BIOMASS PRODUCTION FROM SALICACEAE-PART II

M. I. Sheikh*

Biomass Production

Biomass studies were conducted on 1-year, 2-year and 6-year old plants of some of the clones which are represented in the populetum and other experiments, established on the premises of Pakistan Forest Institute, Peshawar. Trees of *P. euramericana* cv. I–214, aged 10 years, were measured from Changa Manga plantation as old trees of this clone were not available in the Peshawar area. (28)

Production from poplars of different ages

One year old plants:

The plants were uprooted and green weight of the stems roots and leaves was recorded for each plant. (The plants did not have any branches as these were planted at a close spacing of (0.5m x 0.5m.) The weights, with dbh and height, recorded for each tree and different clones, are given below:

Table 10

Biomass from one year old plants of ten poplar clones planted at 0.5m x 0.5m.

Name of clone	DBH (cm)	Height (m)	Green Weight (Kh) Stem	Root	Branches	Leaves	Total/ trees
I 63/51	1.9	3.74	0.380	0.210	–	0.140	0.730
I 18/62	2.3	3.33	0.480	0.400	–	0.180	1.060
I 69/234	1.6	2.34	0.180	0.180	–	0.100	0.460
S7C 20	2.0	3.08	0.280	0.180	–	0.100	0.540
S7C3	2.0	3.40	0.380	0.280	–	0.100	0.760
ST 92	1.8	2.72	0.240	0.160	–	0.100	0.500
S7C 2	1.9	1.34	0.240	0.110	–	0.090	0.440
ST 66	2.3	3.56	0.400	0.220	–	0.160	0.780
AY 48	1.9	2.72	0.340	0.200	–	0.120	0.660
Y 727	1.9	2.40	0.230	0.140	–	0.100	0.470

The data show that biomass production from clone I–18/62 was the highest, followed

* The author is the Director General, Pakistan Forest Institute, Peshawar.

by ST 66, S7C3 and I–63/51. Over-all average of one-year old plants for all the clones was 0.640 kg per plant.

Two year old plants:

The following table 10 gives data collected from 2-year old plants:

Table 11

Biomass from 2-year old plants of seven poplar clones planted at 4.0m x 0.5m.

Name of clone	DBH (cm)	Height (m)	Green weight (Kg)				
			Stem	Root	Branches	Leaves	Total/ tree
Y – 542	8.9	9.25	15.000	3.676	2.600	0.800	22.076
Y – 707	7.5	8.85	14.750	5.675	3.000	0.800	24.225
Y – 514	5.1	6.40	5.750	2.850	2.650	0.800	12.050
Y – 533	6.6	8.40	10.500	2.250	4.000	0.800	17.550
Y – 528	6.8	9.35	12.150	2.350	3.375	0.600	18.475
Y – 706	8.0	10.50	16.350	3.250	4.450	0.700	24.750
I – 77/51	5.6	6.24	7.400	1.960	1.200	0.380	10.940

The highest biomass production was given by Y–706 and Y–707, followed by Y–542 and Y–528. Over-all average for 2 years old plants of all the clones is 18.6 kg per plant.

Biomass of 2 year old plants of 7 other clones planted 2 x 2m was also recorded as under:

Table 12

Biomass from 2-year old plants of seven poplar clones planted 2m x 2m.

Name of clone	DBH (cm)	Height (m)	Green weight of stem including branches/tree (Kg)
I–63/51	4.8	6.5	8.6
S7C13	5.7	6.9	11.0
AY 48	4.4	6.3	6.4
Unknown (China)	2.9	4.5	2.4
S7C3	4.7	6.0	6.5
ST 67	5.2	7.4	10.7
I – 18/62	4.4	6.3	5.7

The biomass production of stem and branches, from the clones S7C13 and ST 67, was the highest, while that from the clone of Chinese origin was the lowest. Evidently, the Chinese clone is not performing well under the climatic conditions obtaining in Peshawar.

Six-year old plants:

Six-year old tree of I – 63/51 were felled for assessment of biomass production from plants grown in Peshawar. The following data were collected:

Table 13

Biomass from 6-year old trees of I – 63/51 planted 4.5m x 4.5m.

Name of clone	DBH (cm)	Height (m)	Volume of logs (m^3)	Green weight (Kg)			
				Stem	Root	Branches	Total/ tree
I – 63/51	21.8	17.37	0.255	245	72.5	40	357.5
"	21.0	17.37	0.304	241	72.0	44	357.0
"	19.6	18.29	0.222	204	54.0	35	293.0
"	20.2	17.7	0.292	255	58.5	45	358.5

Over-all average for the clone comes to 341.5 kg per tree.

