ShortFor meeting 14th December 2016

Effects of planting density on the growth and physiological responses of selected short rotation forestry species

Under Directive 2009/28/EC

By 2020 at least 16% of all energy consumed in the state is from renewable sources

Biomass is one renewable resource

Short rotation forestry (SRF) has potential to provide some of this biomass

www.coillte.ie

ShortFor Project aims to explore the potential of SRF in Ireland

Short rotation coppice **Short rotation forestry** **Conventional forestry**

Short rotation coppice approx. 2-5 years

www.cropsforenergy.co.uk

One spacing approx. 0.75–0.80m in twin rows 1.5m apart

Short rotation forestry approx. 8 - 20 years

www.spacecollective.org

A substantial reduction in final tree size, planting spacing could be reduced

But by how much??

Conventional forestry approx. 30 - 80 years

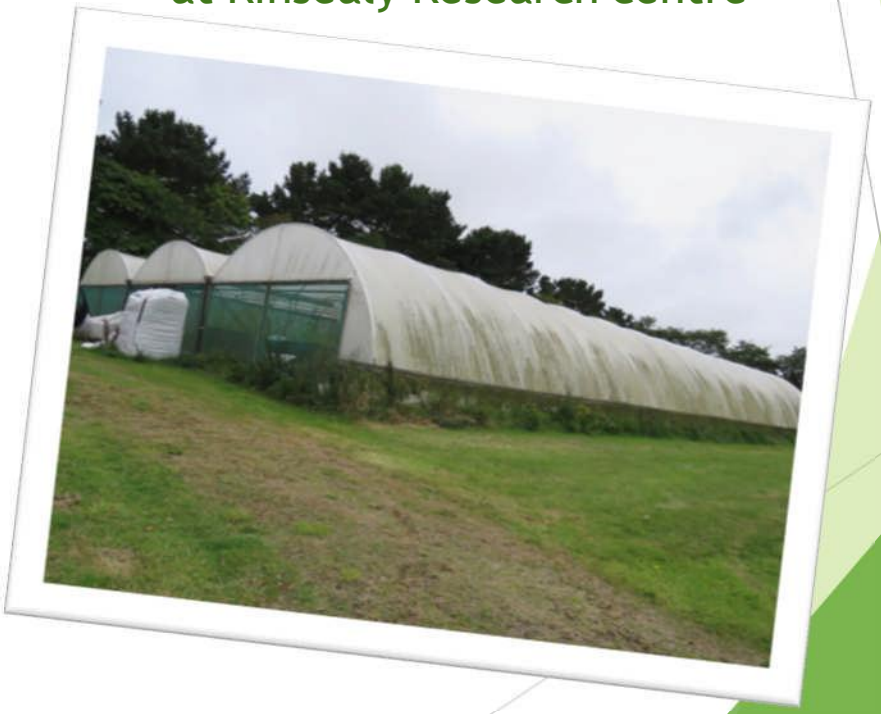
www.forestry.ie

Conventional spacing for most species is 2x2

Study aims to evaluate and maximise the optimum spacing for selected SRF species

Establishment of trial at Johnstown Castle

Establishment of experiments at Kinsealy Research centre



Johnstown Castle field trial

Planted with alder, eucalyptus and Sitka in June 2014
4 spacings, 5 blocks

The effect of **planting density** on juvenile competition

- survival
- growth
- physiological response

Johnstown Castle Trial Site 2017

- Morphology -stem height and diameter, phenology, leaf area index
- Physiological responses - leaf-level gas exchange
- Biomass allocation

Teagasc Kinsealy Research Centre

Purpose:

- controlled condition
- maximise measurement and experimentation period
- increased replications
- inform future plans

Experiment:
3 species using 3 spacings

Density – per pot	
Low	1 plant
Medium	4 plants
High	8 plants

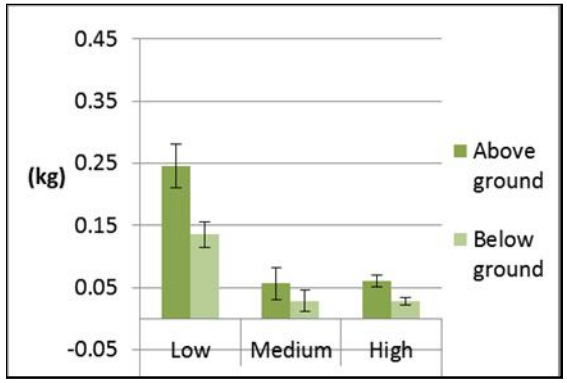
- carbon assimilation
- morphology of leaf and canopy
- biomass allocation

