TGG

paulownia technical bulletin # 1

PAULOWNIA PLANTATION ESTABLISHMENT

1) **SELECT PLANTATION SITE.** The site should contain free draining soil, access to full sun and at least 1 megalitre of water per hectare per year (unless in a tropical zone with reliable summer rainfall). Protection from severe wind is an advantage if practical. It is well worth getting a soil analysis done so any corrective trace elements needed or lime to bring the pH up to around 6 can be added prior to cultivation. In Australia it is generally appropriate to spread superphosphate prior to cultivation. On sites with areas prone to water-logging and or salinity, electro-magnetic scanning is recommended to detect 'hot spots' that will need extra attention or to be avoided for planting Paulownia.

2) **CLEAR SITE FOR PROPER CULTIVATION.** Choose the area to be planted, remove woody weeds, slash and rake up pasture and pick up and cart off any logs, rocks and other debris to allow for proper lands to be constructed.

3) **GROUND WORKS:** A) See the table below 'Paulownia Plantation Models' and after assessing the best model for your circumstances, begin ***planning*** how best to proceed. At this stage you may want to call a meeting of any various contractors to be involved. Set out for them what you want to achieve (based on the following cultivation and management information) and be willing to adapt your plans depending on their experience and machinery available - whilst avoiding compromising the needs of the Paulownia trees. If it is to be an irrigated plantation, the irrigation contractor should begin work on the design now, so involve them right from the start.

PAULOWNIA PLANTATION MODELS:

~ clear fell, non thinning options*

SPACING	DENSITY / ha	1ST HARVEST Year	EST. D.B.H. AT HARVEST TROPICAL	TEMPERATE	ESTIMATED YIELD / Ha TROPICAL	TEMPERATE	POTENTIAL USES	COMMENTS
1 x 1 m	10,000	1	4 cm		32,000 kg fresh 11,600 kg dried		pelletised fodder (green stem & leaves)	theory only, experimental
1 x 3.3 m	3,000	3	12 cm		150 m^3 in logs 195 m^3 total		biomass for energy production	theory only, experimental
2 x 2.5 m	2,000	2	7 cm		16,000 kg fresh		ethanol production (green stem & leaves)	theory only, experimental
2.5 x 4 m	1,000	3	12 cm		50 m^3 in log		poles, MDF, paper pulp	theory only, experimental
2.5 x 5 m	800	4	20 cm		141 m^3 in log		poles, MDF, paper pulp	theory only, experimental
5 x 5 m or 4 x 6.25 m	400	6	29 cm		160 m^3 in log		MDF, low grade timber	youngest viable timber (tropics)
5 x 5 m or 4 x 6.25 m	400	7	34 cm		247 m^3 in log		low - medium grade timber	
5 x 5 m or 4 x 6.25 m	400	8	41 cm	33 cm	400 m^3 in log	240 m^3 in log	low - high grade timber	youngest viable timber in temperate zones
5 x 5 m or 4 x 6.25 m	400	10	54 cm	41 cm	732 m^3 in log	400 m^3 in log	medium - high grade timber	recommended harvest age in tropics
5 x 5 m or 4 x 6.25 m	400	12		48 cm		560 m^3 in log	medium - high grade timber	recommended harvest age in temperate regions

ha = hectare (2.47 acres) D.B.H. = diameter at breast height (1.3 m) m^3 = cubic metre

*using P. fortunei or fortunei x hybrid with correct management, including intensive fertilising, irrigation if needed and correct pruning for timber where applicable.

In selecting the most suitable model it is best to begin with the required end product and work back. The spacing must be wider for older trees and high grade timber production, mostly due to the need for adequate light penetration. Any Paulownia branch consistently in 70% or more shade will die. This means that after complete canopy closure in a plantation the lower limbs die, resulting in reduced photosynthesis, forcing increased compensatory upper growth, and thus leading to a reduced trunk girth increment. The spacings listed allow for canopy space up to the recommended harvest age.

