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PAULOWNIA Sieb.&Zucc: A NEW EXOTIC GENUS FOR MULTI-PURPOSE USES IN KASTAMONU - TURKEY

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Summary:*Paulownia* is a native and fast growing tree in China. Nine species used for medicinal purposes, seed oils, fodder, manure, charcoal, reclamation of mined land and other are *Paulownia fortunei, P. tomentosa, P. fagesii, P. australi, P. elongata, P. taiwaniana, P. albiphloea, P. catalpifolia and P. kawakamii,*. In addition, *Paulownia* wood is widely used for various purposes, for example, house construction, paper pulp, furniture making, farm implements, music instrument and handicrafts. *Paulownia* genus has also an unique biological character, its root system grows in deep earth and its crown develops in loose structure, which enable it suitable to be intercropped with crops or mixed planting of other shade-tolerant trees. So, *Paulownia* is also a good tree for development of agro forestry.

The aim of this study is to compare of growth performance and determination suitable *Paulownia* species and origins as directed to multiple uses in nursery stage at Kastamonu Forest Nursery. Four *Paulownia* species and sixteen origins of those species have been studied. The seeds of this species and the origins have been obtained from China. The height growth and root collar diameter of the seedlings of the species and origins have been measured at the end of the first growing season.

It was determined that, *P. tomentosa x fortunei* hybrid has the highest seedling height value (72.627 cm) among the used species and origins in this study. According to root collar diameter and seedling percentage, statistical significant difference was not determined in Kastamonu ecological conditions. The highest plagiotropic growth rate was determined for *P. fortunei x tomentosa* Shen x Ihnan origin which has the highest seedling height at the same time. As to seedling height and root collar diameter, significant differences were established among the clones. Basing on this determination, it can be pointed out that in *Paulownia* studies, observations and evaluations should not be only done for each species and origin, but also for each clone.

1. Introduction

It is estimated that the gap between supply and demand of industrial wood in Turkey will become 6.7 million cubic meters in 2010 (OGM, 1988). Therefore the emphasis has been given to the establishment of industrial plantations with fast growing species in order to meet the shortage. Moreover, *Paulownia* is well suited to the establishment of special purpose usage. It can able to use in short-rotation plantations for biomass production and house construction, paper pulp, furniture making, farm implements, music instrument, handicrafts, medicinal, animal feed and manure.

The aim of this study is to compare of growth performance and determination suitable origins as directed to multiple uses of some *Paulownia* species and their origins at nursery stage in Kastamonu.

2. Usage of *Paulownia*

Dhiman (1997), described *Paulownia fortunei* as an eco-friendly multi-porpose species. *Paulownia* has nine species that are used for medicinal purposes, seed oils, fodder, manure, charcoal, reclamation of mined land and other uses. It is a native species of China, but planted in India, widely. *Paulownia* wood is widely used for various purposes and some of these are briefly described (Zhu Zhao-Hua et. al. 1986; Lu, X., Xong, Y., 1986).

(i) For house construction

As the strength of wood is not high, it is not suitable for uses which require mechanical strength but it is quite widely used for houses. Roof beams and purlin made of *Paulownia* wood are light and keep in shape for many years so they do not put the house out of shape. In Cichung County, Szechuan Province, the roof beams of *Paulownia* wood in a temple more than 100 years old are still in good condition. There is no decay in houses more than 100 years old which are completely made of *Paulownia* wood. *Paulownia* wood is very good for making doors, windows, partition boards, ceilings and inner roofs.

(ii) Wood for paper pulp and other uses

Paulownia wood is an ideal material for model air-planes and gliders and is increasingly used in air-craft, vehicles and ships both in China and in foreign countries because it is light, rot-resistant, free of warping, cracks and knots. As the wood is about 40% lighter than ordinary wood, delivery volume can greatly increase when it is used for packing boxes. Paulownia wood wool is an ideal material for use as a cushion filler, an insulation material for cooling systems, “mulching” chips for bedding material in cow sheds or litter in fowl houses and for making toys etc. *Paulownia* is very promising for pulp and paper. The wood is white and produces good, high strength pulp.

