Silvoarable Agroforestry

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Summary

The evolution of a broadleaved silvoarable system - the cultivation of trees and arable crops on the same area of land - in England is briefly described together with notes on current research using hybrid poplars and four other deciduous timber producing broadleaved species. The objectives of such a system include timber and nut production, benefits to arable cropping and greater diversity of habitat and landscape. The potential for the system to be more profitable than comparable monocultures is being investigated. Currently recommended methodology is described and discussed.

Introduction

A silvoarable system of land management implies the cultivation of trees and arable crops on the same area of land, a system practised quite commonly in southern Europe and in the tropics. The system comprises two components: tree rows, generally one tree wide, and arable alleys, alternating across the field. The first major development of silvoarable practice in the UK took place during the 1960s and 1970s when Bryant & May established extensive poplar plantations on lowland farmland in southern England to supply their own market for match veneer timber (Beaton, 1987). Since the demise of the Bryant & May market for match timber in 1978, interest in the potential for silvoarable systems lay dormant until the advent of food crop surpluses in the 1980s.

Some, at least, of this interest is founded on the need to find alternative uses for land that is, or may become, surplus to food production in northern Europe. Additionally there seems to be a growing awareness that vast areas of monocultural systems of agriculture may no longer be generally acceptable to public perceptions of good land management and those who now pay the 'piper' so handsomely may be demanding a greater say in the 'tunes' being played. Accordingly, changes in the arable area payment system now being considered by the UK Government may be more favourable to silvoarable systems which can provide more diverse habitats and greater variety of landscape.

A further attraction for the combination of trees and crops lies in the contribution such systems could make towards reducing the large annual cost of importing timber and timber products into the UK. England particularly is one of the less well forested countries in Europe and it is understood to be Government policy to encourage the planting of trees in the lowlands. Silvoarable agroforestry could make a significant contribution to this policy.

Current Research

Bryant & May investigated the effects of crops on the growth of poplars but, with the termination of the forestry company in 1978, all such research ended. Although a silvoarable agroforestry research programme was started by S. Newman at the Open University in 1979, particularly into walnut *(Juglans regia)* agroforestry for both timber and nut production, (Newman *et al.*, 1991b), it was not until 1988 that

Figure 1. Winter wheat harvest with rows of poplar 10 m apart in the 5 th growing season. Silsoe College, Bedfordshire (Cranfield University). Source: P Burgess

large silvoarable experiments were planted in England; at the Open University with poplar as the tree component, (Newman *et al.*, 1991a and 1998; Dupraz and Newman, 1997) and at Leeds University, (Incoll *et al.*, 1997b) with ash *(Fraxinus excelsior)*, sycamore *(Acer pseudoplatanus)*, cherry *(Prunus avium)* and walnut. The latter, although capable of producing high quality furniture timbers, are much slower growing than poplar which was chosen because of its rapid growth (particularly the new Belgian clones), good form and widely utilisable timber. In both these experiments, tree rows are 2-m wide and 14 m apart with 12-m wide cropped alleys. The poplars are 4 or 6 m apart in the rows in the Open University experiment and the trees at Leeds are 4 m apart giving 179 trees ha^{-1}.

In 1992 an experiment was established at three sites in England (Incoll *et al.*, 1997b) to provide information on the effect of arable crops on the growth of four poplar clones, the effect of the trees on crop yields and to assess the feasibility and the economics of the system compared with an arable monoculture. Each of the sites, at Leeds University in Yorkshire, Silsoe College in Bedfordshire and the Royal Agricultural College, Gloucestershire, has a similar randomised block layout with four poplar clones, three arable treatments and an arable control. The experiment has been intermittently funded by MAFF. The width of alleys is only 8 m, designed to meet minimum stocking requirements for the planting grant then offered by the Forestry Commission. This alley width is now impracticable because the minimum length of a commercial spray boom is 12 m. Tree rows, 10 m apart, are 2.0 m wide aligned approximately north/south and partly covered by continuous strips of black plastic sheeting which act as a mulch. The trees are 6.4 m apart in the rows giving a stocking density of 156 trees ha^{-1}.

