MANAGEMENT OF HYBRID POPLAR FOR OPTIMUM YIELD OF WOOD

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1. Introduction

Hybrid poplar was introduced in Pakistan in late fifties. Through the years methods of growing this tree on a large scale have been perfected and particular clones which would successfully grow under different climatic conditions have been identified. However, the optimum growing space requirements of poplars still remained to be standardised. Such a study had a special significance in Pakistan in view of the tremendous shortage of raw material for various end uses and a final decision was required to be taken as to the spacing and the rotation on which poplar should be grown for maximum volume production for different end uses.

Although studies on spacing of poplars have been conducted in many countries, yet the results could not entirely be applicable to Pakistan owing to different climatic conditions obtaining in this part of the world. It was observed that due to comparatively long growing season, here, the rate of growth was faster. Simultaneously low rainfall, high temperature and poor edaphic conditions affected the plants adversely. Some studies on spacing were laid out in the country in 1969 but the treatments were not properly replicated and distributed. To find a possible answer to these questions this PL–480 study was started in Change Manga irrigated plantation in February, 1976.

2. Design of the Experiment

The experiment was laid out over 19 hectares (47 acres) in a randomized complete block design with 1.8x1.8 (68x6′), 2.4x2.4 (8′x8′), 3.0x3.0 (10′x10′), 3.7x3.7 (12′x12′), 4.3x4.3 (14′x14′), 4.9x4.9 (16′x16′), 5.5.x5.5 (18′x18′) meter spacing and seven replications of each treatment, plot size 0.33 ha. Detail is as under:

Table 1. Layout and design of the Experiment

Spacing (metres)	No. of measurement trees	No. of border rows	Total number of plants in a plot including surround
A 1.8 x 1.8	350 (14 x 25)	6	962 (26 x 37)
B 2.4 x 2.4	180 (10 x 18)	5	560 (20 x 28)
C 3.0 x 3.0	112 (8 x 14)	4	352 (16 x 22)
D 3.6 x 3.6	84 (7 x 12)	3	234 (13 x 18)
E 4.2 x 4.2	50 (5 x 10)	3	176 (11 x 16)
F 4.8 x 4.8	32 (4 x 8)	3	140 (10 x 14)
G 5.4 x 5.4	32 (4 x 8)	2	96 (8 x 12)

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17,640 well grown one year old poplar plants of uniform size and of the same clone (CV–1–214) were planted in February, 1976. Failures were restocked in February, 1977. Manual hoeing in closer spacings (1.8 x 1.8, 2.4 x 2.4 and 3.0 x 3.0 m) and soil cultivation with tractor in the remaining 4 spacings was completed in March, 1977.

3. Management of plantation

3.1 *Soil marking*

As weeds grow profusely on soils which have been properly worked and which are given irrigation water from canals, it is essential to keep the soil clear of these by weeding, hoeing, soil cultivation etc. Manual hoeing was done in closer spacing as it was not possible to use machinery there. However, cultivation by tractor was done in winder spacings. The schedule adopted for hoeing and soil cultivation is given below:

Table 2. Schedule prescribed for various soil related operations

Treatment	A 6 x 6 Hoeings	B 8 x 8 Hoeings	C 10 x 10 Hoeings	D 12 x 12 Soil Cultivation	E 14 x 14 Soil Cultivation	F 16 x 16 Soil Cultivation	G 18 x 18 Soil Cultivation
Year	N	U	M	B	E	R	S
I	2	2	2	2	2	2	2
II	2	2	2	2	2	2	2
III	x	x	x	2	2	2	2
IV	x	x	x	x	2	2	2
V	x	x	x	x	x	2	2

3.2 *Irrigation*

In Pakistan irrigation is necessary to make poplar plantations a success. Lack of water supply during the critical period, that is, after planting till the beginning of the monsoon causes severe damage to poplar plantations. Water has to be given by flooding over the surface. Depending upon the supply of canal water the schedule usually adopted is given below:

Table 3. Schedule of irrigation in a plantation

Month	No. of irrigations to be given	Month	No. of irrigations to be given
February	2	March	2
April	2	May	4
June	4	July	1
August	1	September	1

In the beginning some difficulties were faced in getting the requisite water supply as the actual season of irrigation starts from the middle of April. However, with the cooperation of the Forest Department, this handicap was utlimately overcome and the situation of irrigation remained quite normal during the period. Usually heavy rains were received during the month of July and August thereby reducing the water requirements to a great extent.

