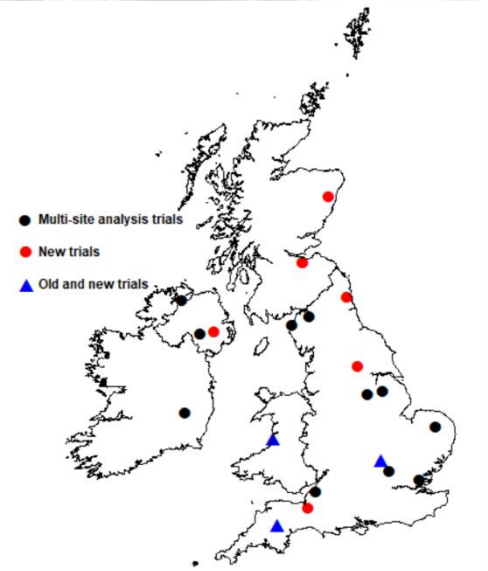
Growers guide to short rotation coppice willow (SRCw) varieties for biomass.

This guide provides information to help growers minimise risk by making informed choices when choosing to grow short rotation coppice willow (SRCw) for biomass. It will be updated as new information becomes available. PDF and printed versions should be cross checked with the Biomass Connect and Rothamsted Research AWBD Project websites for the latest version (see date below).



A novel multi-site statistical analysis was performed on **biomass yield** (t ha^{-1} yr^{-1} dry weight; DW) and the **dry matter** content of the wood as harvested (%DM) data from trials planted between 1997 and 2016. The performance of individual varieties, the overall reaction of SRCw to weather conditions and the specific variety reactions to those weather conditions are described.

The map shows where the trial sites (black dots and blue triangles) were located. New trial sites to expand the geographical range are shown as red dots.

A total of 71 distinct harvest events occurred as some trials had multiple harvests, however, not all varieties were present at all harvest events or in each trial. Most trials received first-year-cutback and harvest took place on 2-year-old-stems. These differences were accounted for in the statistical analysis. The procedure is described in the Accelerating Willow Breeding and Deployment (AWBD) project Phase 1 Report for BEIS (now the Department for Energy Security & Net Zero) found here.

The weather effects upon SRCw biomass yield were quantified using mean temperature, total rainfall (65 harvest events) and total sunlight (solar radiation, 60 harvest events) according to availability of data. The two years of growth before harvest were split into calendar months.

Table 1 shows the variety means for biomass yield (t ha^{-1} yr^{-1} DW) and the dry matter content (% DM) when harvested for comparison of varieties. Five varieties exceeding 49% dry matter, at harvest, are highlighted in red. Varieties with higher %DM may be of interest to those using a direct cut and chip harvest method and transporting biomass to the end-user.

This work was conducted by Rothamsted Research with funding from BEIS (now the Department for Energy Security & Net Zero). The original trials from which the data were collated were funded by Defra, BBSRC and interested parties from the private sector.

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Table 1. *Yield and dry matter at harvest from the leading Short Rotation Coppice willow varieties. Genetic Diversity Group (colour code), Breeder and Gender are added to aid selection and sourcing of a diverse mixture.*

Diversity Group†	Breeder*	Gender	Variety	Yield t ha^{-1} yr^{-1} DW	Dry Matter % winter harvest
IIIc	RR	F	Roth Tryfan	12.30	45.0%
I	EWB	F	Ester	11.99	47.3%
	EWBP	F	Advance**	11.99	43.3%
IIIb	SE	F	Lisa	11.96	46.5%
I	EWBP	F	Aurora	11.86	47.7%
IIIb	EWB	F	Emma	11.84	48.6%
IIIb	RR	M	Roth Drum	11.54	45.4%
IIIa	EWBP	F	Challenger	11.44	48.2%
IIIb	EWBP	F	Resolution	11.14	46.5%
II	EWBP	F	Endurance	11.02	51.3%
IIIa	RR	F	Roth Cheviot	10.90	45.9%
IIIb	SE	M	Sven	10.89	46.3%
IIIb	SE	M	Olof	10.88	46.4%
IIIc	EWBP	M	Alert	10.52	48.6%
IIIa	SE	F	Inger	10.50	46.9%
IIIb	RR	F	Roth Chiltern	10.44	46.2%
I	RR	F	Roth Skiddaw	10.43	49.4%
IIIb	EWB	M	Wilhelm	10.36	46.0%
IIIb	RR	F	Roth Hambleton	10.35	45.2%
IIIb	SE	F	Tordis	10.32	47.3%
IIIc	SE	F	Tora	10.31	45.0%
IIIa	RR	F	Roth Mourne	9.77	49.8%
IIIb	SE	F	Torhild	9.33	47.0%
II	EWBP	F	Paramore	9.29	48.4%
IIIb	SE	F	Klara	9.29	48.0%
	EWBP	F	Meteor**	9.26	49.0%
I	EWBP	F	Terra Nova	8.44	45.0%
IIIb	EWB	F	Bella	8.27	49.0%
IIIb	SE	F	Linnea	8.20	44.3%

† See Table 2

*EWB European Willow Breeding, EWBP European Willow Breeding Partnership, RR Rothamsted Research, SE Salix Energi

**missing genetic diversity data for Advance, Meteor

Variety information is provided based upon the science. Please check availability of varieties with suppliers.