Preliminary results from this research have shown conclusively that even with the increased size of modern farm machinery, silvoarable systems are feasible in the lowlands of the UK. However with only some ten years of research it is too soon to demonstrate the full effects of tree growth on crops and of crops on tree growth. By the end of the sixth year at Leeds, Silsoe and Cirencester and the seventh year at the Open University, no consistent effect of a particular poplar clone on the yield of arable crops had been established although there had been a reduction in yield at Cirencester and Leeds. Across all three sites the mean yield reduction was 4% in the first three years and 10% between years 4 and 6. In the Leeds 'furniture timber' experiment there was no evidence of an effect of trees on crops after nine years. Conversely tree growth has been reduced by arable crops in some years so that the rotation for the tree component may be extended, perhaps by one or two years. Of course the arable area of the field is reduced by the proportion of the area taken up by tree rows, approximately 14% with 12 m alleys and 7% with 24 m alleys, but the above assessments are based on yields per unit area of arable crop.

Silvoarable Agroforestry in Practice

The successful establishment of a silvoarable system requires

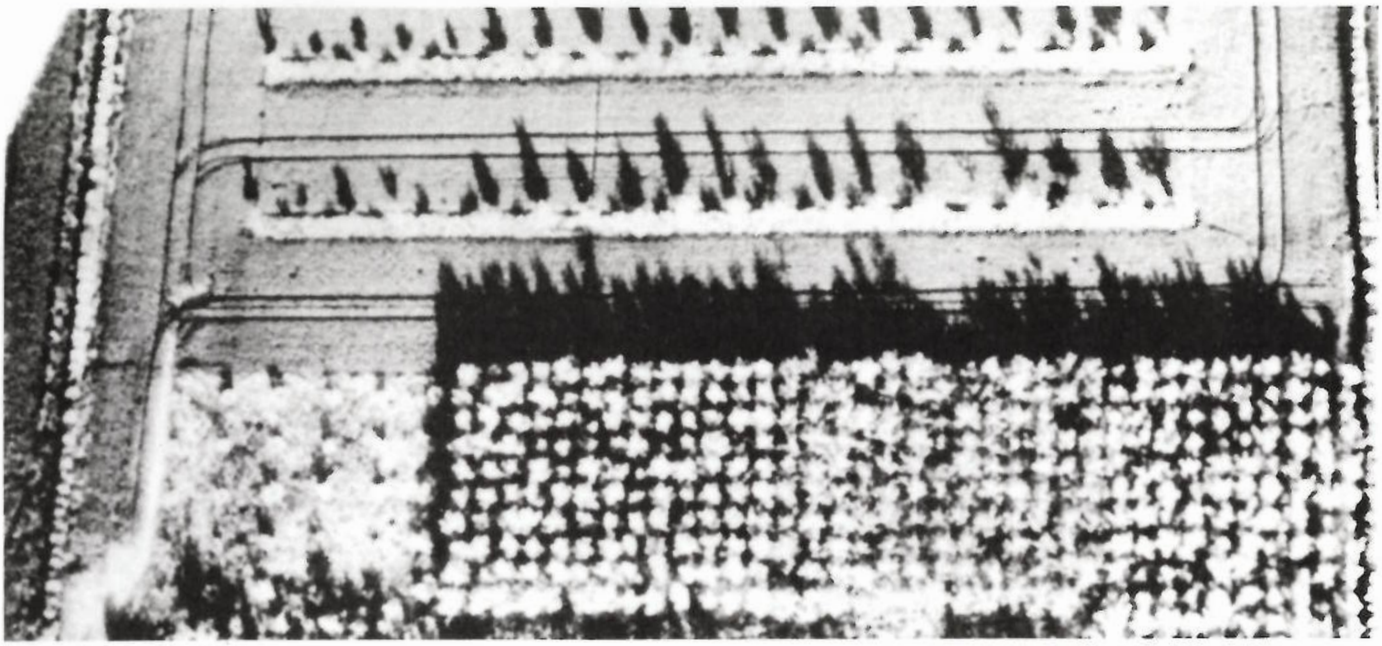

Figure 2. Aerial view of silvoarable experiment with high quality timber trees showing:- i) three arable alleys, 12 m wide with central 'tramlines'; ii) four tree rows, 2 m wide and 14 m apart with trees 4 m apart in rows; iii) turning space, 12 m wide, at ends of tree rows; iv) forestry planting of sycamore, cherry and ash at 2 m square spacing. Leeds University. *Source: A Chadwick*