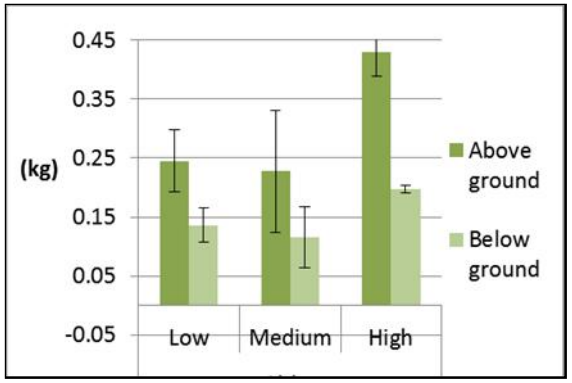
Kinsealy Dec 2016

Mean biomass DW per plant

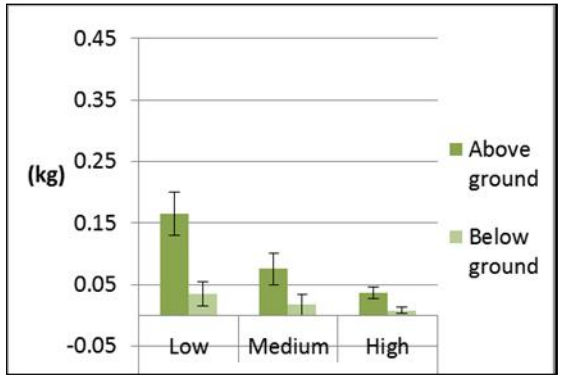
Mean biomass per pot

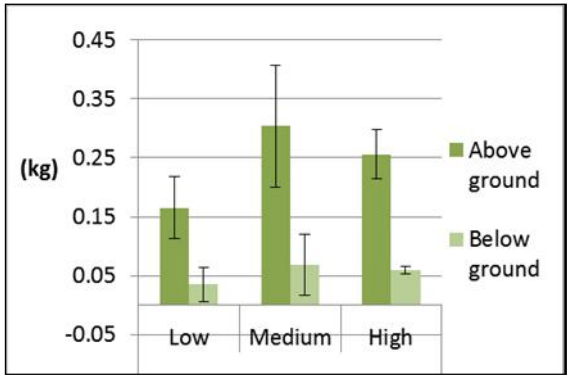
Alder



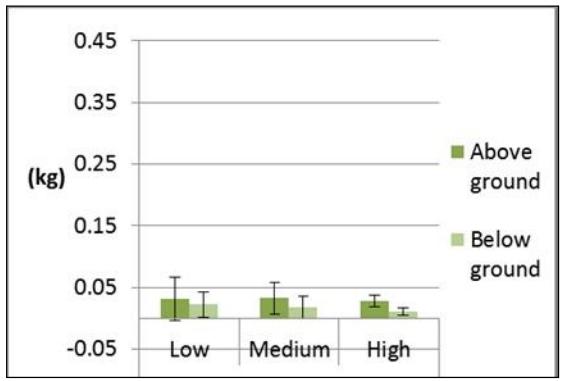


