PAULOWNIA BIOMASS PRODUCTION

a concise report by James S. Lawrence of TGG ~ toadgully.com.au

Introduction

The first fuels utilised by humans, biomass remains the principal energy source for more than half of the world's population and accounts for between 11[1] and 14[2]% of total energy consumption.

Climate change and fossil fuel supply insecurity has led to increasing realisation of the real value in pursuing sustainable biomass production systems.

Paulownia as biomass

The calorific value of Paulownia biomass is little over half that of coal (as is other forest biomass) but the lower content of pollutants such as sulphur (lower in Paulownia than most other biomass) and the fact that Paulownia is a readily renewable resource clearly points to its environmental benefit.

Paulownia wood has the advantage of lightness, dramatically reducing transport costs comparative to other woods. Under most conditions it will readily air dry to moisture content between 15 and 10%. Its air dried density generally ranges between 260-330 kg/m^3[3].

Under the right conditions Paulownia is surely one of the most rapidly growing plants. Paulownia utilises highly efficient photosynthesis to fix carbon. Soil carbon levels increase within a Paulownia plantation from accumulation of organic matter such as leaf drop, and the extensive root systems play an important function in ongoing carbon sequestration. Paulownia may be cropped from the same root system at least 4 - 5 times and their growth improves the soil, setting them apart as truly sustainable compared with other biomass systems.

Paulownia growing requirements

Within a climate range from temperate to tropical the various strains of Paulownia species can tolerate a temperature range from -20 to 47℃. The optimum temperature for growth of trunk diameter and height is around 27℃.

Annual rainfall within the natural distribution of Paulownia ranges from 500mm to 3,000mm[3]. To support rapid growth within a commercial system in a warm climate at least 700mm of rain is required during the peak growing season (late spring to early autumn) or supplementary irrigation should be provided.

Paulownia will grow in a wide range of soil types but prefer deep, well drained soil rich in nutrients or adequately supported with fertiliser application.

Weed control should be close to total within at least a 1m wide strip down the centre of each planting row. Inter-row may be slashed.

CAF15+ *P.fortunei CAF GD Select*
17 mths after harvest of 3 year old trunk.

TG2021 *P. taiwaniana x kawakamii*
5 months after first coppice.

Paulownia are a tree with truly astounding growth potential under ideal conditions but will perform badly in poorly selected sites or if mismanaged. TGG can assist with detailed growing information tailored to any given site. Should areas not be suited to Paulownia other biomass trees such as Acacia spp. may be substituted. TGG can recommend and supply these parallel to the supply of Paulownia planting stock. For example Acacia mearnsii, for which we have propagation experience, provides a high density wood at around 800kg/m3 with a calorific value of about 17MJ/kg. However these Acacia require replanting after each harvest and are unlikely to surpass the yield of Paulownia under conditions optimum to Paulownia.

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[1] Victorian (Australia) Dept. of Primary Industries, June 2008. Plantations for Energy.
[2] **Liao Cuiping**, **Wu Chuangzhi**, **Yanyongjie**, **Huang Haitao**, 2004. Chemical elemental characteristics of biomass fuels in China.)
[3] **Zhu Zhao-Hua**, 1986. Paulownia in China: Cultivation and Utilization.

Paulownia woody biomass plantation model

The paramount input for a Paulownia plantation is sunlight for photosynthesis. This means that even if there is theoretically no restriction on the inputs of water and nutrients, growth will be limited once the trees begin to crowd each other and excessively compete for light.

Biomass can be obtained from waste material after harvesting Paulownia cultivated for fine timber, generally planted at a density of 400/ha or less and grown for a period of 10 to 20 years. However the annualised yield of dry matter (DM) per hectare will be low relative to that possible from dedicated Paulownia biomass plantations.

Starting by ascertaining feedstock requirements - depending upon whether to be used for ethanol production or combustion, for example - combined with our knowledge of viable planting density correlating to different stem size requirements and harvest age, plantation modelling can determine optimal production systems.

The following model assumes a requirement for woody biomass from single stem trees of reasonably uniform size with a diameter at breast height (DBH - 1.3m) at harvest greater than 10cm and not more than 20cm. It is possible a higher planting density and / or allowing multi-stem coppice regeneration may be advantageous under different feedstock requirements. Plantation methodology is moderately flexible and open to modification as knowledge expands or if requirements change. Stem / ha density is difficult to increase post establishment but may be decreased.

Using improved strains of Paulownia fortunei and / or suitable Paulownia hybrids TGG can supply economical clonal planting stock in the form of PreStarters™. The land should be cultivated and, as necessary to improve drainage or topsoil depth, the planting rows mounded with 3.3m centres. The PreStarters™ can be planted using mechanised or hand tool methods at 1m spacing down the peak of each mound or row centre. The trees must be planted into moist soil and immediately watered in. Fertiliser and possible irrigation requirements should be determined based on soil analysis and plant growth. The first growing season should be regarded as a period of root establishment and any trees less than 3 metres tall at the end of this season should be coppiced to encourage a stronger trunk to regenerate. The first harvest is likely to be around 3 years after planting. Each subsequent regenerated crop is likely to take 2 years to reach harvest size. Under TGG trials on the Mornington Peninsula, Victoria, Australia 2 year old regenerated stems ranged from 10cm to 15cm DBH. In a warmer climate, with good management, an estimate of 15cm DBH may not be overly optimistic. Factoring in losses, a median of 12.5cm DBH is a reasonable supposition.

3,000 STEM / HA PAULOWNIA BIOMASS PLANTATION MODEL (1m x 3.3m spacing)

AGE AT FIRST HARVEST	AGE AT EA SUBSEQUENT ROTATION	EST AVG DBH AT HARVEST	EST AVG VOLUME YEILD / TREE trunk | total	EST AVG VOLUME YEILD / HA trunk | total	EST AVG DRY MATTER YEILD / HA trunk | total
3-4 years	2-3 years	10cm (cautious)	0.035m^3 | 0.045m^3	105m^3 | 136 m^3	27.3t | 35.36t
3-4 years	2-3 years	12.5cm	0.059m^3 | 0.077m^3	177m^3 | 231 m^3	46.02t | 60.06t
3-4 years	2-3 years	15cm (potential)	0.089m^3 | 0.116m^3	267m^3 | 348 m^3	69.42t | 90.48t