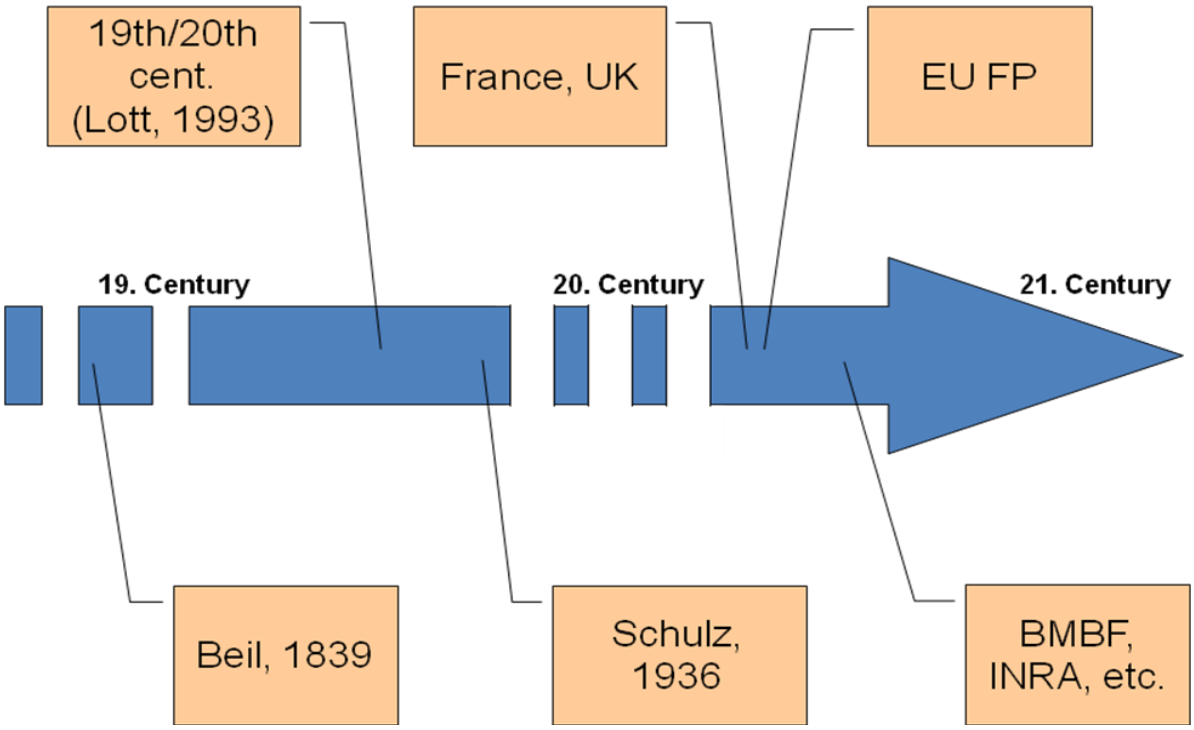

Abb. 1: Forschung und Entwicklung zu Agroforstwirtschaft in Europa in den letzten beiden Jahrhunderten.

Fig. 1: Main agroforestry research and development in Europe over the past two centuries.

2.1 Arable *Streuobst* in Germany

For farmers the combination of arable crops and fruit trees was of particular interest. In fact, the expansion of fruit production in the 19th century was only possible because fruit trees did not impede the crop rotation (LOTT 1993). Basically, rows of standard fruit trees were planted at different distances (Fig. 2), distances were wide enough for crop production to prevail. This fundamental scheme, which was to remain valid for about a century, was varied in numerous ways: high and low stem trees could be altered within the rows, different types of arable crops such as cereals, root crops to vegetables, strawberries, etc. were chosen, often fruit trees were also combined with berry production on bushes (currant, gooseberry, etc.). Arable undercropping was the pre-condition for the extension of fruit production: farmers would have uprooted the trees immediately if they would have had to abandon undercropping (LOTT 1993, p. 98). Specialised fruit production was not possible because of the long period without fruit yield which had to be overcome. Apparently there was a conflict between scientists, who aimed at improved and maximised fruit production and farmer organisations. In 1910 the farmers' organisations stated that: „The otherwise quite good experts, who think that commercial fruit production cannot be combined with undercropping, are not able to calculate" (LOTT 1993, p. 100). It seems that the experts lacked an appreciation of this agroforestry system and were biased towards the tree component, whereas farmers had a comprehensive understanding and aimed at optimising the overall financial return.

