BIOMASS PRODUCTION SYSTEMS FROM SALICACEA – PART I

Mahmood Iqbal Sheikh*

Summary

Pakistan is suffering from a chronic shortage of wood. Most of the indigenous species are rather slow growing and take a long time to mature. The existing deficiencies can only be met through planting of local and exotic fast growing tree species such as poplars and willows in climatically suitable areas. Exotic poplars were, therefore, introduced in late fifties. Over a period of time techniques of scientific production of nursery stock and field planting have been developed and streamlined. Spacing studies and clonal trials have given quite indicative results. Plantations have been raised in pure blocks, with agricultural crops, around farms and along roads, canals and rivers. As it brings handsome revenue within 5 – 6 years, the tree has become a favourite of the farmers.

Native willow cuttings have been planted for more than a 100 years on almost the same sites as suited to poplars. Using methods have been initiated. Sports goods industry is the main user of willow wood.

Biomass research on Salicacea is comparatively new to Pakistan. It has been found that different poplar clones grown under the same set of conditions yield different quantities of biomass.

Introduction

Three species of poplars grow in nature in Pakistan. These are *Populus ciliata*, *P. alba* and *P. eupharatica*. While ecologically the first two are strictly temperate, growing bitween altitudes of 1300 – 3000 m and occupying cool and moist sites in the moist temperate zones, *Populus euphratica* descinds lower down in the sub-tropical and tropical environments along river banks. The species thus occur in different ecological conditions and exhibit *euphratica* is being planted in the southern province of Pakistan because of its greater commercial value as timber. *Populus ciliata* erosion and to meet their firewood requirements. *Populus alba* is fourth species *Populus nigra* is not indigenous to the country and was most probably introduced by the Moghals when they came to India in the seventeenth cintury. Proir to the introduction of hybrids, this species, using branch cuttings, was being planted throughout the country along water channels, as an avenue tree or as a dependable windbreak in the plains as well as in the mountains upto an altitude of about 3,000m. The species is, however, biing now easily replacec by hybrid and deltoides clones of poplars due to the fast rate of growth of the latter. Planting of exotic poplars in Pakistan was started in late fifties. The first introductions were from Italy followed by clones from U. S. A., Yugoslavia, Turkey, Netherlands. Australia, etc. Over a period of time, scientific studies on raising of plantations, management

* Director General, Pakistan Forest Institute, Peshawar – Pakistan

and utilization have been conducted with useful findings. Recently some bionass studies on poplaus and willows have been initiated. (1, 4, 10).

As regards willows, a total number of 31 species, sub-species, varieties and hybrids of willows including 12 exotics have been reported for Pakistan by Stewart. (29), These species grow at altitudes from 300 to 5,000 m in different climatic zones including sub-tropical, mainly temperate, sub-alpine and alpine environments in a variety of habitats along water courses, irrigation channels, streams, river and canal banks and even in the snow-melt habitats. These species render a variety of goods and services to the community and contribute in the development of the national economy.

The important species are *Salix acmophylla, S. tetrasperma, S. Denticulata, S. sericocarpa, S. julacea, S. pycnostachya, S. viminalis.* The most important of the exotic species is *Salix babulonica* which is widely grown as an ornamental plant. So for willows have always been planted from branch cuttings.

PLANTING MANAGEMENT AND GORWTH OF POPLARS

Poplars are planted in the form of compact blocks, with and without agricultute, as wind-breaks on field borders and as individual scattered trees on the farm land. Although exotic poplars were introduced more than 2 decades back, compact plantations do not exceed 5000 ha. It is primarily due to the fact that poplars require lot of water and good, deep fertile soil, thus coming indirect competition with agriculture. However, due to sustained effort on the part of the researchers who also worked as extension specialists, these poplars have become a hot favourite of the farmers of Peshawar valley and the district of Hazara which is blessed with about 1000 mm average annual rainfall supplemented by the water available from several rivers, rivulets and streams. In these two areas, about 10 million poplar trees have already been planted and about 100,000 plants are planted every year.

