

## Technology and practice development research for the cultivation of *Paulownia fortunei*

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### I. Introduction

Intensive research and investigations have been carried out the world over to find out fast growing tree species for raw material supply to industries, in particular species that can produce light – colour timber of high quality for the wood – based panel and utility furniture industries. Among many other species, *Paulownia* spp. have attracted the attention of more than one investor and scientist. Their timber is well - known for its light weight, light colour, decorative figures, its ease for being seasoned and carved, and not the least its freedom from twisting, cupping and its resistance to insects and fungus attacks. Besides, the species are also famous for their root systems developed at deeper soil layers, thus enabling their uses in combination with a variety of agro-forestry systems. By now, some 1,800,000 hectares of *Paulownia* have already been established with success in combination with farm crops in China. Other neighboring countries follow suit. For instance in Vietnam, the species in use is *Paulownia fortunei*, but its vernacular names sound differently from place to place, with the lowlanders calling it Cay Hong or Cay Bao Dong, and the ethnic groups ( the Tay, the Nung and the Dzaos) using other names of May djoc, May khang or Tong dang lang respectively, showing extensive habitats of the species. *Paulownia* spp. form the only timber genus of Scrophulariaceae; they are identified as *P. elongati*, *P. fortunei*, *P. albiphloea*, ... ; altogether nine species.

Since the 1960s, with the greening campaigns spreading all over the world in particular for agricultural crops protection, *Paulownia* spp. have much been sought for research and technology development. Systematic studies of the species have been made in particular by the Chinese Academy of Forestry (CAF), dealing with all aspects of the problem at work: from species identification, ecological requirements and habitats to technology to be adopted for the plantation of specific species. By now, much more success seems to have appeared in a number of topics, related to improved yields of the species and efficient use of their products. Because of the properties of their timber, *Paulownia* spp call for urgent research so that new gene resources can be made available for the completion of our national plantation programme nation- wide and in specific areas where they looks promising.

### II. Research methodologies and Materials

The research done here has its focus on *Paulownia fortunei* found in its natural habitats in Vietnam, with some extra experiments being made outside its ecological range for future technology extension, using for these the seed source available from mature standards of high quality.

#### 2.1 Research objectives. They are:

- To find out the natural habitats of *Paulownia fortunei* in Vietnam;
- To make experiments for technology and practice development to better grow the species in the mountains of the North of Vietnam; and
- To establish plantation models in some areas/ zones to pinpoint the conditions required for successful plantation.

#### 2.2 Research content: The main points are:

- Summing up and collating of all documents dealing with *Paulownia* cultivation;
- Additional research to find out new habitats/ areas where investigations/ surveys were not made, so to give comprehensive information on *Paulownia* habitats;
- Further experimentation and technology development for improved plantation of the species.

#### 2.3 Methodologies. The main approaches are:

- To adopt experimental ecological surveys for the determination of the species habitats, and their fundamental ecological factors and relationships;
- To carry out field experiments using complete randomized block designs; and
- To process and compare the data collected, using Excel software.

### III. Research findings

#### 3.1 Morphological characteristics

The *Paulownia fortunei* found in this country is well known for its straight bole, its developed but open crown,

its opposite unifoliate leaves having long stalk and quite large blade when young measuring 40 – 50 cm wide and 50 – 60 cm long. When getting mature, its leaves become much smaller and more elongate with their length being 2 times their breadth. Flowers are in inflorescences of 2 to 5, having calyces with many bell-shaped corolla lobes of receptacle and 5 irregular lobes; and fruits are ovate – ellipsoidal. The above, other specimen and classifications in hand help Vu Van Can and Tran Quang Viet identify the species under study as *Paulownia fortunei* (Seem).

### 3.2 *Paulownia fortunei* habitats in Vietnam.

The species is found in some provinces of the North West, the Central North, and the North East of Vietnam, where mean annual precipitation is about 1,300 – 1,400 mm with the highest value reaching 2,800mm, and with no prolonged dry season not more than one month, or almost no dry month at all. The species mainly occurs in secondary regrowths all together with many other pioneer tree species in the provinces of Lai Chau, Son La, Lao Cai, Yen Bai, Phu Tho, Bac Kan, Cao Bang and Lang Son. Sometimes, its frequency is rated as quite high with 200 – 250 trees per hectare (accounting for almost 50% of the standing stock).

