

The United Kingdom network of experiments on site/yield relationships for short rotation coppice

by Alan Armstrong



Summary

It has long been known that the early performance of willow and poplar is very dependent on good site preparation and management, and particularly on rigorous elimination of weed competition. Given good husbandry, yield depends on interactions between the genetic material, soil conditions and climate. In order to assess the performance of willow and poplar clones at a range of site types a network of 49 sites was established by Forest Research (FR) on contract to ETSU for the Department of Trade and Industry (DTI) between 1994/95 and 1995/96. Sites were selected throughout the UK to cover the major soil types suitable for poplar and willow, over a wide range of climatic conditions. The resulting data will be used to construct yield models which can be used to advise planners, energy producers and growers of the most suitable clones to plant in a given area and to indicate the likely average yield. This Note provides information about the network and on the data being collected.

Background

The Rio Agreement of 1992 set new targets for the reduction of carbon dioxide (CO₂) and sulphur emissions. This was followed in 1994 by The Declaration of Madrid, which set the objective of substituting 15% of real primary energy demand in the EU with renewable energy sources.

Early research with species that coppice has shown that poplar and willow are the most reliable species for use as energy crops (Potter, 1990). The use of short rotation coppice (SRC) of poplar and willow as a substitute for fossil fuels is environmentally beneficial as it produces no net CO₂ emissions from its combustion. The carbon budget is more favourable when yield is maximised. The combustion of coppice also produces emissions low in NO_x and SO_x pollutants compared with fossil fuels.

Experiment design

Energy coppice should employ clones of poplar and willow which are disease resistant and vigorous (Tabbush and Parfitt, 1995). Breeding programmes continually develop new clones, and it is unlikely that the list of clones recommended today will be the same as that recommended in 5 years' time. This means that yield models must be generalised, so that they can be adapted to make predictions for new clones based on their general characteristics. The approach adopted was to select good examples from each parent group (e.g. pure *Salix viminalis*; *Populus interamericana* hybrids, etc.) and examine variations in yield over a large number of sites (Extensive sites), using a relatively simple experiment design. Predictions of yield for clones not included can then be approximations based on the representative clonal type. This would be unsatisfactory unless good

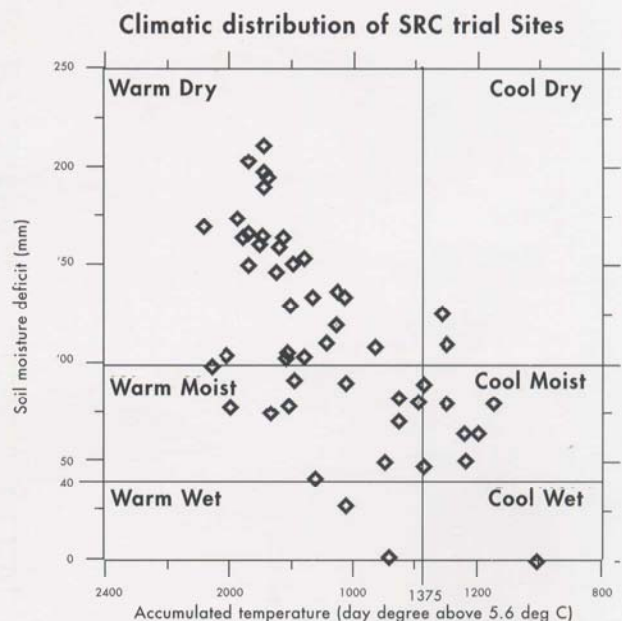
information was available on how the new clone differed from its relative in the experiments. For this reason a small number of larger experiments each containing a more comprehensive range of clones (Intensive sites) was established.

In combination with records of the climatic conditions, these data can be used as inputs to empirical growth models developed from the extensive trials.