Ten-year trees of *P. euramericana* cv. I – 214

Studies on biomass production were also extended to 10-year old trees of *P. euramericana* cv. I – 214, growing in Changa Manga. The trees were felled and samples taken from the lowest and the highest diameter ranges. The data gathered are given below:

Table 14

Biomass from 10-year old trees of *P. euramericana* cv. I – 214 planted at 5m x 5m.

DBH (cm)	Height (m)	Volume of log (m^3)	Green weight (kg)			
			Stem	Root	Branches	Total/tree
24.4	19.20	0.400	413	50.0	55	518.0
36.1	21.95	0.908	728	115.0	150	993.0

Average biomass production from a 10-year old tree of I – 214 comes to about 755.5 kg.

Determination of oven-dry weight and moisture content

Samples from different parts of freshly-cut stems of different clones were taken for determination of over-dry weight and moisture content. The initial green weight of samples of each clone was recorded and the samples kept in oven at a temperature of 102–105° C for 30 hours to get the oven-dry weight. The moisture content for samples was calculated as under:

$$\text{Moisture content (\%)} = \frac{(\text{Green weight} - \text{Oven-dry weight}) \times 100}{\text{Oven-dry weight}}$$

The average green weight, oven-dry weight and moisture content percentage for different clones is given below:

Table 15

Green weight, oven-dry weight and moisture content of various different age clones.

Name of clone	Age (years)	Green weight (gm)	Oven-dry weight (gm)	Moisture content (%)
I – 18/62	1	23.48	11.60	102.4
Y – 727	1	5.73	3.04	88.5
ST – 66	1	9.22	4.85	90.1
S7C2	1	11.78	5.71	106.3
ST – 92	1	9.87	5.09	93.9
I – 63/51	1	27.57	13.87	98.8
S7C3	1	12.94	7.21	79.5
AY 48	1	9.91	5.04	96.6
S7C20	1	12.77	6.18	106.6
I – 69/234	1	7.65	3.88	97.2
–do–	2	16.28	8.96	81.7
Y – 542	2	20.08	11.21	79.1
Y – 533	2	9.95	5.76	72.7
Y – 514	2	22.05	11.82	86.5
Y – 528	2	9.34	5.39	73.3
I – 77/51	2	11.40	6.31	80.7
Y – 706	2	14.85	8.32	79.6
Y – 707	2	8.01	4.08	96.3
ST – 67	2	11.11	6.26	77.5

From the table it is clear that there is a linear relationship between age of the plant and moisture percentage. All the clones have almost 90% or more moisture content at one-year of age whereas it declines roughly to 80% at 2 years of age.

Samples from four trees of the clone I – 63/51, aged 6 years gave the following result:

Table 16

Green weight, oven-dry weight and moisture content in clone I – 63/51, aged 6-years.

Tree No.	Green weight (gm)	Oven-dry weight (gm)	Moisture content (%)
1	34.90	24.60	41.9
2	55.94	36.95	51.4
3	43.92	29.90	46.9
4	51.62	30.67	68.3

The overall average moisture content works out to be 52.1%. It seems to have reduced to one-half in 6-year old plants, as compared to one-year old, exhibiting better mechanical properties for old poplar wood.

PLANTING, MANAGEMENT AND GROWTH OF WILLOWS

The 31 willows in Pakistan grow at altitudes from 300 to 5000 m in different climatic zones, including subtropical, mainly temperate, subalpine and alpine environments and in a variety of habitats along water courses, irrigation channels, streams, river and canal banks and even in snow-melt habitats. (29)

Of the many willows growing in the country, only the following 7 are important in the national economy:

Salix acmophylla: The most common of the willows. Small tree from 300–1600 m altitude in dry sub tropical and dry temperate forests along moist sites, canal and river banks.

Salix tetrasperma: Almost as common as common as above, a medium sized tree in swampy, wet and moist places all over the community.

S. denticulata: Small tree or a tall shrub as under growth in temperate coniferous forests and sub alpine zone at 200–3700 m altitude.

S. julacea: A shrub or a small tree 1700–3000 m altitude in temperate coniferous forest zone.

S. pycnostachya: A shrub or a small tree at 3600–4600m altitude in the Alpine zone.

S. viminalis: A tree or a large shrub at 200–3800 m altitude in the arid temperate coniferous and sub alpine forest zones.