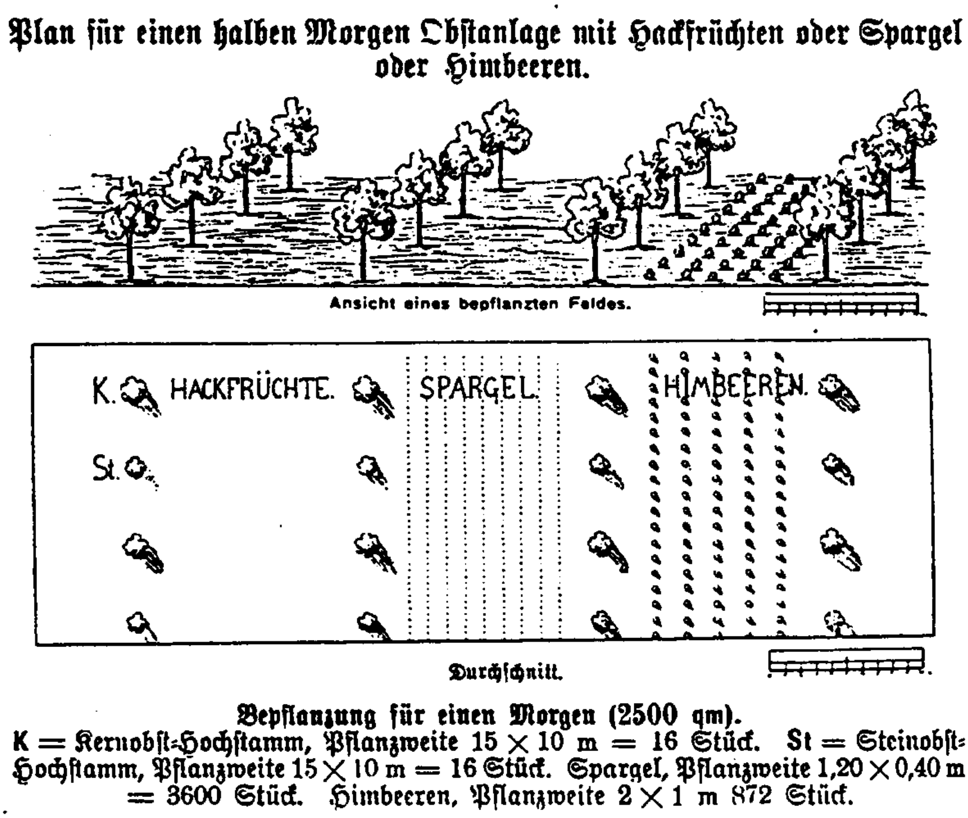

Abb. 2: Plan für einen halben Morgen [ca. 0.12 ha] Obstanlage mit Hackfrüchten oder Spargel oder Himbeeren, datiert Ende 19./Anfang 20. Jh. (LOTT 1993, Abb. 12, Referenz 229).

Fig. 2: "Plan for a fruit orchard of half a *morgen* [ca. 0.12 ha] with root crops or asparagus or raspberry" established at the turn of the 19th to the 20th century. In the tree lines pomme fruit ("K") and stone fruit ("St") are alternated, tree planting distance is 15 x 10 m (from LOTT 1993, Fig. 12, Reference 229). Similar plans exist for combinations with strawberry, currant, etc.

From the fruit tree statistics of 1938 it can be assumed that in the 1930s there were about 800'000 hectares of (mostly silvo-arable) Streuobst in the German Reich of that time (relating to the boundaries before the second World War, SRA 1940)[1]. In a review TRENKLE (1944) examined the impact of understorey crops in fruit orchards on the nutrient and water balance and on the yield of the

[1] 78.9 $*10^6$ fruit trees, assuming 100 trees per hectare. In addition 110 $*10^6$ fruit trees grew in home gardens, they were often also underplanted.

fruit trees. In the 1940s fruit production was still mainly in the hands of small family farms which combined fruit and arable production in order to achieve subsistence and harvest sufficient fodder for farm animals. Crops were part of the normal rotation which usually consisted of cereals, root crops (potatoes, sugar and fodder beet), vegetables, clover and grass. TRENKLE (1944) stressed that the competition for water and nutrients, especially between May and July, may reduce fruit production. He concluded that in regions of lower rainfall (bellow 700 mm per year) undercropping should be abandoned, trees should be spaced more closely and only undercropped with root crops during the first years after planting. In regions with higher rainfall (above 850 mm per year) trees may be underplanted with grass. This may even be advantageous for timber production and quality because of the high evapotranspiration in autumn.