Guidance for creating diverse planting mixtures to limit the impact of pests and diseases.

SRCw is best **planted in mixtures** of **genetically diverse varieties**. Varieties listed here currently have good resistance to the common pests and diseases. However, given that a crop may remain in place for around 20 years there are possibilities of resistance breaking down. It is not practical to apply pesticides to a fully grown crop (~7 m tall) without the use of specialist equipment. Planting a mixture of 6 varieties, selected across the diversity groups indicated, greatly reduces the risk of crop failure.

Table 2 *The genetic basis of the Diversity Groups in Table 1.*

Diversity group†	
I	Hybrids of *Salix miyabeana*
II	*Salix rehderiana* × *Salix dasyclados*
IIIa	*Salix viminalis* × *Salix schwerinnii*
IIIb	*Salix viminalis* × *Salix schwerinnii*
IIIc	*Salix viminalis* × *Salix schwerinii*

Group III, *Salix viminalis* × *Salix schwerinnii*, splits into three sub-groups based upon genome analysis which showed distinct genetic differences between varieties resulting from various crosses between these two species. It does not imply the presence of genes conferring resistance or tolerance to any specific pest or disease. It is subject to revision as new knowledge is generated.

Varieties showing a lower yield in Table 1 should not be discounted. In many cases, including one of these varieties as one sixth of the mix can be beneficial as they may sit below the primary canopy and capture otherwise wasted light.

Unfortunately, trials of mixtures are by their very nature large and therefore expensive. Very little data exists on which modern varieties to recommend for the composition of a mixture other than the genetic diversity group and canopy structure.

Optimal varietal selection must be combined with best practice agronomy and management to ensure a successful, profitable SRCw plantation. Envirocrops provides a decision support tool for SRCw and other energy crops. Biomass Connect has eight best practice demonstration sites located across the UK.

Willows are dioecious, individuals are either male or female. Whilst **gender** has not been shown to have a notable effect on performance in the field it is of interest in that willow provides an excellent source of nectar and pollen in early spring. It is therefore worth considering a mix of females and males when designing a mixture to plant.

General observations on variety performance.

- On a high-quality site, where biomass yields might be expected to be higher, **Tora** and **Sven** are the varieties most likely to yield slightly higher than average compared to other varieties.
- In those same conditions, **Torhild** is likely to yield considerably better than the average of the others, however, on a poor, low yielding site it may under-perform.
- **Endurance** and **Resolution** tend to perform better than the average of others on all sites.
- **Endurance** consistently produces wood of the highest % dry matter from a winter harvest, irrespective of site.

The effect of weather on SRCw yield.

Most weather effects detected by the analysis had the effect of increasing yield (see Table 3). The strongest effects were of greater temperature and rainfall two years before harvest. One year before harvest the weather had fewer and more variable effects on yield. Greater values of rainfall in June and July one year before harvest resulted in lower yield. Sunlight had a less strong effect across both years.

Table 3 *Summary of the positive and negative effects of weather variables on yield.*

	Weather	March	April	May	June	July	Aug	Sept	Oct	Nov
2 Years before harvest	Temperature		+ + + +		+ + + +	+ + + +		+ + + +		
	Rainfall		+ + + +		+ + + +	+ + + +	- -			
	Sunlight	- - -			+ + +	+ + +				
1 year before harvest	Temperature			+ + + +	+ + + +				+ + + +	
	Rainfall	+ + +		+ + + +	- - -	- - - -				
	Sunlight	+ + +						+ + +		+ + +

Scale of effects: most positive + + + + to most negative - - - -

Variety specific response to weather.

The variety specific yield response to weather uses the conditions over all months of the 2 years immediately prior to a harvest.

Mean Temperature.

- **Resolution** and **Tora** produced higher yields in greater temperatures, whereas **Terra Nova** had greater yields in cooler temperatures.

Total Rainfall.

- **Endurance**, **Olof**, **Sven**, **Terra Nova, Tordis** and **Torhild** showed greater yield when rainfall was higher.
- Only **Roth Mourne** produced greater yields in low rainfall conditions.

Total Sunlight.

- **Roth Mourne** and **Terra Nova** produced greater yields when total sunlight was less.

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