B) ***Cultivation*** for Paulownia should be more akin to cultivation for vegetables or fruit trees rather than most other forestry trees. Firstly the surface soil over entire site should be broken up using discs, rotary cultivator or chisel plough (depending on soil type and available machinery).

C) At this point, for a project of any more than a few hectares it is well worth getting a ***professional survey*** done. A detailed site map may be prepared, but at the very least the row centres should be pegged at the ends and every 50 m between. Make sure the pegs are tall enough and have a white top or bright ribbon to ensure they are clearly visible.

D) Whether ***ripping*** is advantageous or not is a complicated issue, dependant mostly on soil type and structure. However it is unlikely to do harm so usually we would recommend deep ripping down the planting line to a depth of 700 - 800 mm. preferably using a winged foot ripper behind a bulldozer or powerful tractor. If you can't use a winged foot ripper it is best to rip both ways so that each tree will be planted over a cross rip (to avoid the roots running only way along a narrow rip line). If the site has sandy soil extending for more than a metre deep ripping is not necessary as Paulownia roots readily penetrate into soft soils.

E) ***Install irrigation mains***. The supply lines and pits for your irrigation should be laid before the next stage of cultivation.

F) ***High mound*** the planting rows, preferably using a grader to push up the loosened topsoil, whilst also cutting into the inter-row to a depth of *at least* 20 cm so as to result in a 'v' drain between the rows for drainage and flat edges on the mounds for easy slashing and plantation maintenance work. It would be difficult to over-mound. Paulownias need excellent drainage. A grader gives a superior pyramid-shaped mound, but if you can't use a grader a heavy duty disc plough (large discs capable of at least 25 cm depth) can be used to raise the lands. To achieve this the driver starts with a pass down the planting line only slightly off the centre so that the soil in the centre is turned. After this first pass ploughing back up the other side of the planting line in the opposite direction with sufficient overlap will ensure as high as possible point on the centre of the mound. It is best to complete the first pass in each direction on all of the mounds first so as to allow for adjustment to the discs for the next runs. The operator then repeats this process gradually moving out from the centre of the mounds until all are complete with a good drainage furrow between each. *Regardless of the method make sure there is at least 50 cm variation between the lowest point of the 'v' drain or furrow and the centre of the mound. Higher is needed on sites with a high water table or little slope.* In order to achieve a friable planting bed, most soils will now require a pass down the centre of each mound with harrows.

G) Be sure to continue the ***drainage*** beyond the edge of the plantation. Each drainage furrow should drain freely to the catchment end of the plantation area, flowing into a smaller silt catching dam (of at least a few hundred cubic metres capacity) which will catch the silt washed down with run-off - preventing expensive loss of capacity in the main dam - before draining the clean water into the main storage dam. The silt catching dam can be cleaned out when dry. If necessary, drainage levels should be adjusted to ensure there is no water lying on the surface anywhere in the plantation area during the wettest part of the year.

4) **SET UP IRRIGATION.** A 120 mesh filter should be used (and maintained regularly). It's generally best to use a multi-seasonal integrated dripper line (with emitters with a labyrinth and vortex structure which create a turbulent water flow which results in clearing of residues and resistance to clogging). The lower the litres per hour rating of the emitters the more can be run at the same time (2 Lph is adequate but up to 4 Lph is suitable in soil types where the water does not pool). The emitters should be spaced at 50 cm so that a drip emitter will never be further than 25 cm from the stem of the plantlet - this is critically important in the early weeks after planting, especially in sandy soil. Close emitter spacings also result in more even delivery to the root system of more mature trees. The dripper line should be run straight down the centre of the mounds.

HOW TO WATER

Unless in a zone which receives reliable summer rainfall, watering Paulownia is critical for fast growth.