Out of the exotic willows *S. babylonica* is widely grown as an ornamental tree in different parts of the country.

Planting practices

The tree has usually been planted along water courses in the irrigated plantations, canal banks, rivers and streams and agricultural fields using 30 cm long cuttings. Since the essential cultural methods required for proper growth of willows have not been adopted due to lack of sufficient information, the trees are crooked, malformed and forked providing very little clean and utilizable bole. Apart from the defective planting techniques, poor quality of the produce is due also to use of planting stock regardless of the source, planting in unfavourable sites and subsequent poor silvicultural and management operations. It has been indicated that 1-year old second stage nursery plants should be planted in the month of December/January. However, in case there is a stress in moisture or the weather heats up suddenly, the sprouting is not satisfactory resulting in half dead plants from the tops. With further experimentation, it has been observed that planting 20 cm long and 4 cm diameter cuttings at 1 x 1 m is more economical and sprouting is almost 100%. The obvious advantage is that there is very little branching and a considerable clear length of stem us available which is in great demand by

sports goods industry. Every alternate plant is removed after 1 year and further thinning can be done as and when indicated. (9)

Growth rate

The rate of growth of five willows planted in 1980 has been compared as under:

Table 17.

Comparison of the rate of growth of 5 willows

Name of species/clone	Avg. dia. (cm) 1981	Avg. dia (cm) 1983	Avg. ht (m) 1983
Sl – 59/62	1.0	6.0	6.6
Sl – 17/64	1.7	5.9	6.5
Salix tetrasperma	1.4	7.2	7.0
Salix argentinensis	1.1	6.9	7.3
Salix alba	1.2	8.0	7.3

Sl–17/64 was the best clone in diameter growth in 1981, but two years later i.e. in 1983, *Salix alba* was on top, being the best in diameter as well as height. (23)

Nawaz (3) has reported the performance of willows planted in 1943. The species included *Salix babylonica, Salix tetrasperma* and *Salix acmophylla*. In all, 1900 cuttings were planted, giving 289 trees at the end of 1958. No cultural operation was done except weeding and fencing in the first 2–3 years. All the species grew very well and attained the diameter of 30–40 cm over a period of 13 years. The growth data are tabulated below:

Table 18

Average growth and out-turn per tree.

S.No.	Name of species	Average height (m)	Average dbh (cm)	Average yield per tree	
				Timber (m^3)	Firewood (kg)
1.	*Salix babylonica*	15.24	33.0	0.453	150
2.	*Salix tetrasperma*	14.78	40.6	0.510	224
3.	*Salix acmophylla*	12.49	30.5	0.255	186

Salix babylonica and *Salix tetrasperma* did very well while *Salix acmophylla* gave poor

results. It was further noticed that a large number of trees, particularly of the first two species, has developed heart-rot apparently due to delayed exploitation. The timber had to be rejected, being unfit for manufacture of sports goods.

Salix babylonica timber was obsolutely white and was preferred by the sports industry. The trees had grown tall and provided knot-free celar boles. Timber from the rest of the two species had a reddish colour. It was not much appreciated by the manufacturers of sports goods.

Volume tables: (2)

Commercial volume tables of *Salix tetrasperma* were prepared by Malik and Abbas based on data collected from 600 trees, growing along water courses and distributaries.

The trees were cut into logs varying in length from 2 meters to 3 meters upto thin and diameter of 15 cm. The volume under bark was measured upto merchantable height. Volume for 2.5 classes is given in Table 18.

Table 19

Local Volume Table for *Salix tetrasperma* (Solid Πr^2 volume in m^3).

Mean diameter (cm)	Volume (m^3)
15.24	0.05
17.78	0.08
20.32	0.11
22.86	0.14
25.40	0.19
27.94	0.23
30.48	0.29
33.02	0.35
35.56	0.42
38.10	0.50
40.64	0.59
43.18	0.68
45.72	0.77
48.26	0.90
50.80	1.02
53.34	1.15
55.88	1.29
58.42	1.44
60.96	1.60
63.50	1.76

Biomass from willows (28).