Planting practices

One year old poplar plants from well established nurseries are used for planting. The common sites are government lands, private farms, as well as the high rainfall areas in the moist temperate forests or along the banks of rivers at a spacing varying from 2 x 2 and 5 x 5 m in the months of January and February every year. In the plains, proper irrigation is necessary and usually 16–18 irrigations are given per season by flooding surface area or through trenches. Usually inter-cropping is done to suppress the weeds. (6, 8).

A number of studied have been conducted on the management practices of poplars. These include comparison of rate of growth with other species, effect on agriculture crops, and vice versa, the growing space requirements, suitablity of clones for different climatic zones, response to depth of irrigation applied, effect of fertilization and pruning regimes.

Comparison with other species

Populus euramericana cv. I-214 one year old plants, stem cuttings of the same,

Eucalyptus camaldulensis, and *E. tereticornis* one-year old plants, were compared for growth under intensive methods, viz inter-cropping between the lines, and the conventional methods, viz. planting on trenches in Changamanga irrigated plantation. The data on 3-year old crops indicated that hybrid poplars under the intensive method gave much better performance both in height and diameter (10.4 m ht., 15.8 cm dia) as compared to the eucalypts (5.1 m ht., 5.6 cm dia). It also transpired that stem cuttings of poplars should not be planted directly in the field at a wide spacing. Growth of all the species was comparatively poor under conventional methods. (5)

In Peshawar valley, rate of growth of *Populus deltoides* I–63/51, *Eucalyptus citriodora, Dalbergia sissoo* and *Salmalia malabarica* planted at 4.3 x 4.3 m spacing was compared at the age of 5 years. Poplar had a distinct edge over the rest. (22)

Table 1

Comparison of rate of growth of four species.

Name of species	DBH (cm)	Height (m)
E. citriodora	14.6	13.6
Dalbergia sissoo	14.8	10.4
Salmalia malabarica	19.8	9.2
P. deltoides I–63/51	21.1	16.6

In another study in Peshawar valley, the effect of agricultural crops on the growth of *Populus euramericana* cv. I–214 was measured after 4 years of cultivation. No crop was grown in the control and only soil cultivation was done.

Table 2

Response of poplars to different cultural treatments.

Treatment	DBH (cm)	Height (m)
1. Trifolium and poplars	15.0	11.0
2. Wheat and poplars	14.4	10.2
3. Soil cultivation and poplars (control)	14.4	10.6

It is indicated that the agricultural crops did not have any adverse effect on the rate of growth of poplars. As a matter of fact, they helped. (24)

In another study to find out the effect of poplars on the yield of wheat in the Changa Manga Irrigated plantation, it was found that *Populus euramericana* cv. I–214 planted at 5.5 x 5.5 m at 4 years in age, with 15 m height and 19 cm diameter did not affect the yield of wheat grown in between the lines. (25)

Effect of spacing on growth of poplars

To find out the effect of spacing on growth of poplars two studies have been conducted in the central zone of the country under irrigated conditions.

At Bhagat (13) planting of one year old plants of *Populus euramericana* cv. I–214 was done at 5 different spacings viz. 1.9 x 1.9m, 2.7 x 2.7m, 3.7 x 3.7m, 4.6 x 4.6m, 5.5 x 5.5m. Growth measured in 1983 gave the following measurements.

Table 3

Growth pattern of cv. I–214 under different spacings, age 10 years.

Spacing	DBH (cm)	Height (m)	Vol./ha (m^3)
1.9 x 1.9	17.2	21.40	160.0
2.7 x 2.7	21.5	21.80	191.0
3.7 x 3.7	23.0	23.0	205.0
4.6 x 4.6	25.7	22.30	214.0
5.5 x 5.5	27.2	22.40	175.0

It is indicated that 4.6 x 4.6m and 5.5 x 5.5m spacing are the best ones for diameter growth and are highly significant as compared to the rest; 1.9 x 1.9m spacing gave the least diameter.

Volume of wood was also calculated and it was found that maximum volume (214 m^3/ha) was available from 4.6 x 4.6 m spacing and the least from 1.9 x 1.9m.

At another location, Changa Manga, spacings of 1.9 x 1.9 m, 2.5 x 2.5 m, 3 x 3 m, 3.7 x 3.7 m, 4.3 x 4.3 m, 5 x 5 m and 5.5 x 5.5 m were tested. The data collected after 7 years gave the following growth figures:

Table 4

Growth of pattern under different spacings, age 7 years.