### 3.3 Growth

Early stem analyses of *Paulownia fortunei* growing in the wild show that its average periodic diameter growth  $D_D$  is about 2.1 – 3.33 cm/ annu, while its current annual diameter growth  $Z_d$  ranges from 2.1 to 4 cm, with the highest increment being noticed when the trees are at its 6 years of age. Similarly,  $D_h$  is estimated at 1.59 – 2 m, while its  $Z_h$  is about 1.1 – 1.7m/ annum. The findings show that *Paulownia fortunei* is a fast – growing indigenous timber species, and that the cultigens found in Bac Kan looks most promising, with the best increments in terms of both height and diameter growth being noticed.

### 3.4 Seedling production and growth in nurseries.

Seeds of *Paulownia fortunei* can be harvested in December and the following January every year. Its fruits are harvested on parent trees and then beaten up to collect seeds for air drying on airy but shady areas, using for this bamboo latticed frames or other containers covered with mosquito – netting for 2 –3 days for the seeds to get dry enough for prompt sowing. Another alternative is to carry out cold storage, through keeping the seeds in nylon bags in a freezer. Cold storage can keep the seeds viable for almost a year, after that a germination rate of about 70% can be expected. The main points related to seed quality are given below:

- Weight of 1,000 seeds reaching 0.25 – 0. 27 g
- Rate of germination of newly collected seeds *in vitro* averaging 90 – 95%;
- Seeds coming up only after more than a week: in spring time 9 – 10 days after sowing, but in winter not less than 15 – 20 days.

Some pretreatments of the seeds seem to be necessary using for this warm water (of 40°C) for 10 minutes to be followed by dipping for 12 hours in water at room temperature. 35 days after sowing the seedling can get a height of 3 – 6 cm and 4 – 6 new leaves. It is time then for seedling potting using plastic bags at 9 x 12cm in size and alluvial soils from river banks or other nutrient – rich soils of light texture or surface soils free from stones.

**Table1. Growth of *Paulownia fortunei* seedlings in nursery**

Sampling plots No/	Seedling age	$D_{oo}$ (cm)	$S_D$ (cm)	$V_D$ (%)	H (cm)	$S_h$ (cm)	$V_h$ (%)	Remarks
1	10 days	0.2	0.03	15.0	3.8	0.74	19.5	Time counted from the date of seedling potting.
	25 -	0.26	0.04	15.3	6.4	1.33	20.6	
	40 -	0.36	0.10	27.0	19.3	4.24	21.9	
	55 -	0.41	0.14	34.1	31.1	11.2	35.5	
2	10 days	0.21	0.05	23.8	3.25	0.71	21.8	
	25 -	0.25	0.04	16.0	5.64	1.20	21.3	
	40 -	0.34	0.05	14.7	18.4	3.69	20.1	
	55 -	0.38	0.06	15.7	32.5	7.78	23.9	
3	10 days	0.26	0.05	19.2	7.31	1.71	23.4	
	25 -	0.30	0.05	16.6	10.8	2.29	21.2	
	40 -	0.34	0.05	14.7	20.8	5.35	25.7	
	55 -	0.48	0.08	16.6	35.2	9.11	25.8	
4	10 days	0.20	0.03	15.0	6.72	0.92	13.6	
	25 -	0.28	0.06	21.4	14.3	3.62	25.3	

	40 -	0.36	0.11	30.5	37.1	10.1	27.2
	55 -	0.45	0.14	31.1	42.9	11.4	26.5
5	10 days	0.25	0.05	20.0	3.8	0.64	16.8
	25 -	0.30	0.04	13.3	8.3	1.26	15.2
	40 -	0.35	0.07	20.0	22.9	8.05	35.2
	55 -	0.49	0.11	22.4	35.5	13.4	34.9

25 days after potting, the seedling begin to grow quickly, in particular after 40 – 55 days they grow very quickly. As a result, preparations should be planned well in advance so to take advantage of the seedlings being at their plantable size.

+ The timing for seed sowing depends very much on the current season. For instance, in winter time the seedling need 120 – 135 days to get to their plantable size, but in summer they may only want 80 – 90 days to grow in nurseries.

+ Vegetative propagation. *Paulownia fortunei* can be propagated very easily, using root cuttings. When using the common AIB or the Chinese ABT at concentrations of 100ppm, the rooting rate may come up to 91 – 97%. The control treatment (i.e. without stimulant) yields rooting percentage of 46%. In case of plenty of root cuttings, the use of stimulant will not be necessary.

+ Plantable size: Various experiments were made in nurseries with seedling of 3 – 6 mm thick and 15 – 55cm high. The results show that seedlings at their age of 90 – 120 days (depending on the sowing season) can have diameter of 4 – 6 mm at their crown of root and a total height of 25 – 45cm, which is found best for planting.

### 3.5 *Paulownia fortunei* planting experiments

Planting tests were made in Vietnam in some areas of different ecological conditions. Treatments and site conditions are given below.