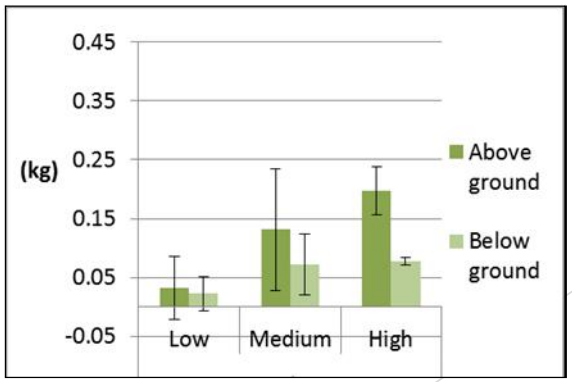
Eucalyptus



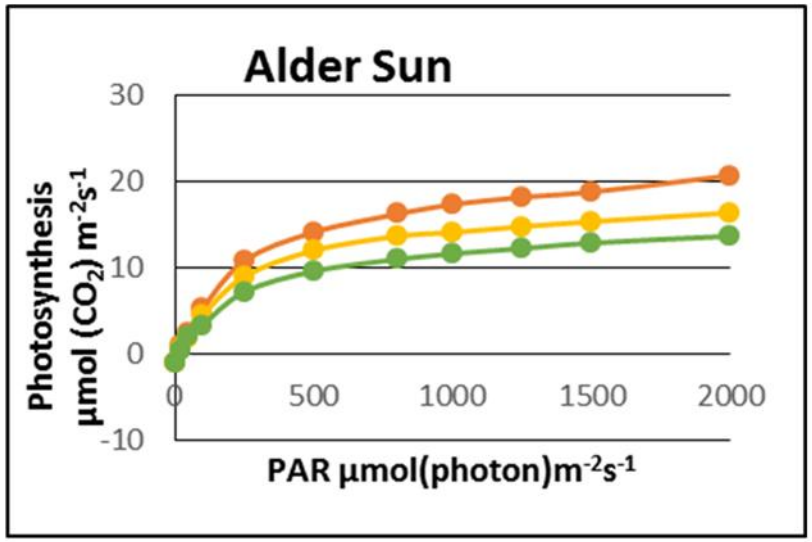


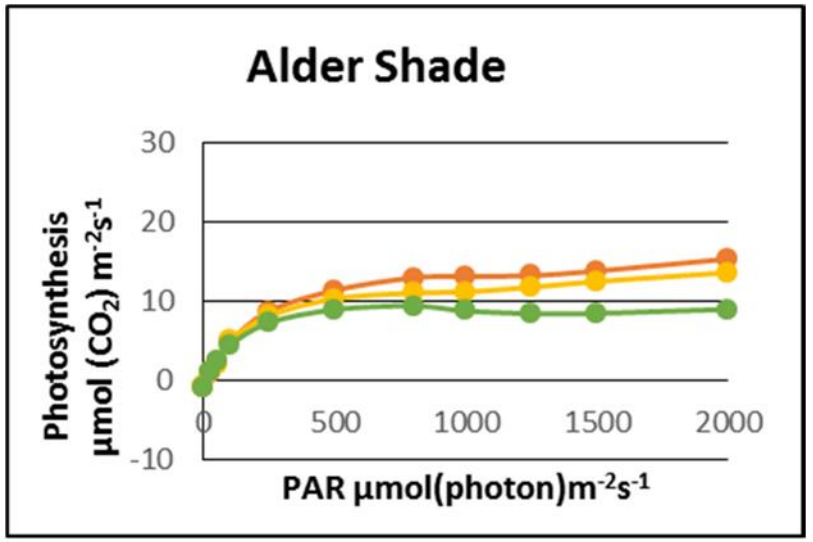
Sitka





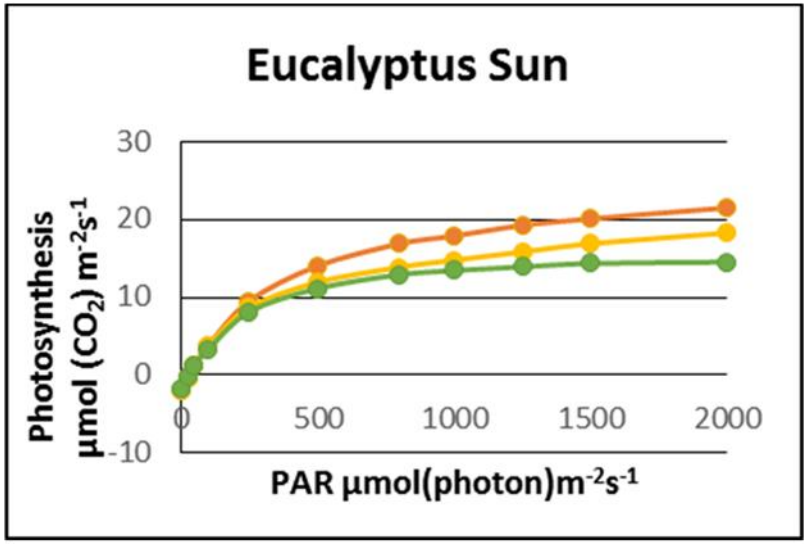
Light response curves on alder, sun and shade leaves at three planting densities