careful choice of the tree component to meet the grower's objectives (Beaton and Hislop, 1998). These may be for timber, for shelter or amenity, for the production of a nut cash crop or for a combination of some or all of these options. A major advantage of silvoarable systems is the flexibility in management they offer so that tree rows may have mixed species composition, including a nut cropping understorey, *e.g.* hazel (*Corylus* spp.)

Following harvest of an arable crop and the subsequent cultivations for the next sowing, tree rows are marked out at the desired spacing across the proposed silvoarable field. The rows should be orientated close to north/south to minimise the effects from irregular shading and the spacing between tree rows must be accurate to avoid future problems with machinery movements. The tree row is effectively 2 m wide and the width of alley must be sufficient to allow movement of the widest machinery to be used in farming operations. In practice this will be the spray boom, so that for an 18 m spray boom, the alleys will be 18 m wide and the distance between tree rows 20 m. Sufficient distance must be allowed between the end of the tree rows and the headland to allow all machinery to turn without difficulty.

Black plastic mulch, UV resistant, 1.5 m wide is laid along the centre of each tree row and ploughed in along both edges using a tractor-mounted laying machine. Trees are planted through the mulch, cutting the plastic just sufficient to allow rooted transplants and merely piercing a hole for unrooted poplar sets to pass through. Poplar sets, 1.5 m long, are the optimum size and should be inserted by hand into well cultivated soil to about one-third of their total length. Larger sets require the use of a steel bar to probe a hole so as to allow the set to be planted to one-third depth. Spacing between trees in the row is an estimation of that required at maturity, for most species grown for timber this would be between 5 m and 10 m. It is essential when planting poplar, whether rooted or unrooted, to ensure that one-third of the plant is in the ground and properly firmed; Jobling (1991) gives full details. Protection against damage from wild animals is best provided by plastic tree shelters, which may also prevent spray drift onto recently planted trees.

The trees in a silvoarable system require intensive management from year one, a distinct contrast to some farming attitudes to the management of trees. Since each tree is likely to be part of the final crop, early and timely crown correction and pruning are essential, both to maximise future timber value and to lift tree crowns above farm machinery as quickly as possible. As a rough guide the pruned stem should be half the total tree height until the desired pruned length of between 5 m and 8 m has been attained. Such treatment has other advantages: firstly it may delay the onset of shading on the arable crop, secondly, the removal of branches is a much cheaper operation when these are small, and early pruning will promote a greater volume of knot free timber. Pruning, as distinct from crown correction, may begin in the third year following planting and with fast-growing poplar should have reached 8 m before the tenth year, (Jobling, 1991). The operation can be carried out using secateurs initially and then a long-handled pruning saw. Pruning from mid to late summer is probably the best time; if carried out immediately after harvest this will allow the branches removed at later prunings to be racked on to stubble and chopped up by tractor mounted machinery or be collected and removed for burning.

Cultivations, weed/pest control and harvesting operations for the arable crop are no different to those of a normal monoculture except that ploughing direction should be reversed year on year to avoid migration of soil towards one side of a tree row. All the main combinable crops, small-grained cereals, legumes, oilseed rape and linseed can be cropped in a silvoarable system. Crops requiring wide or tall harvesting machinery such as maize or root crops are believed to be unsuitable, (Incoll and Newman, 1998). The main unsolved difficulty so far experienced has been the control of weeds in the interface between crop edge and plastic. This interface may be as wide as 50 cm. In the MAFF trials, hand cutting or spraying has been necessary but on a field scale it is believed weed control of this interface could be achieved satisfactorily with offset spray jets on the spray boom, using either the crop herbicide or a wide spectrum herbicide such as glyphosate.

