

HOW TO ESTABLISH PAULOWNIA PLANTATION?



1) SELECT A PLANTATION SITE

The site should contain free draining soil, access to full sun and about 1000mm of water per hectare per year (unless in a tropical zone with reliable summer rainfalls). The protection from severe winds is an advantage. It is important to implement soil analyses, so if there is any need of liming to bring the pH up to around 6 it can be done prior to cultivation. In Bulgaria, in general it is necessary to spread over superphosphate before the time of the cultivation.

2) CLEANING OF THE AREA BEFORE THE PLANTATION. All types of wooden debris, weeds and others, rake up the pastures and pick up and remove all logs, rocks and other debris to allow the construction of proper lands.

3) GROUND WORKS: A) The plantation construction models are shown below. After an assessment of the best model for the specific obstacles and planning the best methods the plantation can start. At this stage a meeting between all the performers is really appropriate and necessary. Discuss what the target is and based on the cultivation and management capabilities adapt your plans. You will depend on their experience and machinery available and try avoiding any compromise with the needs of the Paulownia trees. If this is going to be an irrigated plantation, the constructors of the system have to start working on the design in the moment when the system can be included at the beginning of the planting.

Spacing	Density/ha	First harvest /year	Thickness at H= 1.3 M	Yield per ha/kg/m ³	Potential use	Comment
1 x 1 m	10000	1	4 cm	32000 kg fresh 1 1600 kg dry	Pelletized fodder and green stems & leaves	Theory, experimental
1 x 3.3 m	3000	3	12 cm	170 m ³ logs 230 m ³ total	Biomass for energy production	Theory, experimental
2 x 2.5 m	2000	2	7 cm	1 6000 kg fresh	Bioethanol production green stem & leaves	Theory, experimental
2.5 x 4 m	1000	3	12 cm	50 m ³ logs	Poles, MDF, paper pulp	Theory, experimental
2.5 x 5 m	800	4	20 cm	140 m ³ logs	Poles, MDF, paper pulp	Theory, experimental
5 x 5 (4x4)	400 (600)	6	29 cm	160 m ³ logs (200 m ³ logs)	MDF, low grade timber	Youngest viable timber
5 x 5 (4x4)	400 (600)	7	34 cm	247 m ³ logs (340 m ³ logs)	Low-medium grade timber	
5 x 5 (4x4)	400 (600)	8	41 cm (35 cm)*	400 m ³ logs (450 m ³ logs)*	Low-high grade timber	(Youngest viable timber)*
5 x 5 (4x4)	400 (600)	10	54 cm (43 cm)*	732 m ³ logs (630 m ³ logs)*	Medium- high grade timber	Recommended Harvest
5 x 5 (4x4) 4 x 6.25 m	400 (600)	12	50 cm * (48 cm)*	560 m ³ logs* (800 m ³ logs)*	Medium-high grade timber	(Recommended harvest)8

* The data is for the temperate climate with the use of hybrids Biotree P.elongata x P.fortunei by the correct maintenance of the plantation, including the intensive fertilizing, irrigation if needed and the pruning for timber where applicable.
ha = hectare (2.47 acres) m³ = cubic meter

Note

When selecting the best model is good to begin with the required work product and then backwards. The spacing must be wider for the older threes and high grade timber production, mostly due to the necessity of adequate dose of light. All the branches with 70% or more shading are going to die. This means that after the full canopy closure in a plantation the lower limbs die, resulting in reduced photosynthesis, forcing increased compensatory upper growth and thus leading to reduction of the stems diameter. The spacing listed in the table is recommended for achieving these yields of timber at the required age.

B) Cultivation of Paulownia could be compared to the cultivation of vegetables or fruit trees rather than most other forestry trees. First the surface soil over the entire site should be broken up using discs, rotary cultivator or chisel plough depending on the soil type and the machinery available.

C) At this stage for a project consisted by more than a few hectares a professional survey is needed. A detailed site map must be prepared by marking every single line in the beginning and at the end of it, as well as at every 50 meters between. The pegs should be tall enough and to have a white top or bright ribbon to ensure they are clearly visible.

D) Whether deep ploughing is advantageous or not is a complicated issue, dependent mostly on the soil type and structure. However it is unlikely to do harm so usually and it is recommended deep ploughing down the planting line to a depth of 70-80 cm. preferably using a chisel plough behind a bulldozer or powerful tractor. If you can't use a chisel plough it is best to plough up both ways so that each tree will be planted over a cross rip in order to avoid the roots running only way along a narrow rip line. In a case when the site is having a sandy soil extending for more than a meter deep ripping is not necessary as Paulownia roots rapidly penetrate into soft soils.