Paulownia wood, large in diameter and free of knots, is comparatively good in binding and is good material for plywood. It is easy to slice and plane, with a good colour and beautiful figures. Many factories in China have manufactured plywood (veneer 1.2-1.4 mm thick) for trial and obtained promising results. The planed face veneer can be as thin as 0.25 mm. If the viscosity of the adhesive is correct it does not penetrate to stain the face of the plywood. *Paulownia*-faced composite board and plywood can be used in large amounts for furniture, indoor decorative board, various kinds of boxes, radio set cases etc. It is expected that *Paulownia* will become one of the most important timber trees for face veneer and plywood in China.

(iii) For furniture making

Paulownia is used to manufacture tables and chairs. It is especially suitable for cases cupboards, which are smoke-proof and are little attacked by insects.

Slow grown, fine grained *Paulownia* wood is very good for oil drums, wine or beer barrels, tea boxes, fruit boxes, food grain storage etc. *Paulownia* wood can be used to make bee hives which are not only light

and convenient for transportation, but are also cooler in summer and warmer in winter than the bee hives made of other wood. This reduction in temperature extremes increase honey yield. People in Anhuei Province make vitriol barrels with *Paulownia* because it is acid tolerant.

(iv) For farm implements

Aquaducts made of *Paulownia* wood do not subside and crack, are durable and retain their shape.

(v) For handicrafts

The people in China, Japan and some other countries in South East Asia have a long tradition of making handicrafts with *Paulownia* wood such as flower vases, statue of Buddha or deities, wooden fish, medal boxes, dressing boxes, TV and radio boxes etc.

Paulownia wood can also be used to make blackboards, life rafts, sleds and surfboards. *Paulownia* charcoal can make charcoal crayons, black powder and fireworks and can also be used in industries as active carbon. *Paulownia* bark can be used to make dyes.

(vi) Medicinal properties

Medicines made of *Paulownia* leaves, fruits and wood have certain effects on bronchitis especially on relieving the cough and reducing phlegm. They are made into tablets and injections. The leaves of *P. tomentosa* contain ursolic acid ($C_{30}H_{48}O_3$) and matteucinol ($C_{18}H_{18}O_5$). Its xylem contains Paulownin, ($C_{20}H_{18}O_7.CH_3OH$) and d-Sesamin. From its bark, syringin ($C_{17}H_{24}O_9.H_2O$) and Catalpinoside were separated. Its fruits contain acid, fatty oil, flavanone and alkaloid. A solution prepared from the leaves and fruit dissolved in water, when applied daily to the scalp, is said to promote healthy hair growth and turn grey hair black. Another solution, using the leaves and wood, relieves swollen feet. Pharmacologial experiment shows that fruit extracts can relieve coughs and asthma and fruits can reduce blood pressure.

The large and hairy leaves of *Paulownia* play a very useful role in purifying dust and smoke. *Paulownia* has become the main tree species for afforestation in Chengdou, Szechuan Province, because dust and smoke pollution are comparatively serious there. The sulfur dioxide contents of the clean district where *Paulownia* are extensively grown (*P. albiphloea* var. *chengtuensis*) and the polluted district were respectively 0.169 % and 1.410 %. *Paulownia* still grows normally in the pollured districts whereas many other trees drop their leaves or fail to grow at all under the same conditions.

(vii) For fodder and manure

The leaves and flowers of *Paulownia* are good fodder for pigs, sheep and rabbits. The flower buds, flowers and the leaves of *Paulownia* contain fat, sugar and protein. The nitrogen content in *Paulownia* leaves can be compared favourably with some leguminous plants. People in Kwangsi make green manure with *Paulownia* leaves, which is an excellent fertilizer.

2. Materials and Method

2.1. Materials

In this study, 1+0 aged seedlings, which were produced from seeds of 16 provenances of three *Paulownia* species (*P.tomentosa*, *P.elongata*, *P.fortunei*) and a hybrid (*P. fortunei* x *tomentosa)* obtained from China (Anonymous 1998), were used. General information about these origins are given in Table 1. The seedlings were grown in non-warming greenhouse and open area condition at 800 m elevation in Kastamonu in 2002.