Spacing	DBH (cm)	Height (m)	Volume/ha (m^3)
1.9 x 1.9	13.6	17.6	211
2.5 x 2.5	15.5	18.4	181
3.0 x 3.0	17.8	18.7	169
3.7 x 3.7	20.3	19.3	202
4.3 x 4.3	22.5	19.6	166
5.0 x 5.0	21.4	18.1	144
5.5 x 5.5	21.0	16.7	85

Spacing of 4.3 x 4.3 m gave the best diameter and height but volume in the above data is low due to wind falls.

It is further indicated that at 7 years 1.9 x 1.9 m spacing continues to give maximum volume closely followed by 3.7 x 3.7 m. The highest volume in 1.9 x 1.9 m spacing is due to the maximum number of trees in that spacing. Very low volume in 5.5 x 5.5 m spacing is attributed to biotic factors such as heavy weed growth leading to intensive grazing pressure and damage to the trees by horned cattle. (12, 17, 19)

Growth rate

Sample plots were laid out and data were collected from 24 such plots in spacings of 3 x 3 m, 5 x 5 m and 6 x 6 m ranging in age from 2 – 10 years.

Table 5

Comparison of rate of growth of cv. 1–214 at different spacings and differentlocations

Locality	Spacing (m)	Age (years)	Av dia (cm)	Av. ht (m)	Vol/ha (m^3)	MAI (m^3/ha)
Daphar	3 x 3	6	16.0	18.3	168.0	28.0
"	5 x 5	6	19.0	17.1	87.0	14.5
"	6 x 6	7	23.1	18.9	109.0	15.6
Bhagat	3 x 3	6	18.3	19.2	206.3	34.4
"	6 x 6	7	26.7	19.8	153.6	21.9
Changa Manga	5 x 5	5	22.3	19.2	151.0	30.2
Peshawar	6 x 6	10	29.2	25.6	203.8	20.4

From the above it is clear that with proper management at 3 x 3 m spacing a poplar crop of 6 years can give 1½ times more volume as 6 x 6 m spacing would give after 10 years. The spacings would of course be guided by end use. However, for biomass production, 3 x 3 m spacing seems to be quite suitable. (30)

Comparison and evaluation of clones

Rate of growth of some poplar clones at different locations has been compared as under:

Table 6

Comparison of the rate of growth of 6 poplars planted in Peshawar valley at 6 x 6 m, age 4 years,

Name of the clone	Av. dia (cm)	Av. ht (m)	Vol/tree (m^3)
I–63/51	22.2	17,77	0.34
I–214	21.5	16.75	0.29
I–90/60	19.0	16.19	0.24
I–72/51	18.8	16.37	0.23
I–69/55	18.2	16.48	0.20
I–18/62	19.1	13.43	0.19

I–63/51 out performed the rest of the clones and it is now being distributed to the farmers in addition to I–214. (11)

In another study in Peshawar Valley, 5–year old plants of four clones planted 3 x 3 m gave the following results.

Table 7

Growth rate of four clones, planted 1979, measured 1983.

Clone	DBH (cm)	Height (m)
S4C1	13.3	15.9
I–18/62	13.3	15.1
S7C3	12.4	14.9
S7C4	11.9	14.8

None of the four clones has so far shown significant superiority. (21)

Comparison of clones has also been done in an irrigated plantation in the Punjab. The data obtained are given below: (14, 15, 16)

Table 8

Comparative rate of growth of promising introduced clones, planted at 4.5 x 4.5 m at Bhagat irrigated plantation, age 9 years.

Name of clone	Av. dia (cm)	Av. ht. (m)	Vol/ha (m^3)
I–69/55	25.0	22.40	189.20
I–77/51	24.1	21.33	170.43
I–63/51	23.5	18.55	166.48
I–18/62	22.0	19.28	134.86
I–488	21.4	18.64	130.00
Y–507	21.4	18.59	130.00
I–214	21.4	18.28	129.43
A–65/27	20.8	20.12	107.69

Work conducted by the poplar specialists over a period of last 15 years has indicated the suitability of following poplar clones for different climatic regions. (10)

Southern region:

Hyderabad (Oceanic climate) 25° 23′ N lat., 68° 38′ E long.