Ensure the soil is moist *before* planting - it's often a good idea to have the drippers on while planting. A good deep soaking every 7 to 21 days during their first summer is usually sufficient and generally better than light frequent sprinklings in encouraging a good root system. (The exception to this is if you have shallow soils with a hard clay pan and high water table - in this case more frequent shallower watering may help to encourage the roots to stay within their most viable zone - any which go too deep will only rot in the wet season.) If a drip irrigation system is used it should be left on long enough to thoroughly soak the depth of the root area. Observation and common sense are the keys to correct watering. Obviously sandy soils will need more than heavy loams, but over-watering in sand will result in wastage and leaching of nutrients out of the root zone. It is also important to note it is normal for Paulownia to wilt during a hot day - this is a mechanism for avoiding excessive transpiration. If the trees are wilting because it is hot, but the soil is moist *don't water them* or you risk causing root or collar rot. If they have enough moisture the leaves will stand up again when it cools in the evening.

As a very general guide, in a climate with a hot *dry* summer, to promote vigorous growth you would need to apply the following irrigation (in combination with the correct fertiliser):

age after planting	L/tree	period between watering
1 to 8 weeks	40	3 - 7 days
2 - 4 months	50	3 - 7 days
4 - 7 months	100	7 days (or 50 L twice weekly)
2nd, up to 4th season	120	7 days (or 60 L twice weekly)

A gradual reduction in water application and/or decreased frequency is usually possible, but in a drought year older trees may still require irrigation if good growth is to be maintained. If for any reason irrigation can not be continued, established Paulownia will survive drought, but they will drop their leaves and become dormant until it rains again. It would seem more losses occur due to over-watering Paulownia than under-watering.

If the plantation is irrigated using wastewater, ground water nutrient and water table levels should be monitored regularly and irrigation reduced if required. If necessary pruned branches and the crowns of the trees at harvest should be removed from the site (and used for mulch/ compost) so as to obviate excessive nutrient build up in the wastewater irrigated area.

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5) **PLANT TGG PAULOWNIA PRESTARTERS™ OR HEADSTARTERS™** Use the guide pegs down the centre of your planting mounds to attach a 50 m tape measure (a metal one is best to avoid movement in the wind) so that you can accurately plant at the correct spacing. Pre-marking the tape at the position of each tree will make it even easier. The roots of the plants should not be disturbed. When placing in the planting hole, ensure the general mass of roots are pointing downwards, and they should be planted to a depth to cover the top of the shallowest root with no more than 2.5 cm (1 inch) of soil. Planting may be more efficient with the use of a kidney-shaped carry container (to hold up to a few hundred plants on your hip) and a number 7.5 Pottiputki planting tube for Headstarters or number 6 for PreStarters (to save the back). *Gently* firm the soil around the trunk.

6) **APPLY FERTILISER.** Top dress Incitec Pivot Croplift 800 (or equivalent) N.P.K.S. 8-11-10-7 at 250 grams (one level cup) per tree scattered no closer than 15 cm around the stem to avoid burning - most about 30 cm from stem.

NUTRIENT NOTE: Enormous leaves (with the potential to promote rapid growth due to a high rate of photosynthesis) can be promoted by high applications of nitrogen, especially I.B.D.U. nitrogen, but it must be kept in mind that larger leaves also transpire a large amount of water thus requiring greater irrigation, and this lush growth is susceptible to wind damage. Balanced, strong growth resulting in sturdy well lignified trunks can be achieved with fertiliser which is granulated and water soluble with the following composition-: 8% Nitrogen (N) Ammonium form, 11% Phosphorus (P), 10% Potassium (K) as Muriate of Potash, 7% Sulphur (S) and 6% Calcium (as Superphosphate). Solid fertiliser works best in areas where occasional rainfall helps to dissolve the granules and wash the nutrients into the soil, although even just dripper line irrigation will draw down a fair percentage. Liquid feeding via a fertiliser injector is very effective but if you use sprinklers avoid wetting the leaves with fertiliser rich water during the heat of the day as burning may result. If you choose fertigation consult with your supplier (in conjunction with TGG if you wish) about the best way to liquid feed in a way that will supply the plants with the same level of each element as described above using solid fertiliser. You may choose to use a combination of both as relying on liquid fertiliser alone is often more expensive.

