Scientific and technical basis for sylvopastoral systems in Europe

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Résumé : Un projet de recherche visant à développer de nouveaux systèmes d'utilisation du territoire, plus extensifs et adaptés aux exigences du marché, a démarré en 1993 avec 18 organismes de recherche et développement de six pays européens, avec la participation financière de la Commission Européenne. Il s'agit de diversifier les utilisations intensives des terres agricoles par la plantation d'arbres à croissance rapide, à large espacement pour permettre un maintien d'une activité agricole, et destinés à produire du bois de qualité.
La recherche s'oriente dans deux directions complémentaires :

- le recueil et l'analyse des données techniques sur des aspects concernant : le choix des arbres (espèces, génotypes), les techniques d'installation et de conduite des arbres, les effets des systèmes agroforestiers sur la production agricole ou les systèmes de gestion pastorale et sur la croissance, la forme et la qualité des arbres.
- l'intégration de ces données dans un système de modélisation de l'agroforesterie, permettant de prédire les conséquences à moyen et long termes et au niveau micro- et macro-économique.

Mots-clés : Agroforesterie - Système sylvopastoral - Utilisation du territoire - Modélisation

INTRODUCTION

In the present international agricultural context, particularly within the framework of the GATT[1], and more precisely in Europe with the CAP[2], the European Commission has launched in 1991 a specific research and development programme, with the objective of "*contributing to securing a better match between production of land- and water-based biological resources and their use by consumers and industry through pre-competitive research, technological development and demonstration*".

Within this framework a research project entitled "*Alternative Agricultural Land-Use with Fast Growing Trees*" has been developed with the co-operation of scientists from 18 R&D institutes of six European countries. One of the main objectives of the common European agricultural policy is to improve socio-economic conditions of farmers, particularly in regions which are lagging behind in development. In order to help maintain farmers in rural areas, adapt agricultural production to the demands of the market, and reduce agricultural surpluses, this project aims at developing new, more extensive land-use systems, based upon quality timber production from set-aside agricultural land, inside an agricultural system.

The specific objective of the research project concerns the development of a farm/agroforestry modelling system, taking into account the technical aspects and integrating biological and economic data, devoted to simulation and decision-making for farmers, land-owners, and land-managers. This model is described in detail by Bergez and Msika (1995).

Research is being developed in two main directions :

[1]GATT : general agreement on tariffs and trade
[2]CAP : Common Agricultural Policy

1. A study of the technical aspects of management of farm/agroforestry systems : site characteristics and tree growth potential of available agricultural land, choice of tree genotype, tree establishment and management techniques, impact of agroforestry techniques on tree growth, form, and wood quality, agricultural techniques and rearing systems adapted to agroforestry.
2. An integration of the above biological data into a modelling system : growth models for tree and agricultural components and their interactions, development of a global biologically-based economic model. Social and environmental aspects are also being investigated.

The present paper describes progress of the project after two and a half years of work. It is mainly based upon the first periodic progress reports (Auclair, 1995).

SCIENTIFIC OBJECTIVES AND PRELIMINARY RESULTS

Agroforestry potential of available agricultural land

Determination methods traditionally used in forestry cannot be used in the areas which are likely to become available for agroforestry. It is necessary to develop new efficient tools to determine the characteristics of up to now unforested land and of tree growth potential.

The present project aims at linking three different approaches of site determination, on common areas, in order to establish a typology of agroforestry sites, and to propose simple indicators of this typology : botanical aspects, geo-physical aspects, tree mensuration.

Present results show that there is no simple way of linking geological and geomorphological characteristics of an area to a botanical characteristic, if this area has a complex geological history.

Choice of tree genotypes

Up to now tree improvement programmes have mainly focused on "forest-type" plantations. New genotypes have to be found for very wide spacings such as those used in agroforestry plantations, and adapted to the available soils. The project focuses on three main species : wild cherry (*Prunus avium* L.), common ash (*Fraxinus excelsior* L.), and hybrid larch (*Larix* x *eurolepis*). For these three species a high variability between clones has been observed for all economically important traits under study, which favours a great potential for genotypic selection.

Tree establishment techniques

Land which is being converted from agriculture is likely to present several particular characteristics, which can be either favourable or detrimental for the growth of timber producing trees. Adapted plantation techniques must therefore be applied, relating in particular to competition with grass and to tree protections.

Most techniques used in traditional sylviculture give good responses in agroforestry : underplowing, plot weeding, vole, rust and insect protection give significant results.

- Height growth depends on site conditions and is best in the warmest sites. In France agroforestry trees grow faster than forestry controls. In some plots, they have totally filled their tubes and become resistant to livestock six years after planting ;
- All studies show defects caused by plastic tubes, resulting in high shoot/root and height/diameter ratios. The trees progressively recover their natural taper when they grow above treeshelters. They remain very fragile during several years, however improvements to the tubes are at present under study, and the first results appear very promising.