E) Install irrigation system. The supply lines and pits for your irrigation must be laid down 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. Paulownia requires excellent drainage. The graders are giving very good pyramid – shaped mound. In a case when you cannot use a grader you can replace it by a heavy duty disc plough to raise the lands. To achieve this, the driver starts with a pass down the planting line only slightly off the center so that the soil in the center is turned. The other side has to pass ploughing back up after the first pass of the planting line in the opposite direction with sufficient overlap will ensure as high as possible point on the centre of the mound. The best is to complete the first pass in each direction on

HOW TO WATER

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

Before planting you has to be sure that the soil is moist enough – often it is a good idea to have the drippers on while planting. Usually it is sufficient if you ensure a good deep soaking on every 7 to 21 days during their first summer and generally it is even better than light frequent pouring 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 – and will avoid root decay.) 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. The sandy soils will need more than heavy loams, but the result in case of over-watering in sand will be wastage and leaching of nutrients out of the root zone. It is also important to note that 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 decay. 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 will need to apply the following irrigation if no rainfall (in combination with the correct fertiliser):

<u>age after planting</u>	<u>L/tree/m2</u>	<u>period between watering</u>
1 up to 8 weeks	3 - 5	2 - 3 days
3-4 months	6 - 10	3 - 5 days
5-7 months	10 - 12	5 – 7 days
2nd, up to 4th season	40 - 50	7 days (or 20-25L 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, Paulownia will survive drought, but they will drop down 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) to remove the excessive nutrients accumulated in the wastewater irrigated area.



all of the mounds first so as to allow for adjustment to the discs for the next runs. This process is going to be repeated by gradually moving out from the centre of the mounds until all are complete with a good drainage furrow between each. Regardless of the method be careful that there is at least 50 cm variation between the lowest point of the 'v' drain or furrow and the centre of the mound. On the sites the need is higher with a high water table or little slope. Most soils will now require a pass down the centre of each mound with harrows in order to achieve a friable planting bed.

G) Continuing the drainage is of a great importance beyond the edge of the plantation. Each drainage furrow should drain freely to the catchment end of the plantation area, flowing into smaller silt catching dam or at least few hundred cubic meters capacity that is going to 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. In the case when it is necessary, the 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 AN IRRIGATION SYSTEM. A 120 mesh filter should be used and It has to be 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 l/h is adequate but up to 4 l/h is suitable in soil types where the water does not pool). The space between the emitters should correlate to the planting scheme. This is critically important in the early weeks after planting, especially in sandy soil. Close emitter spacing 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.

5) BIOTREE PLANTING MATERIAL. The use of the signifying metal lining, passing through the pegs, remarking the line for planting is the best option for correct planting. Marking of the line in advance at the spots of planting saves time for the process. The roots of the plants shall be kept undamaged. When they are placed in the pit for planting you have to be sure that they are pointing the down side. They must be planted in a depth that assures that even the most shallow placed root has been covered, i.e. at the level of the bucket (by which the material has been supplied).

NUTRIENT NOTE:

Enormous leaves that are having the potential to promote rapid growth due to a high rate of photosynthesis can be promoted by high applications of nitrogen, but it has to be considered that the 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:- NPK 10/15/5 or manure 1:1 with soil or in combination of TSP, PS and AN. The solid fertilisers are most effective in zones, where the rare rainfalls are helping to dissolve the granules and their penetration in the soils, although the drip irrigation will involve soil sufficient quantities. Liquid fertilizing through the irrigation system is highly effective but in the cases when using sprinklers you have to be careful to avoid wetting the leaves during the hot days because of the danger of fertilisers burning them. If you choose this irrigation you have to make a consultation with your provider for the best application of liquid fertilisers that will to ensure the supplement of the listed amounts of elements for the plant. You are free to choose a combination of both but you have to keep in mind that usually the liquid fertilisers are more expensive.

6) APPLY FERTILISER. No closer than 15 cm around the stem to avoid burning - most about 30 cm from the stem.

7) PLANT PROTECTION AND WEEDS CONTROL.