3.3 *Pruning*

The intensity of pruning would vary according to the silvicultural requirements of the crop. Only conservative pruning, where indicated was done in the first year to remove some lower thick branches. Alongwith the first pruning, the damaged leading shoots, double leaders, forks etc. were also removed. Heavy pruning was not done as it could retard normal growth of the trees. The aim was to have a well-balanced pruning to keep one half of the stem free of branches till about 6 years, taking it upto 2/3rd of clear stem ultimately, before the final felling at the age of 10–12 years.

3.4 *Restocking*

It is ideal if at least 90% of the plants strike roots in the first year. The remaining which failed due to one reason or the other were replaced in February, 1977 with the plants of the same size and age, i.e., two year old plants. In all one thousand plants had to be replaced. Another 300 plants were restocked in February, 1978.

3.5 *Thinnings*

3.5.1 *First thinning*

According to the study plan first thinning was to be done at the age of three years in the two lowest specings viz., 6x6 and 8x8 feet with the following plan:

i. One sub plot from each replication to be thinned after 3 years
ii. Second sub plot of all the replications to be thinned after 5 years.
iii. Third sub plot not to be thinned throughout the rotation period (to be fixed later).

On 28th January, 1979 the experiment was visited for conducting first thinning. To carry out the above (i), (ii) and (iii) the sub plots in each replication were randomised as under:

Table 4. Plan of first thinning in the two closest spacings.

Spacing (feet)	Replications I	II	III	IV	V	VI	VII
6 x 6	(1)	(2)	(2)	(3)	(3)	(1)	(2)
	2*	3*	3*	2*	1*	2*	3*
	3	1	1	1	2	3	1
8 x 8	(2)	(2)	(1)	(2)	(2)	(2)	(1)
	3*	3*	3*	1*	1*	1*	3*
	1	1	2	3	3	3	2

Sub plot numbers in brackets were thinned in 1979; subplots with asterisks were to be thinned at the age of 5 years and sub plot with numbers left as such served as control. Following criteria were adopted for the thinning:

i. To take out almost equal basal area from each sub plot, marking the dead, drying, diseased, branchy and forked trees in the first instance.

ii. If enough trees are not removed under operation No. i then to take out some more trees to provide enough growing space to the remaining stock.

iii. To take care to remove only that much number of trees that the remaining number does not fall below the number in the next higher spacing.

iv. To remove enough number of trees from the first line in 8x8 feet spacing and first and second lines in 6x6 feet spacing in the surround to allow sufficient growing space for the remaining trees.

Keeping in view the above basic principles diameter of thinned trees in the sub plot as well as in the surround was taken. Missing trees were also enumerated. The number of trees and the basal area removed from the plots is given below:

Basal area removed from sub plots (28-1-1979)

Spacing 6 x 6 feet

Replications	I	II	III	IV	V	VI	VII
No. of trees	17	20	15	17	14	7	19
Basal area (sq. ft.)	0.92	0.91	0.98	1.15	0.54	0.54	0.98

Spacing 8 x 8 feet

No. of trees	8	8	8	11	5	8	4
Basal area (sq. ft.)	0.54	0.75	0.59	0.93	0.58	0.61	0.33

A severe wind storm on May 25, 1979 caused considerable damage to the experimental area. Out of 7 replications, 7th was completely destroyed except 6 x 6, 16 x 16 and 18 x 18 ft. spacing. In replication No. 4 all the trees in 6 x 6 ft. spacing were uprooted. This plot was substituted by 6 x 6 ft. spacing in replication No. 7. The data for rest of the years was collected only from 6 replications.

3.5.2 *Second thinning*

The procedure adopted is described below: Randomisation of sub plots.