As trees grow there is an increase in shading and, with the narrowest alley width of 12 m and tree rows 14 m apart, arable cropping may no longer be possible beyond the tenth year and the system will develop into a plantation. At this point the system could be converted into silvopastoral agroforestry. Indeed this could be a way of establishing a silvopastoral system since the major problem of this system is the protection of young trees against damage from grazing sheep or cattle. By adopting a silvoarable system first, the trees will grow to a size so that leaves are beyond the reach of grazing animals and the bark is no longer palatable. At wider distances between tree rows, the duration of cropping will persist for a longer period and beyond 20 m it may even be possible to maintain an arable rotation indefinitely. Currently this is speculative.

Discussion

Although silvoarable systems managed by Bryant & May were very successful in southern England, there is no reported experience further north than Leeds, 54° N. It is not known therefore if such a system would be successful much further north. During the earlier part of this decade, the Strathclyde Greenbelt project included scattered plantings of hybrid poplars in lowland Scotland with some promising results. The feasibility of a silvoarable system would need to be tested before any recommendations could be made for Scotland. Elsewhere in the UK the system is seen as an alternative land use which may have particular value in the fertile lowlands of eastern England and in other regions with little woodland cover. Exposure is a major constraining factor to plant growth and farming could benefit significantly by the presence of widely spaced tree rows across exposed arable land.

There are also other perceived benefits from a silvoarable system. These include the potential for increased dry matter production due to a better seasonal use of water and nutrient resources. During winter dormancy of deciduous trees, autumn-sown crops may be largely unaffected by the presence of the trees. Following harvest the reverse is true - the trees no longer have competition from the arable crop, yet both are growing in close proximity. This is known as complementarity *i.e.* when the yield of the two components of the system is greater than the yield of either of the component crops as monocultures (Dupraz and Newman, 1997). Then the system allows farmers to grow a tree crop on land still mainly devoted to arable production, with quality timber providing a tax-free bonus, possibly during a working lifetime. Finally the system provides increasing landscape and environmental diversity and has the potential to reduce the requirement for chemical pest and disease control measures. Naeem *et al.* (1997) and Griffiths *et al.* (1998) discuss aphid response and slug damage, respectively, in a silvoarable system. By growing two crops in alternate alleys across the field, as demonstrated recently at the Royal Show, arable crop pests and diseases may be reduced even more.

At the present time a silvoarable system as described above fails to benefit from the Farm Woodland Premium Scheme (FWPS) or from Set-Aside payments and will only qualify for a proportion of the Woodland Grant Scheme (WGS) planting grant. At wider spacings between rows the Better Land Supplement (BLS) would not at present be approved. The

Figure 3. Silvoarable demonstration at Royal Show, Stoneleigh Park, Warwickshire. Alternate alleys are cropped with oilseed rape and linseed. Note the plastic mulch and first year growth of P."Beaupre" from unrooted set. *Source: J. Howard-Duff*

system would be eligible for Arable Area Payments. Assuming a distance between tree rows of 20 m, and 5 m between trees in the row, only 100 trees ha^{-1} will be planted. Poplars grown at that spacing on land to Yield Class 18 (YC 18) will produce approximately 300 m^3 of timber in 30 years giving a tax-free return of about £7,500 ha^{-1}. Thomas and Willis (1998) and Burgess (*pers. comm.*) have analysed the relative profitability of the silvoarable system with poplars compared with arable cropping. Their studies indicate that silvoarable systems are profitable. However their profitability relative to arable cropping is dependent on land quality, crop prices and the grants and payments available to growers. Currently, agroforestry is penalised by both WGS and FWPS and they suggest a re-examination of these schemes so as to encourage the perceived benefits from silvoarable agroforestry.

The system plainly contributes to set-aside and seems a more attractive option than requiring land to be left fallow, although this too may be achieved simply by leaving alternate alleys uncropped year on year to give a two course rotation of crop and fallow as was practised by Bryant & May. It is believed that silvoarable systems will have a useful contribution to make in finding alternative uses for surplus agricultural land in the UK.

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