1. *P. deltoides* X caudina Y–509; Y–510
2. *P. deltoides* I–6/64
3. *P. deltoides* A–65/27; A–65/31, A–Y–48

It has convincingly been proved that:

- Hybrid poplar has no future in the southern region.
- deltoides clones can be planted successfully only at close spacing since they perform poorly on wider spacing.
- the recommended deltoides clones especially Australian ones can be planted on large scale, at a close spacing of 0.9 m x 0.9 m to 1.5 m x 1.5 m either from cuttings for plants, on a short rotation of 2-3 years.

When raised from cuttings, these clones attain an average height of 3.0 m and a diameter of 4.0 cm. in one year.

Central plains

Changa Manga 31° 00′ N lat., 73° 52′ E long.
Daphar (Gujrat) 32° 32′ N lat., 74° 10′ E long.
Chichawatni 30° 15′ " " 72° 20′ " "
Clonal trials have indicated the superiority of the following:

P. deltioides	I–63/51,	*P. deltoides*	I–64/55
" "	I–77/51,	" "	A–65/27
" "	Y–507,	" "	I–4/64, 4/65
" "	I–90/60,	" "	I–72/58
" "	I–69/64,	" "	I–6/64
P. euramericana	I–214,	*P. euramericana*	I–408
" "	I–18/62,	" "	I–BL

Northern region

Peshawar 34° 00′ N lat., 71° 30′ E long.
Mingora (Swat) 34° 36′ N lat., 70° 17′ E long.

Following clones have shown promise in this area:

1. *P. euramericana* cv. I–214; cv. I–021
   cv. I–488; cv. I–79/234, I–72/58

2. *P. deltoides* I–63/51; D/ I–90/60 S7C3, S7C20
   I–69/55;

3. *P. deltoides* x (?) I–18/62.

These poplars have been planted in the form of compact blocks with and without agricultural crops, as wind breaks, and as individual scattered trees on the farm land.

Effects of different regimes of irrigation

In 1978, a study was started in Chichawatni irrigated plantation to compare the rate of growth of four clones under different depths and frequencies of irrigation over a period of 6 months in a year. The three depths of irrigation were 0.91 m (D1), 1.37 m (D2) and 1.82 m (D3). 30 cm long stem cuttings of I–90/60, I–72/58, I–4/64 and I–69/55 were planted on trenches. An assessment was made in 1983 and the results are given below: (27)

Table 9

Diameter (cm) height (m) and volume/(m^3)/ha of 6–year old plants under different depths of irrigations.

Treatment	D_1			D_2			D_3		
Clone	Dia	Ht.	Vol.	Dia	Ht.	Vol.	Dia	Ht.	Vol.
I–90/60	12.9	15.3	225	12.7	15.9	195	12.9	16.4	216
I–72/58	13.3	16.0	217	13.7	16.2	231	13.8	17.0	257
I–4/64	14.4	16.6	261	14.8	15.7	297	15.3	16.8	316
I–69/55	14.4	17.7	241	15.1	18.1	299	15.8	18.5	356

Following conclusions can be drawn from the study.

- Irrespective of delta delivered I–90/60 is the poorest performer for diameter, and volume followed by I–72/58, I–4/64 and I–69/55. Almost the same trend is indicated for height growth.
- I–90/60 and I–72/58 have not responded to different depths of water in case of dia. However, there is slight increase in height due to decrease in irrigation.
- I–4/64 and I–69/55 have shown progressive increase in dia but for height, only I–69/55 has attained progressive increase.
- The best performer out of the four is I–69/55 recording maximum diameter and height and volume directly related to the quantity of water given.