Plots under treatments of 6′ x 6′ and 8′ x 8′ spacing had already been divided into 3 sub plots and those under 10′ x 10′, 12′ x 12′ and 14′ x 14′ spacings into 2 sub plots each leaving adequate no. of tree rows in between to serve as surround. One sub plot each from the farmer two treatments was chosen at random and thinned in January, 1979. Another sub plot was earmarked through randomisation to be thinned two years later i.e. in December, 1980 or January, 1981. Similarly one sub plot of the next three spacings was chosen for thinning in 1980-81 through randomisation. These have been shown in sketch 'A'. The sub plots marked with oblique lines were thinned in January, 1979; those marked with reverse oblique lines, thinned in December, 1980 and those left blank are not to be thinned to serve as control. No thinnings were carried out in plots under treatments 16′ x 16′ and 18′ x 18′ spacing. Table 'B' shows the sub plot numbers thinned in 1980.

Basically the criteria adopted for the first thinning were followed while marking the trees for thinnings. The criterion No. (i) was changed so as to retain almost equal basal area in all the sub plots under the same treatment instead of taking out equal basal areas from them.

In some of the cases, sub plots chosen for thinning could not be thinned due to large gaps created by wind falls or otherwise missing trees. Such sub plots were readjusted either completely in the surround or by joing a portion of the surround with the plot excluding the gaps. Sizes of sub plots thus made were kept equal to original ones. The positions of such sub plots were marked with dotted lines in sketches numbered C/1 to C/7. Their description is given below:

Sketch No.	Rep. No.	Treatment spacing	Sub plot No.
C/1	I	6 x 6	2
C/2	I	10 x 10	2
C/3	III	14 x 14	1
C/4	IV	6 x 6	2
C/5	V	10 x 10	1
C/6	VI	6 x 6	2
C/7	VI	14 x 14	1

Their boundary trees were marked with red rings at breast height.

In addition to that the following treatment plots were badly damaged due to a wind storm and had such a large number of missing trees what thinnings could not be carried out in them. The sketches numbered D/1 to D/3 show their present position. They are:

Sketch No.	Replication	Treatment
D/1	I	12′ x 12′
D/2	II	14′ x 14′
D/3	VI	12′ x 12′

3.5.3 *Thinning marking procedure*

Diameter of all the sub plot trees was measured as the first step. In case of readjusted sub plots DBH measurements of the included trees were carried out. The basal areas for all the diameters were recorded which when summed up gave the total basal area of the sub plot. Trees in sub plots chosen for thinning through randomisation in each treatment were then marked to allow sufficient growing space for the trees to be retained. Number and basal area of the marked trees were worked out and their percentage as well as that of retained trees with respect to total trees calculated. Care was taken to remove only that much number of trees in each spacing so that the remaining number did not fall below the number in the next higher spacing. Since the total basal area of trees before thinning in all the plots under the same treatment was unequal due to difference in health and vigour of the crop, the basal areas of the retained trees could not be expected to be equal. Efforts were therefore, made to keep the percentage of retained number or basal area as close to each other as possible in the sub plots under the same treatment. Variations still present are due to the fact that in certain cases number of already missing trees was so large that more trees could not be removed in thinnings. In such cases the percentage of basal area removed was comparatively low and therefore the percentage of retained trees was comparatively high. In other cases the number of trees removed was more due to inclusion of some leaning trees and consequently the percentage of retained basal area was comparatively low.

3.6 *Selection of sample trees for volume estimation*

Straight defect free trees from the thinned ones were selected as samples and their full measurements recorded for volume calculations.

Similarly sample trees were selected in plots under 16′ x 16′ and 18′ x 18′ spacings covering all the available dia classes and full measurements carried out. The data for these two treatments have been pooled up for development of regression equations for estimation of volume.

4. Collection of data

Data on height and diameter growth were recorded for 1976, 1977, 1978 and 1979 growth seasons.

Data for 1980 growing season were collected in December 1980 and analysed as follows:

4.1 *Height*

Table 5. Height growth (feet) in December, 1980 under various spacing treatments

Treatment	6 x 6	8 x 8	10 x 10	12 x 12	14 x 14	16 x 16	18 x 18	Rep. Total
Replication								
I	51	50	55	48	51	45	26	326
II	49	55	48	53	48	35	46	334
III	54	57	49	50	56	49	47	362
IV	52	54	55	56	52	47	46	362
V	49	53	47	47	50	49	48	343
VI	49	54	53	43	51	50	47	347

The results of 't' test to separate the means of different spacing treatments are reproduced in Fig. 2. below:

Fig. 2: Results of 't' test on height growth under various spacings

18 x 18′, 16 x 16′, 12 x 12′, 6 x 6′, 10 x 10′, 14 x 14′, and 8 x 8′

8 x 8′ spacing produced highest height growth followed closely by 14 x 14′ and 10 x 10′ spacings. 18 x 18′ spacing produced lowest height growth. The height growth in 18 x 18′ and 16 x 16′ spacings was significantly lower than all other spacings but there was no appreciable difference between height growth of these two spacings. 16 x 16′, 12 x 12′ and 6 x 6′ gave similar height growth but were lower than 10 x 10′, 14 x 14′ and 8 x 8′ spacing treatments.