Table 1.The used *Paulownia* species and provenances in this study.

No	Species	Provenance	Altitude (m)	Mean Annual Precip. (mm)	Mean Annual Temp. (C°)	Lowest Temp. (C°)
1	*P.tomentosa*	Shannxi-Xi'an	1200	470	9.3	-15
2	*P.tomentosa*	Henan-Luoyang	100	640	14.2	-10
3	*P.tomentosa*	Shannxi-Taiyuan	750	604	13.3	-10
4	*P.tomentosa*	Shangdong-Chenwu	40	672	14.2	-10
5	*P.tomentosa*	Beijing-Daxin	50	682	11.6	-18
6	*P.tomentosa*	Anhui-Tongling	120	1000	15.7	-7
7	*P.elongata*	Henan-Shanggiu	50	640	14.2	-10
8	*P.elongata*	Shannxi-Xi'an	750	604	13.3	-10
9	*P.elongata*	Anhui-Tongling	120	1000	15.7	-7
10	*P.elongata*	Beijing-Daxin	50	682	11.6	-18
11	*P.fortunei*	Guangxi-Guilin	560	1873	18.8	-2
12	*P.fortunei*	GuiZhaou-Xinren	1100	1200	15.3	-2
13	*P.fortunei*	Zhejiang-Lin'an	650	1200	16.1	-6
14	*P.fortunei*	Hubei-Hunan	20	1260	16.3	-7
15	*P.fortunei*	Anhui-Tongling	120	1000	15.7	-7
16	*P.fortunei* x *tomentosa*	Shen xIhnan				

2.2. Method

The seed sowing was carried out in 50% peat+ 25% forest soil+ 25% stream sand germination medium in the greenhouse on 5 th May, 2002. After germination phase, when the seedlings reach 5-10 cm height, the seedlings were uprooted from sowing boxes, and transplanted in polyethylene tubes, filled with 60% forest soil+ 20% barn manure+ 20% stream sand mixture on 17-21st June, 2002. The physical and chemical analyses results of the above mentioned media are given in Table 2.

Table 2.The physical and chemical characteristics of the germination and growing media.

Medium	Specific gravity g/cm^3	Porosity % Vol.	Air Capacity %Vol.	Water Capacity %Vol.	pH	Organic matter %	Total N %	Cation Exchange Capacity me/100gr	Electrical Condactivite 1/2.5 Volume mS/cm
50% peat + 25 % stream sand + 25% forest soil *	2.42	57	7	50	6.9	6.90	0.34	22.95	1.07
60% forest soil+ 20% barn manure+ 20% stream sand**	2.45	58	8	50	7.6	9.35	0.46	38.62	0.60

* Germination **Growing

The seedlings were grown in the greenhouse, during 2-2.5 months of the first growth period. In this time, the seedlings completed the germination and succulent phase more or less. Seedlings were grown in open area condition in the rest of the growth period. The climate data of the research area is given in Table 3.

Table 3. Some of average climate data of Kastamonu meteorology station for 2002.

Year	January	February	March	April	May	June	July	August	September	October	November	December
2002	Monthly total precipitation amount (mm)											
	41,6	5,3	21,0	68,4	13,4	62,4	73,8	46,5	133,4	54,1	26,6	17,8
	Monthly minimum temperature (ºC)											
	-15,5	-9,1	-6,2	-5,1	0,8	5,1	10,9	5,8	4,0	-3,0	-4,0	-18,2
	Monthly average temperature (ºC)											
	-3,8	3,1	6,6	9,0	14,1	18,4	22,2	19,2	15,8	11,3	5,4	-3,2
	Monthly maximum temperature (ºC)											
	13,0	18,2	25,0	23,2	31,9	35,9	35,1	34,8	30,2	26,0	20,7	12,2

2.3. Statistical Analysis

The seedling height (SH) and root collar diameter (RCD) data were obtained by measuring on 1+0 aged seedlings. The plagiotropic growth rate (PGR) and seedling percentage (SP) data were got on the basis of observation and count at the end of the first growth period.

