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## PHENOLOGICAL AND MORPHOLOGICAL STUDIES ON DIFFERENT PAULOWNIA SPECIES GROWING AT PESHAWAR

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### ABSTRACT

Observations made on the phenology of three-year-old plants of 5 *Paulownia* species namely *P.australis*, *P.elongata*, *P.fortunei*, *P.tomentosa* and *P.forgesii* indicated that flower bud production occurred in the month of August in the first four species. *P.forgesii* did not produced any flower buds. The blooming took place in first week of March before foliation. *P.elongata* flowered earliest of the species in the first followed by *P.fortunei* in the second, *P.australis* and *P.tomentosa* in the third week of March. The fruit setting commenced in the first and second weeks of April in *P.australis*, *P.elongata*, *P.fortunei*; and *P.tomentosa*. However, the fruit ripening period was found to vary in different species from the fourth week of August to first week of October. Leaf shedding was observed from the fourth week of December to the first week of January.

Studies on flower morphology showed that the calyx hairy surface material was of ash grey color (easily removable) in *P.fortunei* while it was golden brown (sticky) in *P.tomentosa*, *P.australis* and *P.elongata*. The corolla color was white in *P.elongata*, dark purple in *P.tomentosa*, light purple in *P.australis* and mild off white in *P.fortunei*. The flower length was maximum (10.9 cm) in *P.fortunei* and minimum (7.9 cm) in *P.tomentosa*. The percentage of inflorescence bearing plants was 88 in *P.elongata*, 61 in *P.fortunei*, 35.5 in *P.tomentosa* and 30.1 in *P.australis*. The number of flowers/cyme varied from 2-5 in *P.australis* and *P.elongata* and 3-5 in

*P.fortunei* and *P.tomentosa*. Fresh fruit weight, fruit length, fruit breadth, seed weight/fruit and placental length were maximum in *P.fortunei* and minimum in *P.tomentosa*. The leaf size was largest (238.8 cm<sup>2</sup>) in *P.fortunei* and smallest (124.6 cm<sup>2</sup>) in *P.forgesii*.

### INTRODUCTION

Plant phenology, the science of seasonal timing (periodicity) of the life event of plants, is closely linked with the forestry activities. It is, therefore, very important to know the time of fruit ripening of a particular tree species for raising nursery in time for establishing forest plantations. Similarly, planting of seedlings, especially of deciduous species, is related with sprouting and the emergence of new leaves. Lack of knowledge about the phenology of tree species would result in collection of fruit either at immature stage or after the loss of seed viability (Beniwal, 1987). Different workers (Ganapathy and Rangarajan, 1964; Kaul and Raina, 1980; Ansari, 1989 and Beniwal and Singh 1989) have reported phenological observations on some important forest trees.

Morphology, the science of general appearance of an organism, provides information to distinguish among different species, genera, families etc., present at a particular location. Likewise, the plant morphological characteristics of root, stem, leaf, flower, fruit and seed, though somewhat comparatively stable characteristics but they should be used with caution (Anon., 1986).



Genus *Paulownia* is indigenous to China (Anon., 1986), but is new in Pakistan with great scope for cultivation due to its fast rate of growth (Siddiqui and Khan, 1989 and Khan, 1992) and is suited for intercropping with agricultural crops because of its special branching pattern through which the light can easily penetrate and root system. It is a broad leaved and deciduous tree with late defoliation. *Paulownia* is mainly grown in shelter belts and for inter-cropping with wheat and maize etc., along with other forest trees like poplar, elms and jujube trees in China (Anon., 1986). Its wood is widely used for insulation material, sound conduction, house construction, paper and pulp, cabinet making, farm implements, handicrafts, medicines, fodder and manure (Anon., 1986; Hardie *et.al.* 1989; and Siddiqui and Khan, 1989).

The present study was therefore, carried out to determine phenological and morphological characteristics of various *Paulownia* species introduced in Pakistan.

## MATERIAL AND METHODS

The study on the phenology of *Paulownia* species was carried out on trees growing in Research Garden of the Pakistan Forest Institute, Peshawar from February 1993 to February 1994. Three-year-old 20 plants of each five *Paulownia* species e.g *P. australis*, *P. elongata*, *P. forgesii*, *P. fortunei* and *P. tomentosa* were selected for this purpose. The observations on flower bud production, blooming, foliation, fruiting, fruit ripening and defoliation were recorded at weekly intervals till 50% of the plants produced the specified characteristics. The particular stages at which the characteristics were noted are given below:

**Table 1. Different stages at which the appearance of particular phenological characteristics were recorded.**

S.No.	Phenological characteristics	Stage at which particular characteristics were noted
1.	Flower bud production	When the plants produced small bud like structures at the terminal ends of the branches.
2.	Blooming	Time at which the flower buds produced flowers with their characteristic shapes.
3.	Foliation	Time at which the leaf bud produced clearly differentiated leaves.
4.	Fruiting	Time at which the corolla leaves of 50% flowers started to shed and fall on the ground.
5.	Fruit ripening	When the fruit started to change their color from green to berger brown.
6.	Leaf shedding	When the leaves started to change their color from green to yellowish brown.