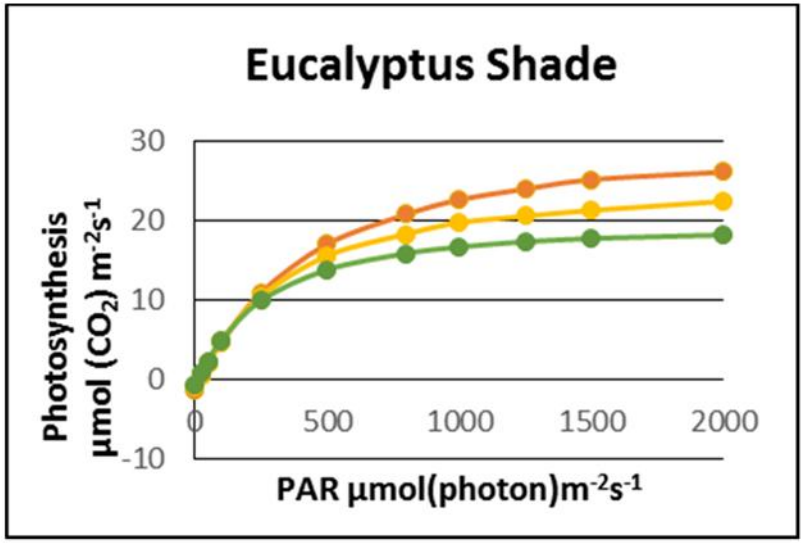




Low density
Medium density
High density

Light response curves on eucalyptus, sun and shade leaves at three planting densities





Low density
Medium density
High density

Summary

Treatment effects can be detected using gas analysis

Photosynthetic rates are higher in eucalyptus than in alder

Eucalyptus shade leaves more efficient than sun and shade leaves in alder

Biomass accumulation highest in alder

Dissemination

Irish Plant Scientists Association Meeting (IPSAM) 2016, Trinity College

Measuring the physiological and growth responses of potential short-rotation forestry species to variations in planting density

Susan Foreman[1,2], Niall Farrelly[3], Brian Tobin[1], Ian Short[2], Conor O'Reilly[2]
[1] UCD School of Agriculture and Food Science, University College Dublin, Belfield, Dublin 4.
[2] Teagasc, Ashtown Research Centre, Ashtown, Dublin 15.
[3] Teagasc, Athenry Research Centre, Mellows Campus, Athenry, Co. Galway

- Short rotation forestry (SRF) has potential to provide biomass, contributing towards Irelands 2020 EU renewable energy target
- There is a need to provide information on the optimum planting density to maximise production for a range of species over a short rotation period.
- The effect of planting density on juvenile competition, survival, growth and physiological response of three potential SRF species – Italian alder (*Alnus cordata*), Sitka spruce (*Picea sitchensis*) and shining gum eucalyptus (*Eucalyptus nitens*) are being investigated
- A potted experiment at Teagasc Kinsealy was used to assess the impact of competition stress
- Observations and measurements have included leaf-level gas exchange, shoot growth phenology, height and diameter increments and other measures of biomass production
- SRF trials will take 8-12 years to mature. The data collected herein will provide information on likely responses to competition which can be scaled up from leaf to canopy level to enable stand productivity to be modelled. To this end a field trial site has been set up at Teagasc Johnstown Castle, Co Wexford

Sitka, eucalyptus and alder growing in 35 litre pots at three planting densities at Teagasc Kinsealy

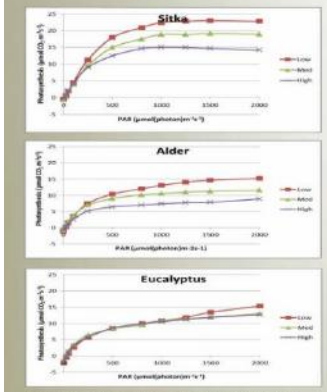


Figure 1: Light response curves on Sitka, alder and eucalyptus at three planting densities. Low density = 79500 stems ha^{-1}, medium density = 318000 stems ha^{-1}, high density = 557000 stems ha^{-1}.

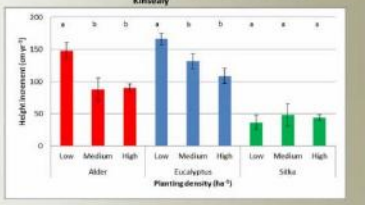


Figure 2: Mean height increment of alder, eucalyptus and Sitka after 8 months growth. Low density = 79500 stems ha^{-1}, medium density = 318000 stems ha^{-1}, high density = 557000 stems ha^{-1}. Error bars = 95% confidence interval of the mean. Letters indicate significant differences (P<0.05) within a species.