4.2 *Diameter growth*

The diameter growth under various spacing treatments are given in table below:

Table 6. Diameter growth in December, 1980 under various spacing treatments (ft.).

Treatment	6x6	8x8	10x10	12x12	14x14	16x16	18x18	Rep. Total	Means
Replications									
I	4.2	4.5	6.0	6.1	5.5	5.8	4.6	36.7	5.24
II	3.9	5.3	4.9	6.4	4.1	4.5	5.5	34.6	4.94
III	4.6	5.1	5.7	5.6	6.6	6.6	6.1	40.3	5.76
IV	4.5	5.3	6.4	7.2	7.2	6.7	5.1	42.4	6.06
V	4.5	5.6	5.9	6.1	5.8	6.4	6.8	41.1	5.87
VI	4.8	5.8	6.5	6.6	7.6	8.1	6.5	45.9	6.56
	26.5	31.6	35.4	38.0	36.8	38.1	34.6	241.0	
Means	4.42	5.26	5.90	6.33	6.13	6.35	5.76		

The 't' test was applied to test the significance of mean diameter differences under different spacing treatments. The results of 't' test are given in Fig. 1.

Fig. 1 : Results of 't' test on diameter growth under various spacings

Spacing	6x6	8x8	18x18	10x10	14x14	12x12	16x16

Treatment underlined with the same line are not significantly different from each at .05 level.

Thus 16x16′ spacing gave highest diameter growth followed by 12x12′ and then 14x14′ spacing. 6x6′ spacing gave significantly lower diameter growth than all other spacings. 8x8′, 18x18′ and 10x10′ spacings did not differ in diameter than 14x14′, 12x12′ and 16x16′ spacings.

4.3 *Volume measurement*

Diameter at breast height of all the trees under study was recorded during December, 1980. Using the hybrid poplar volume tables for Changa Manga, volume of the growing stock in each plot was worked out. It was projected to unit area (acre). The data are tabulated below:

Table 7. Yield per acre (cft) of hybrid poplar under different spacing treatments

Treatments	6x6	8x8	10x10	12x12	14x14	16x16	18x18	Rep. Totals
Replications								
I	1382	1211	1570	695	810	579	255	6502
II	979	1633	847	1369	332	275	571	6006
III	1798	1393	1259	886	1205	784	795	8120
IV	1519	1208	1694	1692	1517	917	470	9017
V	1660	1880	1345	1029	819	832	644	8209
VI	2061	2156	1797	1414	1515	1377	622	10942
Treatment Total	9399	9481	8512	7085	6198	4764	3357	48796

The figures of volume/acre under various spacings were analysed using 'F' test. The test revealed that the treatments effect on volume was highly significant. To know the performance of the treatments separately, 't' test was applied from which it was concluded that:

Highest volume production was obtained from 8x8′ spacing, being highly significantly better as compared to others. It was followed by 6x6′ spacing not significantly different from 8x8′ spacing. The least volume production was obtained in 18x18′ spacing. The treatments can be listed in descending order of merit as 8x8, 6x6, 10x10, 12x12, 14x14, 16x16 and 18x18 ft.

5. Conclusions

Height

6x6 ft. spacing was the best in the first two years but 8x8 ft. showed better growth in the last three years.

Diameter

12x12 ft. spacing was the best in diameter from 1976 through 1979. Only in the last year of the report 16x16 ft. had a slight edge.

Volume

If poplar plantations are to be worked on 5-year rotation, 8x8 ft. spacing would give the highest yield per acre and can be prescribed to the field foresters and the farmers for raising compact plantations.

To find out the effect of the spacings after 1980, it is imperative to maintain the study for another 5 years. At the end of 10 years we would be able to know the best spacing for veneer and other end uses.