Analysis of variance was applied to the data obtained from SH, RCD and SP. Newman Keuls's Multiple Range Test was used for the grouping of the species and origins in case significant differences appeared between the species and the origins. For this analysis, TARIST Statistical Packet Programme was used by selecting Model 7. After arc-sin transformation on SP parameter, variance analysis was applied (Anonymous, 1994).

3. Results and Discussion

The original values of average SH, RCD, SP and PGR for each origin and species are given in Table 4.

Table 4. The average performance values of *Paulownia* species and origins at the end of the first growing season .

No	Species	Provenance	Average Values			
			Seedling Height (cm)	Root-collar Diameter (mm)	Seedling Percent (%)	Plagiotropic Growth Rate (%)
1	*P.tomentosa*	Shannxi-Xi'an	58.61	8.14	85.71	45
2	*P.tomentosa*	Henan-Luoyang	71.95	8.65	87.14	20
3	*P.tomentosa*	Shannxi-Taiyuan	59.43	8.98	83.78	30
4	*P.tomentosa*	Shangdong-Chenwu	59.16	7.52	84.84	50
5	*P.tomentosa*	Beijing-Daxin	81.32	8.99	75.71	35
6	*P.tomentosa*	Anhui-Tongling	50.20	6.89	86.56	10
P. tomentosa			**63.44**	**8.19**	**83.95**	**31.7**
7	*P.elongata*	Henan-Shanggiu	62.96	8.90	81.15	15
8	*P.elongata*	Shannxi-Xi'an	54.72	8.87	82.60	5
9	*P.elongata*	Anhui-Tongling	77.81	9.14	81.69	55
10	*P.elongata*	Beijing-Daxin	80.76	9.26	83.56	25
P. elongata			**69.06**	**9.04**	**82.25**	**25.0**
11	*P.fortunei*	Guangxi-Guilin	-	-	-	-
12	*P.fortunei*	Guizhaou-Xinren	36.66	9.24	82.85	5
13	*P.fortunei*	Zhejiang-Lin'an	47.56	9.43	79.16	10
14	*P.fortunei*	Hubei-Hunan	55.55	8.56	76.05	50
15	*P.fortunei*	Anhui-Tongling	52.58	7.60	89.39	10
P. fortunei			**48.08**	**8.70**	**81.86**	**18.8**
16	*P.fortunei* x *tomentosa*	Shen x Ihnan	72.62	9.16	82.60	85
P. fortunei x tomentosa			**72.62**	**9.16**	**82.60**	**85**
General mean			**63.30**	**8.77**	**82.66**	**40.12**

The result of variance analysis for SH measurements of the species and origins showed significant differences (F=18.023**, F=7.479***). As to the result of multiple range test, the best SH was determined for *P.fortunei* x *tomentosa* Shen x Ihnan (72.627 cm) hybrid. *P. elongata* (69.06 cm) and *P. tomentosa* (63.44 cm) species follow this hybrid, respectively (Table 6).

Table 6. Comparison of the average SH of the species by Newman Keuls test at 1% level.

Original order	Height (cm)	Order after test	Species	Height (cm)	Homogeneous groups	
1	63.44	4	*P. fortunei x tomentosa*	72.62	a	
2	69.06	2	*P. elongata*	69.06	a	
3	48.08	1	*P. tomentosa*	63.44	a	
4	72.62	3	*P. fortunei*	48.08		b

According to the evaluations for each origin, in Kastamonu condition, the highest SH was determined for *P. tomentosa* Beijing-Daxin (81.320 cm), *P. elongata* Beijing-Daxin (80.767 cm), *P. elongata* Anhui-Tongling (77.817 cm) and *P. fortunei x tomentosa* Shen-Ihnan (72.627 cm) origins, respectively. However, the lowest SH was determined for *P. fortunei* Guizhaou-Xinren (36.663 cm), *P. fortunei* Zhejiang-Lin'an (47.567 cm) origins, respectively (Table 7, Figure 1).