Tree management techniques

For the same reasons as for tree establishment, the characteristics of land converted from agriculture, the presence of animals and/or an agricultural component, and the wide spacings which will be used in order to favour the growth of both tree and agricultural compartment, are likely to have effects on growth and form of trees. In order to produce high quality timber, specific tree management techniques must be implemented, in particular tree protections and bole formation.

New designs of tree shelters are being implemented, principally to meet the physiological requirements of the trees during the early stages of their establishment.

As high quality timber is the objective, adequate pruning techniques are necessary. Results to date show that pruning operations must begin at a very early stage of tree growth, cutting branches inside the tree shelters. One single leading shoot should be kept, and pruning should be performed before branch diameter reaches 3 cm. The objective is to maintain a well-balanced crown by pruning not only the lowest branches, but also inside the crown.

Wood quality

In order to fit the market it is important to know, and to improve, the quality of wood produced in the new systems studied, in particular in connection with border effects and wide spacings, which may influence tree architecture and branching, but also diameter growth and wood density. This is also related to the new genotypes which will be used in agroforestry situations.

The first results concerning wood properties show a high variability of basic density at the tree level in relation with ring width variations. In addition, wood colour and aesthetic properties are being studied on open grown, fast growing *P. avium*, in particular on samples from the above-mentioned genetic trials.

Experimental trials at wide spacings on highly fertile land outline the absolute necessity of performing pruning operations correctly. Too severe pruning results in proliferation of epicormics, and too light pruning produces large branches : this causes a great number of wounds, which can taking a long time to heal and providing a potential entry for pathogens.

Pasture growth - interaction with trees

Tree species, tree planting density, tree planting pattern, tree pruning (canopy and root), botanical composition of the crop or pasture, the use of fertilisers and herbicides and the frequency of harvesting or of defoliation of the pasture will all influence the extent of competition between trees and understorey for light, water and nutrients. The success of the understorey in capturing light, water and nutrients will determine its botanical structure and its potential growth rate.

Provisional results show that light transmitted to the ground level is always more than 75% of incident light with 4.6m trees at 4mx4m spacing. Good relationships have been found between tree leaf area and more easily measured dimensions of stems and branches supporting that leaf area in *Acer*.

Impact of agroforestry on rearing systems

The presence of widely spaced trees and the resulting understorey pasture growth will have an effect on the production of grazing animals. All the factors mentioned above influence pasture botanical structure and potential growth rate. Utilisation of the pasture by grazing animals will be directly affected by its structure and growth. Pattern of use of understorey pasture by grazing animals may also be directly influenced by the presence of the trees.

Provisional data from the UK sites suggest that levels of animal production remain unaltered by the presence of trees of up to seven years old.

Tree growth modelling and biophysical agroforestry model

Tree or stand growth models which have been developed for forestry are misadapted to agroforestry : large spacings, border effects, plot heterogeneity can influence yield both in quantity and in quality and can affect height and diameter distributions. The two main objectives in the tree growth modelling task are : to predict quantity and quality of timber produced in agroforestry situations, and to predict whole tree development in relation to other agricultural crops, in order to describe in detail the biophysical interactions.

In addition to tree growth, a synthetic model is being built, adapted to the conditions of the participating countries, relating forage production to particular indicators expressing in the best possible manner mesoclimatic modifications linked to the presence of trees. This is described in more detail elsewhere (Bergez and Msika, 1995).

Economic impact of agroforestry techniques

Although not the single one, the economic aspect of introduction of agroforestry practices into an agricultural organisation is extremely important. Economic knowledge has impacts on the possibility of adoption of agroforestry by farmers, and also on the policy to be implemented at a regional or community level. Surveys are undertaken at three different levels : plot, farm, region. The models developed at these three levels will then be linked together, with inputs from the biophysical model described above.

Ecological impact of agroforestry techniques

The potential ecological impacts of agroforestry can be extremely diverse, and the present project is restricted to some aspects concerning landscape organisation, and to simple indicators of biodiversity both at the plot and at the regional level.

A survey of botanical composition, vegetation structure and bird populations on small woodlots has shown the importance of woodlot shape on biodiversity. Maximum diversity is obtained for a round woodlot. Preliminary results from a survey of carabid beetle biodiversity along a gradient ranging from agricultural areas to old mature stands clearly show that agroforestry experimental plots have more diverse populations than agricultural sites.

FUTURE OF THE PROJECT

The project is at present entering its final phase. Most of the preliminary results are now being confirmed : technical informations on management of agroforestry plots will become available in the near future, and a biophysical model for simple sylvopastoral plots will soon be produced. However some scientific questions still remain unanswered, such as the underground tree-grass interactions, root growth and competition, or nitrogen cycling in the presence or absence of N-fixing plants.Tree growth models are now validated in the early stages, but still need to be improved for older trees grown in agroforestry situations. The sylvopastoral plot biophysical model should be extended to other situations (agrisylvicultural plots) and to a higher level (farm scale) in order for economic models to integrate the whole farm organisation. These aspects will have to be addressed in the near future.

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