7) **GUARD THE TREES & CONTROL THE WEEDS.** Weed control is crucial in the early years. Make sure the ground is completely free of weeds prior to planting. If you have a lot of weed seeds in the topsoil it may be best to plant the trees within a small square of biodegradable weed mat (such as Jutemat). Protect the young plants with a plastic tree guard sleeve supported by 3 stakes or a reusable wire frame. This allows the spraying of glyphosate weed killer (such as Round-up or Zero) using a stripper dome sprayer which is mounted on an ATV (four wheel "farm bike" - causes less soil compaction than a tractor). Stripper domes are generally 60 cm wide so a run up each side of the tree line results in a 120 cm bare centre strip. The inter-row can simply be slashed - maintaining some green cover on this zone is advantageous in terms of beneficial biology, erosion control and avoiding nutrient run-off and excessive evaporation. A side throw mower is ideal as throwing the grass and weed trimmings up onto the bare strip in the centre of the mound will act as mulch - conserving moisture and inhibiting weed seed germination.

[continued page 4]

HOW TO FEED

Paulownias have high nutrient requirements to reach their full potential.

Usually 200 - 250 grams (one standard cup is about 250 g) per tree of a **N.P.K.S. 8-11-10-7** granular fertiliser (such as Incitec Pivot Croplift 800 - *not slow release*) is applied as a manual top dressing at spring planting. Later in the season a further 300 g - 500 g (depending on soil, climate and observation of growth) per tree is applied using a fertiliser spreader with a side shoot that directs the granules down the centre of the planting row. (A small four wheel "farm bike" or all terrain vehicle is suitable for this job and will not compact the soil like a heavy tractor can.) This is repeated in the following seasons as needed to maintain rapid green growth during the warm weather (usually 2 or 3 applications per season until year 4 or 5 when one broadly spread application of 500-600 g per tree at the start of each season should be adequate).

As a very general guide, in a warm climate with well structured but infertile soils you could expect to get good results from the following fertiliser application:
assuming spring / early summer planting

NPKS 8-11-10-7 granular fertiliser

timing	g/tree	method
at planting	250	top dressing by hand
2 - 3 months after planting	500	lineally spread down the centre of each row (full length) using a side spreader on an ATV
late winter prior to second season	500	" " " " "
4 months after growth resumed	500	" " " " "
***OR** in high summer rainfall zones:*		
late winter prior to second season	*500*	" " " " "
3 months after growth resumed	*300*	" " " " "
6 months after growth resumed	*300*	" " " " "
3rd season - as per second		adjustment should be made to the side-throw spreader to allow for a band of 1 to 1.5m width (the root spread is now wider)
4th season	600	broadly spread (mound centre and sides)
5th season +	400 - 600	" " " " "

if or as needed to maintain rapid, robust growth with rich green leaves

The best type and rate of fertiliser will vary from site to site, depending on climate and soil type.

In a very dry climate liquid fertiliser (fertigation) may be the only way to adequately supply enough nutrition as granulated fertiliser requires rain to properly wash it into the root zone.

After a number of seasons a self supporting nutrient cycle develops from the now deep roots and the normal falling of the leaves in autumn (if the leaves are not collected).

A safer (but expensive) option for active Paulownias is the selective herbicide Fusilade, which will kill most grasses, but does not harm the saplings provided sprayed directionally (over-spraying may cause some damage to young Paulownia but normal spray drift does not) - it is also best to avoid spraying around Paulownias that have not yet reached the large leaf stage, or are under stress. Fusilade can be used at the highest recommended rate if necessary, e.g. to kill kikuyu, and must be mixed with a wetting agent for best results (as per the instruction booklet provided with the chemical).

Another approach is to prevent weed problems by regularly lightly cultivating or harrowing between the rows of Paulownias to prevent weeds from becoming well enough established to compete with the trees. This has the added advantage of aerating the soil. Of course, care must be taken not to damage the Paulownias in the process, and it is not suited to sites prone to erosion.