TRENKLE (1944) examined competition between fruit trees and crops from the point of view of fruit production. His approach is opposite to the one of WAHLEN & GISIGER (1937) who estimated the annual loss of fodder production (quantity, quality) due to fruit trees on grassland in Switzerland at about 15 – 20 Million Swiss Francs. In neither of the two articles the total productivity of the system was assessed. Still, TRENKLE (1944) recognised the socio-economic justification for combining trees and crops (small holdings, scarcity of land, high share of subsistence).

It is noteworthy that the farmers' rationale of combining trees and crops was also maintained decades later in the former German Democratic Republic. Whilst they were forced to join the large co-operatives, farmers were allowed to farm small plots of land for their own benefit. Even in the 1990ies, after the re-unification of Germany, on some of those plots fruit trees were undercropped with sugar beat, potatoes, alfalfa and oat (Fig. 3).

2.2 The Berlin experiments (SCHULZ 1936)

Schulz (1936) conducted field experiments on silvo-arable agroforestry in mature pear and apple tree orchards in Berlin Dahlem. The trees were 25-30 years old, the experimental design in the pear orchard and in the apple orchard is depicted in Figure 4. Control plots (no trees) were 70 to 300 m from the trees.

In the plantations, he examined yield and quality of undercropped kohlrabi, head lettuce bush bean, knob celery and white cabbage. Vegetable yields were reduced by up to 50% as compared to monocropping. The possible reasons for reduced yield under trees were examined:

- Light: there was a parallel development of light availability and yield (Fig. 5).

Abb. 3: Zuckerrübe in Kombination mit Edelkirsche südlich von Leipzig, Sachsen; ca. 1995
Fig. 3: Fodder beet under cherry trees south of Leipzig, Saxony; approximately 1995.

- Water: in the top layer of the soil there was no real difference in water availability between agroforestry and control. About 13% (26 mm) of the precipitation was intercepted by the tree crowns. Schulz (1936) concluded that differences in water availability cannot be the major cause for yield reduction under agroforestry although he acknowledged that he did not test water availability bellow 25 cm.
- Temperature: temperature was more equilibrated in the agroforestry plot but daily minimum and maximum temperatures differed only by about one degree Celsius. It was concluded that this could not explain the strong reductions of crop yield.

Schulz (1936) concluded that in agroforestry systems the observed reduction of yield is mainly caused by the reduced availability of light. He confirmed this by a parallel experiment where shading was provided by textiles and which resulted in similar values as the agroforestry plot.

The Berlin experiments by SCHULZ (1936) were probably terminated by the second World War. There were no follow-up experiments for more than 50 years anywhere in Europe. Simultaneously, European agroforestry practices were declining (KAPP 1984). Streuobst was still very important in Germany during the war times but in the following decades, trees were increasingly banned from agricultural land. This is mainly due to agricultural mechanisation that is linked to the pressure for increased labour productivity, to land reallocations in the process of consolidations of fragmented holdings and to increasing specialisation of the farming enterprises (HERZOG 1997).