- A randomised block design was used for the Intensive sites with 2 species x 16 clones x 3 replications.
- A completely randomised design was used at the Extensive sites with 2 species x 3 clones x 3 replications. Fifteen of the sites include the same clones combined in additional mixture plots.
- Plot size is 100 trees (10 x 10) with a 36 tree (6 x 6) assessment plot. Spacing is alternately 1.5 m and 0.75 m between rows, and 0.9 m in the rows, to give a stocking (almost) of 10,000 cuttings/ha. This plot size is sufficient to provide some extra guard rows to allow for a small amount of destructive sampling, whilst minimising edge-effects. The mixture plots are 10 double rows wide, and 20 'columns' deep, and contain an assessment plot of 9 trees x 9 trees.

Site selection

- Site selection was based on the need to cover the major soil types suitable for poplar and willow, at an elevation of <250 m above sea level.
- Sites were also selected to cover the wide range of climate types found in the UK, using an ecological site classification developed by Pyatt (1995).
- Climatic zones were identified based on a measure of annual warmth and climatic wetness.



Soil survey

- Sites were sampled to obtain a representative soil profile and analysed for physical and chemical properties.

Checklist of soil features recorded in full profile description (for details, see Hodgson, 1976)

General description

Form of ground surface
Vegetation type
Form of cultivation
Slope and aspect
Elevation

Horizon description

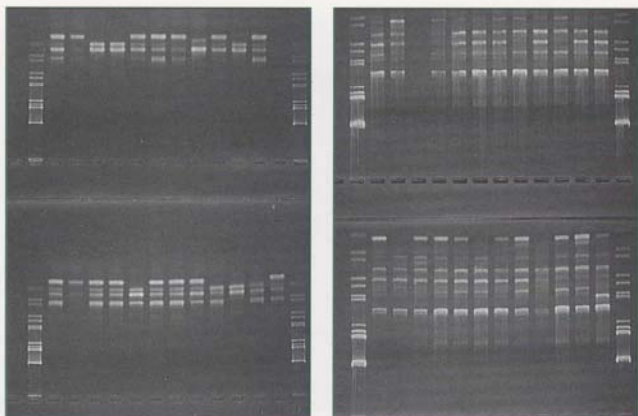
Horizon nomenclature
Thickness
Colour(s); mottling
Particle size class
Structure
Rooting habit
Bulk or packing density
Stoniness; nature of stones
Nature of organic matter (for organic horizons)
Features of pedogenic origin (nodules, etc.)
Carbonates

Chemical analyses

- a. Particle size analysis
- b. pH, P, K, Mg, Ca (ADAS)
- c. Mineralisable NH_4 and NO_3 (on field-moist subsample)
- d. Organic carbon (wet oxidation)
- e. pH (CaCl_2)
- f. Cation exchange capacity

Clonal integrity - DNA

- All of the clones being used were fingerprinted from their DNA using RAPD analysis (Williams et al., 1990).
- This has ensured that all material used in the trials is of known identity.
- As yield information becomes available genetic characteristics can be used to inform the clonal selection programme.



RAPD fingerprint of poplar

Meteorological data

The commonly available meteorological data are unsuitable for use with coppice grown on short rotations (data for many parameters are based on 20 year means and often interpolated from the nearest stations). The following data are therefore collected at each site:

- Intensive sites have been equipped with instruments to measure: wind speed and direction; air and soil temperature, an additional wet bulb thermometer will allow calculation of humidity; rainfall and wetness; solar radiation.
- Extensive sites have been equipped with instruments to measure air temperature, soil temperature and rainfall.



Meteorological data being collected at an Intensive site

Establishment

- Sites were sprayed with a contact herbicide to eliminate perennial weeds prior to ploughing.
- Ploughed sites were power-harrowed immediately before planting with 25 cm unrooted cuttings.
- Residual herbicides were applied immediately after planting and the sites kept weed-free by further applications of herbicide throughout the year (Willoughby and Clay, 1996).

At the end of the first growing season failures were replaced and all trees stumped back to 10 cm above ground level to encourage the stools to become multi-stemmed. Harvesting is planned to follow a standard 3-year cutting cycle, so that data will be readily comparable between sites and with data from other research.



Power-harrowing prior to planting

Non-destructive yield assessment

- Methodologies have been developed to allow an annual assessment of yield to be made.