Effect of fertilization

A study was conducted on a 4 year old crop of *P. euramericana* cv. I–214 in Changa Manga irrigated plantation in 1978 using N, P, K alone and in all possible combinations. Urea, single superphosphate and potassium sulphate were applied at the rate of 667, 750 and 288 Kg/ha. Results assessed in 1983 were non-significant. (26)

Effect of pruning intensities

To find out the effect of different intensities of pruning, a study was laid out in 1976 in an irrigated plantation of cv. I–214 crop planted at 5.5 x 5.5 m in 1973. At that time average diameter of the crop was 12 cm and average height 10 m. Three treatments viz. pruning upto half the length of the tree, one-third length of the tree, and control were applied. After 5 years the effect was assessed. It was indicated that pruning upto half of the total

height effected diameter growth adversely as compared to pruning upto breast height or upto one-third of the total height. (18)

Breeding

Not much attention has been paid to the breeding work of indigenous poplars of Pakistan. One main reason was that the introduced poplars started growing much better than the indigenous poplars and the latter lost the attention of the tree breeders. In early sixties, some work was done on hybridization of *P. euphratica* in the province of Sind but it did not go beyond streamlining the techniques or raising nurseries from the seed collected from different sources.

In the late sixties an attempt was made for selection of *P. ciliata* clones in the Murree Hills. The tree was never given much importance in the past so far as breeding is concerned. Artificial fertilization has not been reported in literature. The ease with which it can be propagated from cuttings did not attract the attention for raising it from seed. Fine specimens of the tree are available in the forests around Murree, Doongagali, Kala Bagh and Nathiagali from 2,000 meters to 2,500 meters above sea level in the moist temperate forests where the tree grows naturally or has been planted in pure patches or mixed with conifers.

Using the criteria, such as straight and cylindrical bole, minimum branches, one leader and absence of insect and fungal damage, seed from plus trees was collected and sown in July, 1968. Depending on the climatic conditions, *P. ciliata* seed matures by the end of June which may be extended upto middle of July. The seed was separated by rubbing the floss on wire mesh. The seed was sown in moist beds in lines immediately after the collection covered with a very thin layer of leaf mold and ordinary nursery soil. Hand watering was done with a very fine spray. Beds were covered against rain.

One year after sowing, seedlings were pricked and planted at 30 x 15 cms. In the third year selection was made on the basis of rate of growth, habit of seedlings and their resistance to fungal and insect diseases in a quantitative manner. 132 seedlings were selected out of about 2,300 A nursery was raised from selected stock for a second selection resulting in the final selection of only 29 seedlings. The results were highly indicative and it would be possible to do selective work on *P. ciliata* to get trees with exquisite qualities with fast rate of growth and excellent form. Credit for initiating this work goes to Dr. Silvio May of poplar Institute, Casale Mon ferrato, Italy. (7).

Some work on genetic improvement was again initiated in 1977 for the species *P. alba, P. ciliata* and *P. euphratica* from a selection of about 700 trees from all over the country. The progenies and cuttings were further multiplied year after year to get sufficient planting stock of the species. *P. ciliata* rooted very easily; *P. euphratica* the least while *P. alba* occupied middle position. Seeds of *P. ciliata* and *P. euphratica* shown 90 percent germination and 80 and 54 percent survival respectively. It was also observed that *P. ciliata* seedlings raised from cuttings and seed has 0.04 and 0.54 heritability (h^2) values respectively at three years of age. The cuttings collected from two year old nursery stock of *P. ciliata* exhibited better survival as compared with those collected from mature trees.

Recently seed of *P. deltoides* from 35 seed sources throughout its natural range of distribution in U.S.A. has been obtained, and 3,000 seedlings have been raised from this seed. This is expected to provide good testing material for trial under various ecological conditions.

Pests, diseases and natural hazards (28,31)

Poplars are susceptible to the attack of a number of insects; fungi, bacteria and wild animals.

The insects include stem borers, shoot borers, defoliators and stitchers. *Ichthyura anastomosis* causes large scale defoliation. *Melanophila picta, Apriona cineraria, Aeolesthes sarta*, and *Indarbela quadrinotata* are very serious borers. Among the fungi, *Septoria populi, Taphrina populina, Melampsora populnea* and *Ganoderma* are important. *Dothichiza populnea*, causing trunk rot in the irrigated plantations has turned out to be quite depressing.

Porcupines are a potential threat to all poplar plantations in the country.

Unusually heavy windstroms can devastate a full grown plantation by uprooting and breaking of tops and limbs.

Almost the same insects and diseases afflict the willows also.

(To be continued)