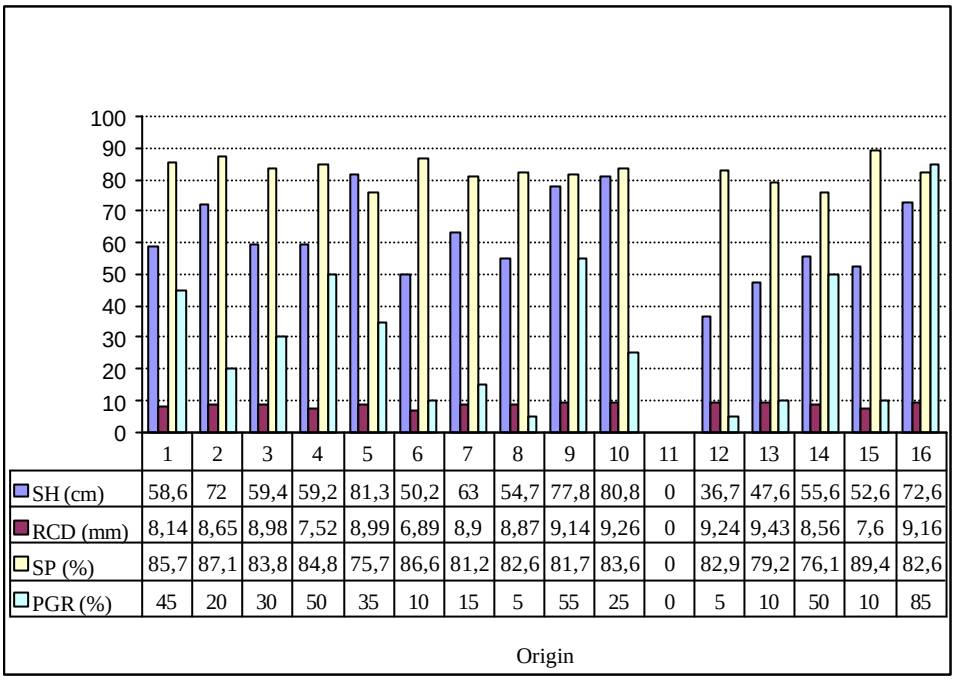
Table 7. Comparison of the average SH of the origins by Newman Keuls test at %0.1 level.

Original Order	Height (cm)	Order after test	Origin	Height (cm)	Homogeneous groups				
1	58,617	5	*P. tomentosa* Beijing-Daxin	81,32	a				
2	71,967	10	*P. elongata* Beijin-Daxin	80,767	a				
3	59,433	9	*P. elongata* Anhui-Tongling	77,817	a	b			
4	59,167	16	P. fortunei x tomentosa *Shen x Ihnan*	72,627	a	b	c		
5	81,32	2	*P. tomentosa* Henan-Luoyang	71,967	a	b	c		
6	50,207	7	*P. elongata* Henan-Shanggiu	62,967	a	b	c	d	
7	62,967	3	*P. tomentosa* Shannxi-Taiyuan	59,433		b	c	d	e
8	54,72	4	*P. tomentosa* Shangdong-Chenwu	59,167		b	c	d	e
9	77,817	1	*P. tomentosa* Shannxi-Xi'an	58,617		b	c	d	e
10	80,767	14	*P. fortunei* Hubei-Hunan	55,55			c	d	e
12	36,663	8	*P. elongata* Shannxi-Xi'an	54,72			c	d	e
13	47,567	15	*P. fortunei* Anhui-Tongling	52,587			c	d	e
14	55,55	6	*P. tomentosa* Anhui-Tongling	50,207			c	d	e
15	52,587	13	*P. fortunei* Zhejiang-Lin'an	47,567				d	e
16	72,627	12	*P. fortunei* Guizhaou-Xinren	36,663					e

There is no significant difference among the species and the origins with respect to the RCD and SP parameters, in Kastamonu condition, at the end of the first growing season. The highest RCD value was determined for *P. fortunei x tomentosa* Shen x Ihnan (9.163 mm), and the lowest for *P. tomentosa* (8.193 mm). This result is parallel with the study which was done by Ayan et al (2002) at Trabzon- Of Forest Nursery.