Probably the most environment friendly approach would be the growth of mulch (ideally leguminous) to place around the base of the trees to prevent weed growth and soil moisture loss. Annual legume crops such as peas and beans can be grown between Paulownia with little detriment to the trees in terms of water and nutrient loss, and when they rot down at the end of the season they enrich the soil with nitrogen. More demanding perennial legumes such as lucerne (alfalfa), clover, and lupins can be used as an understorey crop provided some allowance is made for their nutrient and water needs - they will also add nitrogen when they are cut or die back. Fusilade will generally not kill legumes, and can be used to control persistent grasses.

8) **REGENERATE.** The first aim in the management of Paulownia is to grow a sapling with 4 metres or more trunk height free of branches in *one season*. This will become the butt log - the most valuable part of the tree, producing clear timber - free from knots and flaws. The reason it is worth aiming for such spectacular height growth in one season is it is normal for the tip of the trunk to die back during winter and regrow with a kink the following spring, resulting in a slight wave in the centre grain of the timber and also growth from a trunk that is thin at the end of it's first season is often inferior.

In an ideal climate Headstarters™ may reach 4 metres tall in their first season, but often this is not possible so any trees less than 3 or 4 metres tall should be regenerated by cutting the trunk off at ground level in the winter after its first growing season. Drastic as this may sound, the Paulownia will regenerate from the stump in spring and develop a new trunk, stronger, straighter and larger both in height and girth by the end of the second season than that which would have grown had the original trunk not been removed.

don't worry

If things haven't gone as well as you'd like and you have short trees at the end of the first season all is not lost. As newly planted Paulownia consign priority to root growth a readily achievable trunk of 1 metre tall is adequate in the first season if coppicing (regeneration) is to be carried out. This allows for planting as late as early autumn in most areas.

HOW TO REGENERATE

Once all the leaves have fallen at the end of the first season, cut the trunk off at the base, just above ground level. The cut should be neat and on an angle, so water will run off and not cause decay. In the following spring the trunk will regenerate - often multiple stems sprout; only the strongest one should be allowed to grow. The best shoots usually grow from just below or at soil level. Once the shoots reach 30 cm tall break off the spares - if you do this before they reach 30 cm you will find more shoots will sprout requiring more pruning. As they already have a complete root system and stored nutrients the regenerated trees develop quickly and should reach 4 metres tall by the end of the second season (once the trunk is one season old).

9) **PRUNING.** Usually no branches are allowed to grow on the first year regenerated trunk (or the original trunk if regeneration is deemed not necessary in your climate) - any that sprout from the trunk just above a large leaf stalk are pinched out or cut, but with great care not to remove the large leaves directly attached to the trunk. The large leaves on young Paulownia are the trees' solar panels - catching the sunlight and, in combination with water and nutrients, converting it into rapid growth. *Removing these leaves will slow the growth of the tree.* If the first year branches can not be removed as they grow this may result in some loss of potential height growth, but they can be removed later without causing significant long term damage. The plantation is usually further pruned until about 4 or 5 years of age to ensure a clear trunk to five or six metres. From the second year of the trunk onwards (when the leaves become smaller) lift pruning should be gradual, leaving *at least* one third of the height of the trunk covered with leaved branches. Excessive pruning will inhibit the normal formation of a canopy and prevent the natural establishment of the tree, resulting in slow diameter growth of the trunk.
[For further details on pruning see Technical Bulletin #2.]

CHEMICALS mentioned in this document are generally brand names (used for brevity), as available in Australia. For active ingredients or further details email TGG. Incorrect chemical use can harm Paulownia trees.

PROBLEMS, QUERIES, COMMENTS, SUGGESTIONS. Telephone (03) 5983 5688 [international +61 3 5983 5688] preferably between 8:30am and 5:30pm Australian Eastern Standard Time, Monday to Friday, or any time any day send facsimile (03) 5983 1999 [international +61 3 5983 1999] or email help@toadgully.com.au Visit http://paulownia.com.au

see our website
for plantation photos
toadgully.com.au