Data on the flower morphological characters were recorded on sixty flowers/species. Average flower length (excluding pedicel) was measured in centimeters



with the help of a meter rod. The color of flowers was matched with color chart (Ridway, 1912). Calyx surface material was removed mechanically for comparing its nature on different species. The number of flowers/cyme were recorded from the middle of the inflorescence in each species. The number of plants bearing the inflorescence, were counted to determine the percentage for each species.

The morphological characteristics of the fruit e.g. fresh fruit weight, fruit length and breadth, seed weight/fruit and placental length were recorded on sixty fruits/species. For these observations, a representative plant of each species was chosen and sixty mature fruits were plucked, brought to the laboratory and divided into three groups on size basis and each group consisted of twenty fruits. Fruits in each group were weighed separately on the electric balance and average fresh weight for each species was computed. The average fruit length (excluding pedicel) and fruit breadth (at the middle) were recorded in centimeters with the help of a calliper in each of three fruit groups. These fruits were dried at room temperature for 3-weeks. After that, the open fruits (at the top) were broken in such a way that the placentas remained intact and seeds of each species were collected. These seed were weighed to determine average seed weight/fruit. Placental length was measured in centimeters with the help of a calliper for each of three fruit groups. Leaf size of the *Paulownia* species was determined with the help of a graph paper for 30 leaves/species in the month of August when mature leaves (from the middle of the canopy) were plucked.

## RESULTS AND DISCUSSION

**Phenological characteristics:** The data in Table 2 show that the flower buds were produced in

the month of August in all the *Paulownia* species except *P. forgesii* which did not produce any flower buds. The flower bud remained dormant from production time to the next flower opening time and thus underwent cold treatment of winter before flowering. As far as the flowering time was concerned, out of the five *Paulownia* species, *P. elongata* bloomed first (1st week of March) followed by other three in the order of *P. fortunei* (2nd week of March); *P. australis* and *P. tomentosa* (3rd week of March) with variation of 2-4 days. At the end of third week of March, all the *Paulownia* species except *P. forgesii* bloomed densely and the crown appeared as ice berg, which indicated that the flowering was earlier than foliation. Similar observations were reported by Parker (1926). The leaf bud sprouting time was second week of March in *P. elongata*, third week of March in *P. fortunei*, fourth week of March in *P. australis*, *P. forgesii* and *P. tomentosa* with difference of 2-4 days.

In the first week of April, the ground surface below the tree canopy appeared to be whitish-blue due to heavy fall of the corolla leaves. The fruit setting time varied from first week of April in *P. australis*, *P. elongata* and *P. fortunei* to second week of April in *P. tomentosa*. The fruits matured at the end of August in *P. elongata* and *P. tomentosa* while in *P. australis* and *P. fortunei*, they matured in the first week of September and October respectively. Considerable variation in the fruit maturity time from the end of August to the beginning of October in different *Paulownia* species has also been reported in the literature (Anon., 1986).

In all the *Paulownia* species, maximum defoliation was observed from the end of December to the beginning of January. This late defoliation is considered a beneficial characteristic for intercropping systems because



it provides protection to the wheat seedlings from early frost damage (Zhaohua, 1987). The

data recorded on the phenological characteristics is given in the following Table 2.

**Table 2. Schedule for the appearance of phenological characteristics in different *Paulownia* species.**

Species	Flower bud production	Blooming	Foliation	Fruiting	Fruit ripening	Leaf shedding
<i>P. australis</i>	3rd week of Aug.	3rd week of March	4th week of March	1st week of April	1st week of Sept.	4th week of Dec. to 1st week of Jan.
<i>P. elongata</i>	2nd week of Aug.	1st week of March	2nd week of March	1st week of April	4th week of Aug.	-do-
<i>P. forgesii</i>	NIL	NIL	3rd week of March	NIL	NIL	-do-
<i>P. fortunei</i>	1st week of Sept.	2nd week of March	3rd week of March	1st week of April	1st week of Oct.	-do-
<i>P. tomentosa</i>	2nd week of Aug.	3rd week of March	4th week of March	2nd week of April	4th week of Aug.	-do-

(ii) **Flower morphological characteristics:** The data on flower morphological characteristics of different *Paulownia* species are given in Table 3.