+ In Hoa Binh a test was made at the village of Xom La, Thung Nai, at elevations of 164 – 300 m above sea level on sites covered with high shrubs, mixed with some timber pioneers and a lot of canes and worts. The test was established at a density of 1,600 seedlings/ ha and mix cropped with *Tephrosia candida* for soil and environment conservation. At the beginning the site was cropped with maize. The soil is of a “feralit” type developed on schists with moderately deep layers. Site preparations were made manually through cover vegetation cutting and the digging of holes (of 40 x 40 x 30cm), to be follow by planting – dressing with 1 kg farm- yard manure, 500g of “biofertilizier” and 100 g of NPK (5.10.3) per hole. The planting was carried out at the onset of the rainy season with strips of *Tephrosia candida* sown for isolation and site conservation as mentioned earlier.

- In Ba Vi , another test was established on a degraded old alluvial soil showing patches of lateritic crust. The site, however, had been used for a recent crop of eucalyptus and has required a surface tillage by mechanized means and the digging of holes (of 40 x 40 x 30cm) before planting at spacings of 2m x 3m.
- *Paulownia fortunei* was also tested at Dan Chu, Hoa Binh at spacings of 3 x 3 m on moderately deep soil developed on argillaceous schist and covered with high shrubs in mixture with some timber species such as *Peltophorum tonkinensis*, *Erythrophloeum fordii* and *Machilus* spp.. The plantation was created in April following cover vegetation felling and the digging of holes (of 40cm x 40cm x 30cm), and using homogeneous plantable seedlings of 30 – 35m high and 5 –6 cm thick at root height. (See results on Table 4: Pure tree crop plantation).
- Other tests were carried out by the Tea Company of Thanh Son and Long Phu on 10 –year old tea plantations under cultivation. *Paulownia fortunei* was established at spacings of 5 x5 m along access roads to tea plantations, and at spacings of 10 x 10m on the Tea plantations themselves, all on soils moderately deep developed on argillaceous schists (See results on table: Mixture with tea crop).
- *Paulownia fortunei* was also cultivated in mixture with other tree crops on moderately deep “feralit” soils developed on schists. The other tree crops in mixture were: *Peltophorum tonkinensis* and *Chukrasia tabularis*. The experimental plots were surrounded by strips of *Tephrosia candida*; and the mixture was carried out in rows, 3m apart from each other and in each row in trees, 2 m apart from the other. On the other hand, treatments were arranged in pairs, for instance *Paulownia* + *Peltophorum*, *Paulownia* + *Chukrasia*, and *Paulownia* in pure crop plantation so to facilitate observations and evaluations.
- Other tests were made on 5 – year old coffee plantation at the Tropical Forestry Centre in July 1997. The mixed cultivation of *Paulownia fortunei* with coffee was carried out on deep soils developed on granite (See results on table 3: Mixture with coffee).

Table 2. Soil and Climate Conditions of *Paulowniafortunei* Habitats and Plantation Sites and Related Growth.

	Soil	Climate	Average growth

Locality	pH <sub>KCl</sub>	Humus (%)	N (%)	Rainfall	T <sup>o</sup> C	Relative humidity (%)	D <sub>D</sub> (cm/year)	D <sub>H</sub> (m/year)
Tña Chĩa	4.96	1.84	0.09	1891	19.2	82	2.24	1.60
Mĩ C.Ch¶i	4.15	2.17	0.12	1813	18.7	79	2.96	1.72
Ng©n S-n	4.51	2.38	0.16	1685	20.0	81	3.33	1.59
Hoµ b×nh	4.1	4.40	0.32	1910	23.2	84	3.03	3.01
Thanh s-n	4.51	3.58	0.19	1659	22.8	81	3.81	2.70
D©n chĩa	4.1	4.33	0.33	1910	23.2	84	4.21	3.70
Pl©y Cu	4.47	2.84	0.23	2272	21.8	80	7.01	2.69

Generally speaking, tests and trials to assess the growth of the species can be made in all areas of different climatic and edaphic conditions for comparisons because in all these areas there are suitable sites for the growth of *Paulownia fortunei*, showing good and/ or very growth in terms of diameter (with D<sub>d</sub>: 3.03 – 7.0cm/a) and height (D<sub>H</sub>: 2.60 – 3.70m/a). Favourable soil and humidity conditions play a vital role in the growth of the species. Whenever the climate arid with long spells of drought, paulownia can die back. Some trees might survive but cannot grow further.