Data from willow plants at Pakistan Forest Institute were collected as for poplar. These data are tabulated below:

Table 20

Biomass production from willows, 2 x 2 m

Name of clone	Age (Yrs)	DBH (cm)	Ht. (m)	Green weight (Kg)				
				Stem	Root	Branch	Leaves	Total/ tree
Sl–17/64	1	1.7	2.70	0.238	0.167	0.055	0.043	0.503
Do.	2	3.6	3.70	1.450	0.780	0.450	–	2.680
Do.	3	4.6	4.20	4.400	1.210	1.600	0.220	7.430
Salix viminalis	2	2.4	3.03	0.613	0.280	0.242	–	1.135
Do.	3	4.5	4.00	4.500	1.900	1.700	–	8.100

Three years old *S. viminalis* gives more biomass than 3-year SL–17/64

Cost/benefit ratio of poplar planting (28)

Initially planted at 5.5 x 5.5 m in the state plantations, usually 300 trees per hectare are available on a rotation of ten years. Average volume per tree at this age is 0.425 m^3; one ha yielding 127 m^3. The current market rate of 1 m^3 of poplar wood is U. S. $ 75.00 giving a total revenue of U. S. $ 9,525.00. The discounted value of expenditure as U. S. $ 1,104.53, the cost benefit ratio comes to 1:3.3. These figures do not include the returns from agricultural crops raised in-between the poplar rows.

However, on the farms much better returns are available (1:6) due to low investment. According to the current market rates, one tree of poplar planted along field boundaries fetches the farmer a minimum of $ 8 after six years. The farmer purchases the nursery stock at the rate of 5–8 cents per plant, involves the whole family in planting operations and does not spend anything on the maintenance of the trees as these are usually grown along water courses. He sells the trees either standing or converts and brings the material to the roadside purchase depot on his cattle-driven cart or a tractor. Poplar is one tree which has come to the expectation of farmers and it is perhaps for the first time that researches conducted on an exotic fast-growing tree has benefitted the common man in Pakistan. Willows fetch slighly better prices than poplars.

UTILIZATION OF POPLARS AND WILLOWS (28)

The major use for poplar wood for the time being is manufacture of matches. The wood is in great demand and about 50% factories in the country are totally dependent on poplar wood for raw material. Packaging and shuttering is another important use. 4-5 m long billets are being sold for providing temporary housing to the Afghan refugees. Furniture makers have developed a fancy for this wood and chairs and tables can be seen in the sale shops. Use of leaves, branches, tops and even small sized inferior logs is quite common for cooking and heating. In the plantations the floors are broomed clean of all the leaves for cooking as well as feed for the cattle. Following utilization pattern of poplar wood is expected from 1985–1990:

Type of material	Quantity of round wood (m^3) in use
Veneer logs	16000
Saw logs	20000
Particle and fibre board	6000
Round wood used as such (poles and other assortments)	17800
Total :	59800

Demand for poplar wood for different end uses is increasing especially in packaging, use in scaffoldings, as plywood for inner cores of doors and windows. It is used in shoe heels, wooden carts, and sports goods. There is a demand by the pulp, particle board and fibre board industries but enough material is not available.

Average price for 1 m^3 wood is about U. S. $ 75. During the last 10 years there has been a 10 – 20% increase in prices.

Poplar wood for cooking and heating is in great demand. According to estimates 60,000 m^3 are being used for cooking and heating. It comes natural stands as well as plantations.

Comparing wood properties *P. deltoides* I-63/51 has turned out to be better than *P. euramericana* cv. I-214. Specific gravity of the former was also found better than the latter indicating that total production of solid matter of wood per unit area would be much higher in the case of *P. deltoides* than for I–214 suggesting better biomass yields. In fact all the strength properties of *P. deltoides* were found to be better than those of *P. euramericana*. (28)

The willows provide a variety of goods and services to the people and are handsomely contributing to the national economy providing raw material, fuel wood, raw material for basket making; shoe lasts; essence and tannin manufacture; fodder for goats, sheep and cattle. The willows are also used for consolidation of land slips river and canal banks and in the landscape improvement. Total quality of willow wood produced annually is 7-8 thousand m^3.

REFERENCES

1. Beg, A. R. and M. I. Sheikh 1975: Cultivation prospects of exotic and indigenous Poplars in Pakistan. *Pak. Jour. For.* 25(3): 145–152.

2. Malik, M. Azam and S. Hassan Abbas Moosvi 1970: Commercial Volume Tables for Willow (*Salix tetrasperma* Roxb.) Forestry Research Division Bulletin No. 1, PFI, Peshawar pp. 1–17.