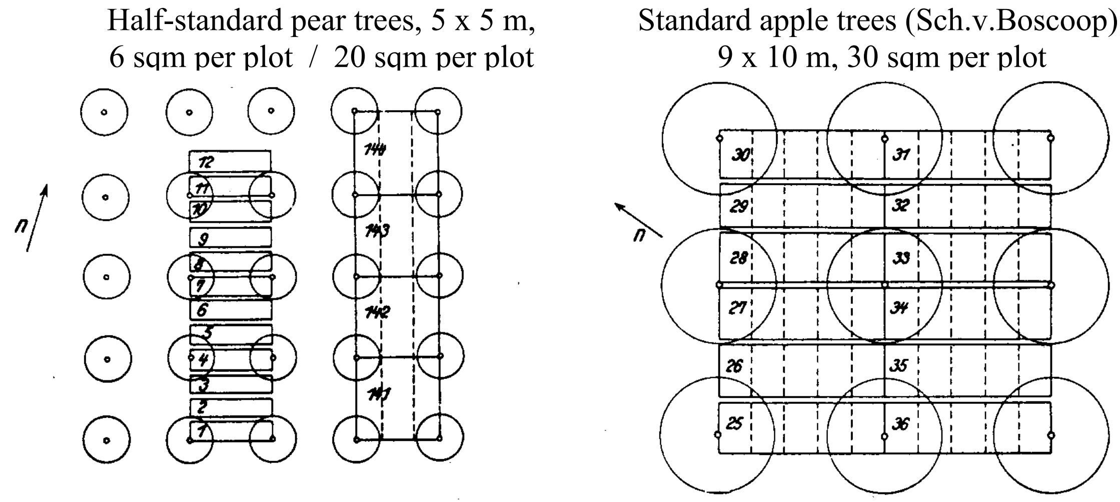

Abb. 4: Plan der Versuchsanlage mit Birnen- und Apfelbäumen von SCHULZ (1936), Abb. 11, 12.
Fig. 4: Experimental design in pear and apple plantations (Figs. 11, 12, SCHULZ 1936).

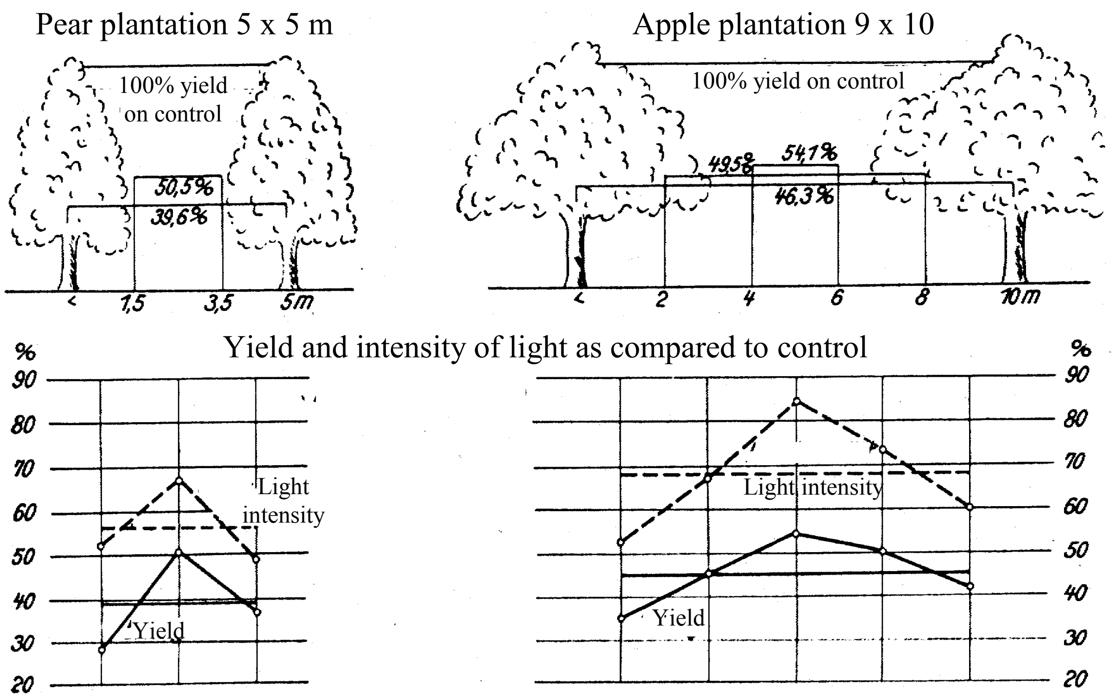

Abb.. 5: Einfluss der Beschattung durch Birnbäume (5 x 5 m) und Apfelbäume (9 x 10 m) auf Lichtintensität und Ertrag von Frühkartoffeln in Abhängigkeit von der Distanz von der Baumreihe (Abb. 24, SCHULZ 1936).
Fig. 5: Relative yield and light intensity of early potatoes under pear trees (5 x 5 m) and apple trees (9 x 10 m) as compared to a control plot without trees (Fig. 24 SCHULZ 1936).

3 Agroforestry research and development today

Only in the late 1980ies, agroforestry experiments were started again, predominantly in France and in the UK. They may have been inspired to some extent by tropical agroforestry research, which had become increasingly important in the 1970ies. GOLD & HANNOVER (1987) were the first to conceptualize agroforestry for the temperate zone. Experiments were installed, amongst others, in southern France (Montpellier region by INRA), at the Universities of Leeds and Cranfield, in Umbria (Italy) and Extremadura (Spain) (EICHHORN et al. 2004).