This will involve measuring the diameter of all stems in the inner assessment plots on a per stool basis. Some selected stems will be used to determine the height/diameter relationship non-destructively. A minimum number of sample stems taken from the guard rows will be used to convert volume to dry weight.

Insect and disease monitoring

- Poplars and willows are host to a wide range of phytophagous insect species and fungal pathogens.
- Defoliation in excess of half of the leaf area has been shown to reduce the growth increment of SRC willow by up to 60% in the year of damage (Larsson, 1983). Assessments are being made twice a year at all sites to record the levels of damage.
- If yield of SRC is to be related to climatic and site factors it is important to monitor the level of insect and disease damage which may be a cause of unexplained variation in yield.



Damage to poplar leaves caused by *Phyloocta* spp.

Parentage of clones being used in the intensive trials:

Poplar	Parentage
Beaupré*	T × D
Ghoy*	D × N
Trichobel*	T
Boelare	T × D
Unal	T × D
Raspalje	T × D
Gaver	D × N
Gibecq	D × N
69,039/4	T × D
69,038/6	T × D
71,009/1	D × T
71,015/1	D × T
71,009/2	D × T
TT32	T × B
Fritzi Pauley	T
Columbia River	T

T = *trichocarpa*; N = *nigra*; D = *deltoides*;

B = *balsamifera*

* = clones used at Extensive sites

Willow

Willow	Parentage
Jorunn*	<i>vim</i> × <i>vim</i>
Germany*	<i>burjatica</i>
Q83*	<i>tri</i> × <i>vim</i>
Spaethii	<i>spaethii</i>
Dasyclados	<i>cap</i> × <i>cin</i> × <i>vim</i>
ST/2481/55	<i>tri</i> × <i>vim</i>
Delamere	<i>aur</i> × <i>cin</i> × <i>vim</i>
Bebbiana	<i>sitchensis</i>
V789	<i>vim</i> × <i>cap</i>
Ing 00010	<i>burj</i> × <i>vim</i>
Ing 00011	<i>burj</i> × <i>vim</i>
Jorr	<i>vim</i> × <i>vim</i>
Bjorn	<i>vim</i> × <i>sch</i>
Tora	<i>vim</i> × <i>sch</i>
Orm	<i>vim</i> × <i>vim</i>
Ulv	<i>vim</i> × <i>vim</i>

vim = *viminalis*; *tri* = *triandra*; *cap* = *caprea*; *cin* = *cinerea*; *aur* = *aurita*; *burj* = *burjatica*; *sch* = *schwerinnii*

* = clones used at Extensive sites

The partners

- The first phase of this work, the establishment of six intensive sites and 22 extensive sites was funded by the DTI through ETSU.
- Phase two, which covers data collection and management until May 1998, is being funded by DTI (through ETSU), Forestry Commission (FC), MAFF, Department of Agriculture for Northern Ireland (DANI) and the trade organisation British Biogen.

Day to day management is carried out by Forest Research and DANI research staff.

A steering committee has been set up to oversee the progress of the project. This committee is made up of representatives from the funders, the Department of the Environment, Transport and the Regions (DETR) and the Scottish Agricultural College (SAC).

The resource is available for research and educational studies which may assist the project. Requests to use the sites should be channelled through the steering committee.

An international modelling panel with representatives from Sweden, Belgium, Denmark, Switzerland and USA, as well as the UK has been set up to advise on the most appropriate models to use and which parameters to assess.

Steering committee

Mr David Thirkell	Chair
Mr Francis Marlow	MAFF
Mr Paul Tabbush	FR
Dr Kerr Walker	SAC
Dr Kathryn Rushton	ETSU
Dr Paul Maryan	Minutes
Mr Philip Callaghan	DoE
Mr Murray Carter	British Biogen
Mr Richard Kettle	DETR
Mr Malcolm Dawson	DANI
Mr James Simpson	FC

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Location of sites: yield models for energy coppice of poplar and willows

Phase 1

■ Intensive

■ Extensive (mixed)

□ Extensive (pure)

Phase 1

■ Intensive

■ Extensive (mixed)

■ Extensive (pure)



Willow coppice 6 months after planting as unrooted cuttings



Willow coppice 6 months after cutting back