**Table 3. Flower morphology of different *Paulownia* species.**

Species	Flower Shape	Flower length (cm)	Flower color		Nature of calyx surface material	Variation in number of flowers/cyme (No.)	Percentage of inflorescence bearing plants. (%)
			Calyx	corolla			
<i>P. australis</i>	Pedicellate and campanulate flower with pentam-erous bilipped corolla	8.5	Golden brown	light purple	sticky	2-5	30.1
<i>P. elongata</i>	-do-	9.4	-do-	white	-do-	2-5	88.0
<i>P. forgesii</i>	Nil	Nil	Nil	Nil	Nil	Nil	Nil
<i>P. fortunei</i>	-do-	10.9	Beig	mid off white	easily removable	3-5	61.0
<i>P. tomentosa</i>	-do-	7.9	Golden brown	dark purple	sticky	3-5	35.5

Variation in the flower morphological characteristics of different *Paulownia* species was also observed. The dense hairy surface material was on calyx ash grey in *P. fortunei*

whereas, it was of golden brown color in the remaining three species. The hairy surface material could be removed easily by hand in *P. fortunei* which was sticky in other three



species.

The corolla was bilipped with two lobes on the upper lip and three elongated lobes on the lower lip. Near the limbs, the upper lip passes downwards and makes the corolla flat. Considerable variation was noticed in the corolla color. It was white in *P.elongata*, dark purple in *P.tomentosa*, light purple in *P.australis* and off white in *P.fortunei*. The corolla interior was dark purple in *P.fortunei*, light purple in *P.elongata* and *P.australis*; and two yellowish wrinkles in *P.tomentosa*.

Maximum length (10.9 cm) and minimum (7.9 cm) flower was observed in *P.fortunei* and *P.tomentosa* respectively. *P.australis* and *P.elongata* had intermediate

lengths. The number of flowers per cyme varied from 2-5 in *P.australis* and *P.elongata* and 3-5 in *P.fortunei* and *P.tomentosa*. This confirms results in the literature (Anon., 1986).

The highest (88.0%) and lowest (30.1%) inflorescence bearing plants, after 3 years of growth, were noted in *P.elongata* and *P.australis* respectively. In the remaining two species the percentage of inflorescence bearing plants was 61.0 in *P.fortunei* and 35.5 in *P.tomentosa*. This indicated the presence of difference in the flowering age in different *Paulownia* species (Anon., 1986).

(iii) **Fruit morphological characteristics:** The differences recorded in the fruit characteristics of *Paulownia* species are presented in Table 4.

**Table 4. Fruit morphological characteristics of different *Paulownia* species grown under Peshawar conditions.**

Species	Fresh fruit wt. (gm)	Fruit length (cm)	Fruit breadth (cm)	Seed wt./fruit (cm)	Placental length (cm)
<i>P.australis</i>	7.2	4.9	2.3	0.4	2.3
<i>P.elongata</i>	9.7	5.0	1.9	0.5	2.5
<i>P.fortunei</i>	19.0	8.7	3.3	1.1	4.4
<i>P.tomentosa</i>	2.2	2.8	1.6	0.2	2.1

In general, the fruit color is green with dirty surface material at early stages and gradually becoming brown and eventually changing to berger brown. The fruit weight and size were maximum in *P.fortunei* and minimum in *P.tomentosa* while the rest of two species showed intermediate fruit characteristics. The maximum fruit length (8.7 cm), fruit breadth (3.3 cm), fresh fruit weight (19.0 gm) and seed weight/fruit (1.1 gm) were recorded in *P.fortunei*. *P.tomentosa*, on

the other hand, produced fruit of minimum length (2.8 cm), fruit breadth (1.6 cm), fresh fruit weight (2.2 gm) and seed weight/fruit (0.2 gm). The placental length of different *Paulownia* species was 4.4 cm in *P.fortunei*, 2.5 cm in *P.elongata*, 2.3 cm in *P.australis* and 2.1 cm in *P.tomentosa*.

(iv) **Leaf size variations:** Data pertaining to the leaf size different *Paulownia* species are given in table 5.



**Table 5.** Comparison of average leaf size of various *Paulownia* species grown under Peshawar conditions.

Species	<i>P.australis</i>	<i>P.elongata</i>	<i>P.forgesii</i>	<i>P.fortunei</i>	<i>P.tomentosa</i>
Leaf size(cm <sup>2</sup> )	208.7	161.0	124.6	238.8	231.9

The Table 5 shows that *P.fortunei* produced leaves of the largest size (238.8 cm<sup>2</sup>) and *P.forgesii* of the smallest (124.6 cm<sup>2</sup>) size. The intermediate leaf sizes e.g. 231.9 cm<sup>2</sup>, 208.7 cm<sup>2</sup> and 161.0 cm<sup>2</sup> were observed in *P.tomentosa*, *P.australis* and *P.elongata* respectively.

## CONCLUSIONS

The results of present study have shown that different *Paulownia* species have distinct phenological and morphological characters. The best time for seed collection of these species, under Peshawar conditions, is between fourth week of August and first week of October. Keeping in view foliation time the planting should be completed by third week of March.

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