**Table 3. Growth of *Paulownia fortunei* in mixed and pure plantations**

Age	Parameters	<i>Paulownia</i> in pure plantation	<i>Paulownia</i> mixed with tea	<i>Paulownia</i> mixed with coffee
40 months of age	D(cm)	12.6	12.57	23.16
	S <sub>D</sub> (cm)	2.21	3.75	6.39
	H(m)	10.11	7.97	8.09
	S <sub>H</sub> (m)	1.39	1.02	1.54

The mixed cultivation of *Paulownia* with tea or coffee looks promising, with average diameter increments ranging from 3.7cm/ annum to 7 cm/ annual, and average height increments varying from 2.39m/a to 2.43m/a. Besides these treatments, paulownia can be grown in the Deltas as dispersed trees. Their performances 3.5 years after establishment are very high with diameters reaching over 30cm at breast height and height attaining 10m. Other mixed plantations made with a number of indigenous timber species (in particular *Peltophorum* and *Chukrasia*, see above) grow also very well during the first tow years. However, all the above needs further follow – up so to consolidate the information obtained.

## IV. Conclusions

### 4.1 Discussions

The study shows that *Paulownia fortunei* naturally occurs and can be grown with success in more than one region in Vietnam. The site conditions found to be suitable for its growth are: elevations ranging from 200m to 1,300m above sea level; average annual temperature from 15.2 to 23.5<sup>o</sup>C; annual precipitation from 1,391 to 2,833 mm; and moist soils not being severely degraded. Under these conditions, the species can yield a diameter growth of 3.0 – 4.5cm annually and a height growth of 2.5 – 3.0m a year. Its crown is large but quite open so to tolerate mixcropping or underplanting with other broad – leaved tree crops. Because of its fast growth, it can quickly provide a favourable environment for the growth of other tree crops; for instance *Chukrasia* and *Pelphorum* spp. In mixture with it can take advantage of the environment given to grow better in particular during the first two years. However, these are only some early observations.

### 4.2 Main findings:

- *Paulownia fortunei* (Seem) is a fast growing indigenous broad – leaved species, yielding light bright timber of fine grain, quite resistant to insect attacks for timber supply to wood- based panel and utility furniture industries.
- The species can be found in many places in Vietnam, in particular in all Northern frontier provinces and in some provinces of the North Central Region, where the annual precipitation varies from 1,391 to 2,833mm with no long spells of drought, or only 1 – 2 dry months round the year, and where the annual air temperature ranges from 15.2<sup>o</sup> to 23.2<sup>o</sup>C, sometimes with a minimum going down to – 4<sup>o</sup>C in winter
- It naturally occurs with a number of pioneer species such as *Litsea odorata*, *Vernomia arborca*, *Canarium* spp, ... and many others vernacularly knows as La nen, Sum long. It can grow in stands, in patches or specially apart from each other in secondary regrowths.
- In natural forests, *Paulownia fortunei* thrives well on good soils. It is well – known for its good diameter

and height growths (with  $D_D = 2.45 - 3.38\text{cm/annual}$  and  $D_H = 1.59 - 2.1\text{m/annual}$ ) The highest current annual growth of diameter  $Z_D = 3.2\text{cm}$  per annual, and the same for height growth  $Z_H = 2\text{m/}$  a can be reached when the tree is four (4) years old. In man – made forest with a standard management as prevailing nowadays, and for the first four years diameter growth  $D_D = 3.03 - 7\text{cm/annum}$  and height growth  $D_H = 2.6 - 2.7\text{m/annum}$  can be expected. By now, it is clear that after five years, *Paulownia fortunei* in plantations thrives much better than the same grown in the wild. In case of higher investments, for improved soil fertilization, the species can grow much more satisfactorily, thus bringing in more profits from the capital invested.

- In plantations, *Paulownia* also do best on sites of medium quality with deep soils of more than 60cm and dense cover vegetation of high shrubs mixed with some canes and worts as found in forests under restoration. On sites severally degraded (denuded hillsides under strong laterization, stony soils, compacted soil, or degraded basaltic soils) and in areas with long spells of drought, it is not advisable to grow the species.

- In some areas where conditions are most favourable entrepreneurs can go ahead with commercial (= industrial) plantation of *Paulownia*. And the practices of mixcropping the species with tea and coffee are offering new opportunities. Referring to what we have witnessed in mixed plantations of that kind for three years, these plantations are believed to produce as many as 30 –40 cu.m per hectare and per year when they are 6 - 7 years old. Another alternative is to plant *Paulownia* around villages, along roadsides, and even on farm lands. The species appears to be a promising tree crop to grow in the Deltas, on flats in particular of light Soil feature but not typhoon – prone.

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