3. Nawaz, M. 1959: Economics of growing willows. *Pak. Jour. For.* 9(2): 132–134.

4. Sheikh, M. I. 1965: Hybrid poplars in Pakistan. *Bureau* of *Agri. Inform.* W. Pak. pp. 33. illus.

5. Sheikh, M. I. 1972: A comparative study of hybrid poplars and Eycalypts. *Pak. Jour. For.* 22(1): 28–42.

6. Sheikh, M. I. 1972: Hybrid poplar plantation in W. Pakistan. A review: 76 pp., illus.

7. Sheikh, M. I. 1973: Selection of *Populus ciliata* clones. *Pak. Jour. For.* 23(2): 149–154, illus.

8. Sheikh, M. I. 1973: Study report on fast-growing species project, Italy. May-Sept. 1973: 75, illus.

9. Sheikh, M. I. 1973: Willow (Salix spp.) Propagation – New techniques. *Pak. Jour. For.* 23(1): 100–50.

10. Sheikh, M. I. 1976: Performance of hybrid poplars in Pakistan. Proc. Sym. on Eastern Cotton Woods and related species Sept. 28–Oct. 2, 1976: 414–419.

11. Sheikh, M. I. 1977: Comparison of six poplar clones for growth and survival. *Pak. Jour. For.* 27(2): 101–118.

12. Sheikh, M. I. 1977: Report on the 3-week study trip to poplar growing area and Research Labs. in U.S.A. Nov. 8–29, 1976 : 85.

13. Sheikh, M. I. 1978: Effect of spacing on the growth of hybrid poplar. *Pak. Jour. For.* 28(2): 93–94.

14. Sheikh, M. I. 1978: Sppravvivenza Ed Accresoimento Dl Cloni Dl pioppo in Pakistan. Estrata da "Cellulosa Carta" N. % Marzo 1978: 17–22. illus.

15. Sheikh, M. I. 1978: Performance of poplar clones under irrigated conditions in the Punjab. *Pak. Jour. For.* 28(2): 120–122.

16. Sheikh, M. I. 1980: Performance of some exotic poplar clones in Pakistan. Proc. Int. Forestry Seminar Kuala Lumpur, Malaysia. 11–15 November, 1980.

17. Sheikh, M. I. 1980: Optimum spacing for poplar plantation. For. Res. Ser. Tech. Note. 23, p. 2.

18. Sheikh, M. I. 1980: Heavy pruning is injurious to poplars. For. Res. Ser. Tech. Note. 30. p. 2.

19. Sheikh, M. I. 1981: Management study of hybrid poplars. Final Tech. Rep. Pak. For. Inst. pp. 51, illus.

20. Sheikh, M. I. 1982: A manual for planting of poplars in Pakistan. Ministry of Food, Agri. and Co-operatives. p. 20.

21. Sheikh, M. I. 1982: Comparison of four clones of Poplars at Peshawar. A Tech. note.

22. Sheikh, M. I. 1982: Performance of *Populus deltoides* c. v. 1–63/51 with other broad-leaved species in conjunction with agricultural crops. Tech. Note 38.

23. Sheikh, M. I. 1982: Propagation of willows. Pak. For. Inst., Tech. Note. 35: 0.1.

24. Sheikh, M. I. 1982: Effect of cultivation on the growth of Poplars. *Pak. Jour. For.* 33(2) : 91.

25. Sheikh, M. I., M. A. Cheema and Raza-ul-Haq 1983: Effect of poplars on the yield of wheat in Changa Manga irrigated plantation. *Pak. Jour. For.*

26. Sheikh, M. I. and S. H. Bangash 1983: Response of hybrid poplar, *P.euramericana* c. v. 1–214 to the application of major fertilizer nutrients. *Pak. Jour. For.* (Under publication)

27. Sheikh, M. I. 1983: Effect of different depths of irrigation on 4 poplar clones. Tech. Note No. 49 p.2.

28. Sheikh, M. I. 1984: Use of poplar and willow biomass for food, fodder and energy – Draft report on Pakistan for F.A.O. (Unpublished).

29. Stewart, R. R. 1972: Flora of West Pakistan. An annotated catalogue of the vascular plants of West Pakistan and Kashmir. pp. 180–188.

30. Walayat, Hussain Raja and M. I. Sheikh 1981: Provisional yield tables of hybrid poplars in Pakistan. *Pak. Jour. For.* 31(4): 165–183.

31. Zaman, M. B., Zakaullah and S. M. Jamal 1969: Disease and insect pests of poplars in West Pakistan. A special report for 1968. Pakistan Forest Institute, Peshawar. pp. 14–41.