As to SP parameter of each origin and species, significant difference was not established. It was determined that the highest SP value for *P. tomentosa* (83.95 %) and the lowest SP value for *P. fortunei* (81.6 %). Also, *P. fortunei* Anhui-Tongling (89.39 %) origin has the highest SP value whereas *P. tome*ntosa Beijing-Daxin (75.71 %) origin has the lowest.

Plagiotropic growth effects the industrial wood rate of a tree negatively by preventing the growth of smooth and quality stem. *P. fortunei* Guizhaou-Xinren (5 %) origin showed the lowest PGR, but *P. fortunei x tomentosa* Shen x Ihnan (85 %) origin showed the highest. The case of *P. fortunei* Guizhaou-Xinren origin has the lowest SH, but *P. fortunei x tomentosa* Shen x Ihnan origin has the highest SH should be noticeable. On the other hand, there is a positive correlation between PGR and SH.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SH (cm)	58,6	72	59,4	59,2	81,3	50,2	63	54,7	77,8	80,8	0	36,7	47,6	55,6	52,6	72,6
RCD (mm)	8,14	8,65	8,98	7,52	8,99	6,89	8,9	8,87	9,14	9,26	0	9,24	9,43	8,56	7,6	9,16
SP (%)	85,7	87,1	83,8	84,8	75,7	86,6	81,2	82,6	81,7	83,6	0	82,9	79,2	76,1	89,4	82,6
PGR (%)	45	20	30	50	35	10	15	5	55	25	0	5	10	50	10	85

Figure 1. Performance of the *Paulownia* origins in Kastamonu Forest Nursery conditions.

4. Conclusions

- It was determined that among the species, used in this study *P. tomentosa x fortunei* hybrid has the highest (72.627 cm) SH. But this value is rather small when compare with the height value (3-4 m) which denoted by Zhao-hua (1986) for 1+0 aged seed originated seedlings. So, in Kastamonu ecological conditions, it can be stated that *Paulownia* species and origins are not worth as a "fast growing species" with respect to the result of this study.

- According to RCD and SP values, statistical significant difference was not determined in Kastamonu ecological conditions.

- The highest PGR was determined for *P. fortunei x tomentosa* Shen x Ihnan origin which has the highest SH at the same time. But, the lowest PGR was determined for *P. fortunei* Guizhaou-Xinren which has the lowest SH.

- In respect of SH, both *P. tomentosa* Beijing Daxin (81.32 cm) and *P. elongata* Beijing-Daxin (80.767 cm) origins showed the best growing at Kastamonu region. This result is noticeable for the research area.

- In this study, as to SH and RCD significant differences were established among the clones of the same origin like Ayan et al. (2002) study. Basing on this determination, it can be pointed out that in *Paulownia* studies, observations and evaluations should not be only done for each species and origin, but also for each clone.

- During the study, PGR at the high rate was observed because of various factors such as excessive growth and non-lignification, storm, snow and so on. The PGR will be able to an important risk for producing industrial wood.

- According to the evaluations of third year of *Paulownia* field experiments at the different elevations of Eastern Black Sea Region, any insect and fungus damage were not observed. But, All seedlings were died because of winter frost of 1999 in the Golkoy-Ordu experiment area (at 1400 m elevation) (Ulu et. al., 2002). Also, during our study, biotic harms as insect or fungus were not observed. But the early frost (-0.8 ^{0}C) occurred at night of 2 nd November 2002, damaged to the top sprouts of the all origins. Not completed the lignifications because of fast height growth, increased the early frost damage. So, It's found out that, the tested *Paulownia* species and origins don't have adaptation capability for Kastamonu region.

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