During the first years the weed control is having a great importance. If the density of the weeds at the topsoil is too high the best is to plant the trees under PE mulch. A plastic tree guard could be a good protection for the young plants. This allows the spraying of glyphosate weed killer (such as Round-up) using sprayer. Generally it is enough to clean the weeds around the plant in the range of diameter from 60 cm. 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. There is one safer but expensive option for active Paulownias - the selective herbicide Fusilade, which will kills most of grasses, but does not harm the saplings provided sprayed directionally. In a case of spraying over young Paulownia leaves it may cause some damage but

HOW TO ADD NUTRIENTS?

Paulownia needs a lot of nutrients to develop its full potential!

Usually granular fertilizer is applied manually on the surface in spring planting. Manure shall be mixed with soil 1:1 in the hole where the planting is. Later during the season you have to use an additional 300 (depending on soil, climate and observed growth) by applying them to the tree using manure- spreaders (with side release) so that the granules will fall directly at the planted on line. (A small four - vehicle "ATV" is appropriate for this activity for a reason that it will not damage the soil like a heavy tractor will do). This will be repeated the next season but it is necessary to maintain a rapid green growth during the warm seasons (usually 2 applications per season until the third year, when there is a full application of 200g fertilizer for a plant during the spring is enough for the year).

The following fertilization scheme is a very basic recommendation for warm climate with well-structured but poor soil. You have to know that there are many places in Bulgaria where the soils are rich enough and possess similar quantities and they are excessive mostly in terms of duration of application are.

**Planting has to be accomplished at the time of late spring or early summer.*

Period	Granular fertilizer	
	fertilizer / tree	method
1. Planting	manure	1:1 with a topsoil
1a. Planting		
Triple superphosphate	500	by hand, at the surface
Potassium sulphate	120	linearly, scattered at the
Ammonium nitrate	150	center of each line
2. Late winter before the second season	300-500g combined fertilizer	

These estimated amounts are approximate and the conducting of the soil analysis is recommended for their specific determination.

During the third season fertilization should be as much as in the second. The fertilizer shall be sprayed at 1.5 meters from the stem, since the roots are more developed.

Fourth season - 600 g manure/wood scattered evenly throughout the plantation.

Fifth season and after only if needed.

The best applied type of fertilizer and its amounts vary according the climate and the soil type. When the climate is very dry the liquid fertilization may be the only possible solution for delivering the necessary substances. After few seasons the cycle of self-sufficiency nutrients beginning to build and fallen leaves starts to feed the root system.

normally does not. It is also good to avoid spraying around Paulownias that have not yet reached the large leaf stage, or are under stress. Weed problems could be prevented by another approach by regularly lightly cultivating or harrowing between the rows of Paulownias to prevent weeds from becoming well enough established to compete with the trees. In this method there is 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. 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. Lucerne (alfalfa), clover, (that are considered as more demanding perennial legumes) can be used as an understory 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 is to grow a Paulownia sapling with 3-4 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 pure 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 the material may reach 4 metres tall in their first season, but often this is not possible so any trees less than 2-3 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 width by the end of the second season than a one that would have grown had the original trunk not being removed.



HOW TO REGENERATE?

Once all the leaves have fallen down at the end of the first season the trunk should be cut off at the base, just above ground level. The cut should be neat and on an angle allowing the water to run off and not cause decay. The following spring the trunk will regenerate – usually multiple stems sprout. According to your opinion you have to allow only the strongest one to grow. The best shoots often grow from just below or at soil level. Once they reach 30 cm tall break off the spares. If you implement this later you will find more shoots sprout requiring more pruning

At the time when the plant is already having 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

9) PRUNING Usually no branches are allowed to grow on the first year on regenerated trunk (or in the first year of planting if the climate allows that). You have to cut any sprout that emerge from the trunk just above the large leaves, 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. The removal of these leaves will slow the growth of the tree. If during the first year branches cannot be removed as they grow this may result in loss of potential height growth, but they can be removed later without causing significant long term damage. The plants are usually further pruned until the age of about 3 or 4 years to ensure a clear trunk up to five or six metres. 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.

DON'T WORRY!

If the things are not going the way you have planned them and you have short trees at the end of the first season. In the first season is adequate that the newly planted Paulownia are developing their roots and achieving trunk of 1 metre tall if a coppicing (regeneration) will be carried out. This is going to allow planting as late as early autumn in most areas.

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The following is intended as a guide only. All the results may vary according to the local conditions and factors outside the author's control. No guarantee is given as to the accuracy or consequences of acting upon any of above.