Searching the CORDIS database of the EU framework programs for the key word *agroforestry* yields 45 hits. Most projects relate to tropical regions and/or investigate the functioning of agroforestry systems (e.g. nutrient fluxes, interactions between trees and crops, etc.). Five to ten projects relate specifically to Europe. The two most prominent projects focused on Europe were "ALWAYS – Alternative Land-Use with Agroforestry Systems", which investigated silvopastoral systems between 1993 and 1996 and "SAFE – Silvo-arable agroforestry for Europe" (2001–2004) (http://www.ensam.inra.fr/safe/). These projects aimed at proposing modern agroforestry systems to European farmers. In contrast to traditional agroforestry systems, modern systems can be managed with modern farming machinery. The trees should impede the crop or grass management as little as possible. Modern agroforestry should yield products for which there is a demand on the market. Timber and – more recently – biomass production are usually the main tree products. The standard agroforestry design is alley cropping with lines of e.g. poplar, wild cherry or walnut trees and crops or grassland in between.

Whilst currently there is no ongoing European research project, national initiatives continue in France (www.agroforesterie.fr) and in the UK (http://www.agroforestry.ac.uk/). In Germany, Cottbus University was probably the first to implement an agroforestry experiment in the 199ies. From 2005–2008 the Federal Ministry of Research funded three agroforestry research programs, two of them focused mainly on short rotation forestry for energy production (www.agroforst.de). In Switzerland, agroforestry innovations by farmer's were studied and their profitability assessed (KAESER et al. 2010, www.agroforst.ch). This survey indicates that farmers are (still) mostly interested in fruits as the main tree product. Also, government payments for environmental services in the context of agri-environmental programs are an important incentive.

4 Can modern agroforestry systems replace traditional Streuobst?

There are many good arguments for promoting modern agroforestry systems. We are increasingly becoming aware that with a growing world population, agriculture will have to produce more food, fibre and energy on the same land area. At the same time, we don't want to further degrade agricultural and natural ecosystems, but need to protect natural resources and want to live in attractive landscapes. With its potential for increased biomass production and environmental benefits, agroforestry can be part of the solution (TILMAN et al. 2002).

Still, although there has been modern agroforestry research in Europe for twenty years, the actual uptake by farmers has remained limited except for maybe France, where several hundred hectares are planted every year (www.agroof.fr). However, this is still far from the 650,000 sqkm in Europe, which were identified as agroforestry target regions by REISNER et al. (2007). We suspect that agroforestry research may only partially address the farmers' needs. Also, laws and subsidy rules should not lead to disadvantages. If area payments are not granted on agroforestry plots, agroforestry cannot compete economically with monocropping.

Modern agroforestry systems can yield numerous environmental benefits (e.g. PALMA et al. 2007, KÄSER 2010). How important these benefits are depends on the nature and management of the system. Modern systems often employ intensive cultural techniques:

- Usually new improved genetic tree material is planted (e.g. poplar clones), whereas in traditional Streuobst old fruit tree varieties contribute to the safeguarding of genetic diversity;
- Trees are usually planted for timber or biomass production, whilst fruit production is being neglected;
- Fast growing poplars or willows for energy production grown in short rotations are a viable alternative to other energy crops – but they are a completely different habitat than traditional fruit orchards;
- The productivity of modern agroforestry systems is usually increased by the application of fertilizers and pesticides, whereas traditional orchards are mostly extensively managed.

These systems target the farms' most productive land, which otherwise is intensively farmed. In those situations, the planting of trees will generate environmental benefits as compared to intensive monocropping, particularly for the protection of soil, water and the atmosphere. Streuobst meadows usually occur at more marginal sites and are less intensively managed. Their main environmental benefits are the habitat values they create (for the conservation of species diversity) and their contribution to landscape scenery. These values can only be created to a lesser extent by the above mentioned intensive agroforestry systems.

However, modern systems can also be designed for biodiversity benefits. In fact, this was a major motivation of most of the innovative farmers we interviewed in Switzerland. They conduct their own experiments by mixing different tree species, alternating trees and shrubs and also by varying intercropping (cereals, vegetables, grassland, fallows, etc.). REEG et al. (2009) have reviewed the potential of agroforestry for nature protection and make recommendations for improving the habitat value, also of intensive agroforestry systems.

Whether, on the long run, modern agroforestry will replace traditional Streuobst remains an open question. From our perspective we argue that modern agroforestry should be regarded as complementary to traditional Streuobst. It is an opportunity to increase agricultural production whilst protecting natural resources, mostly on fertile and high yielding land.

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