- Light response curves of eucalyptus suggest there is little effect on photosynthesis rate caused by planting densities tested (Figure 1)
- Photosynthesis rates of Sitka spruce appear higher than for either eucalyptus or alder (Figure 1)
- There was no difference in Sitka height increment between three planting densities (Figure 2)
- Both alder and eucalyptus had significantly greater height increment at low density than at medium or high density (Figure 2)

Plant Environmental Physiology Group Field techniques workshop, Lisbon 2016

Measuring the physiological and growth responses of potential short-rotation forestry species to variations in planting density

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- Two potted experiments (K1 and K2) at Teagasc Kinsealy, Co. Dublin were used to assess the impact of competition stress on height increment (K1) and leaf-level gaseous exchange and chlorophyll concentration (K2).
- Observations and measurements have included leaf-level gaseous exchange, chlorophyll concentration, shoot growth phenology, height and diameter increments and other measures of biomass production.
- SRF trials will take 8-12 years to mature. The data collected herein will provide information on likely responses to competition which can be scaled up from leaf to canopy level to enable stand productivity to be modelled. To this end a field trial site has been established at Teagasc Johnstown Castle, Co. Wexford.

Sitka, eucalyptus and alder growing in 35 litre pots at three planting densities at Teagasc Kinsealy, Dublin.

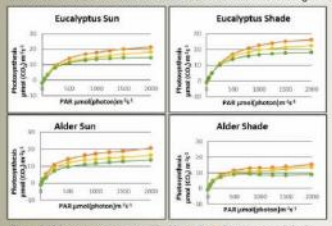

Figure 1: Light response curves on K2 alder and eucalyptus, sun and shade leaves at three planting densities. Low density = 79500 stems ha^{-1}, medium density = 318000 stems ha^{-1}, high density = 637000 stems ha^{-1}. PAR (Photosynthetically Active Radiation).

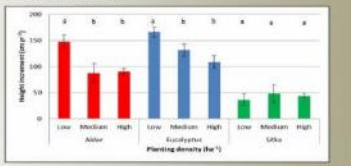

Figure 2: Mean height increment of K1 alder, eucalyptus and Sitka after 8 months growth. Low density = 79500 stems ha^{-1}, medium density = 318000 stems ha^{-1}, high density = 557000 stems ha^{-1}. Error bars = 95% confidence interval of the mean. Letters indicate significant differences (P<0.05) within a species.

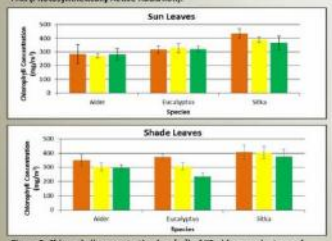

Figure 3: Chlorophyll concentration (mg/m^2) of K2 alder, eucalyptus and Sitka leaves at three planting densities: = 79500 stems ha^{-1}; = 318000 stems ha^{-1}; = 637000 stems ha^{-1}. Error bars = 95% confidence interval of the mean.

- Light response curves of eucalyptus suggest there is some effect on photosynthesis rate caused by planting densities tested (Figure 1).
- Photosynthesis rates of sun and shade leaves of alder appear lower than for eucalyptus (Figure 1).
- There was no difference in Sitka height increment between the three planting densities (Figure 2).
- Both alder and eucalyptus had significantly greater height increment at low planting density than at medium or high density (Figure 2).
- Chlorophyll concentration of Sitka sun and shade leaves suggest no difference across planting density treatments when error bars are included (Figure 3).
- Eucalyptus shade leaves indicates chlorophyll concentration decreases from low to high planting density treatment (Figure 3).
- There is no apparent difference in chlorophyll concentration across planting density treatments for alder sun or shade leaves (Figure 3).
- Sitka has a higher chlorophyll concentration in both sun and shade leaves across planting density treatments than either alder or eucalyptus (Figure 3).

Acknowledgement
Funding was provided by the COFORD and administered by the Department of Agriculture, Food and the Marine.

Future plans

Annual measurement of height and root collar diameter

Planned experiments for 2017 at Johnstown Castle trial include:

- Morphological measurements
- Leaf area index
- Specific leaf area
- Carbon assimilation through gas analysis
- Flushing observations
- Chlorophyll content

Thank You