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## NURSERY TECHNIQUES AND AFFORESTATION OF *POPULUS EUPHRATICA* IN CHINA

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### ABSTRACT

*Populus euphratica* is one of the important tree species in arid and semi-arid areas of the world. During the last forty years about 2000 ha euphrate poplar plantations have been established in Xinjiang and Gansu provinces of China. This paper describes the nursery and afforestation techniques for *P. euphratica*.

Key words: *Populus euphratica*, afforestation, nursery techniques.

### INTRODUCTION

The distribution range of *P. euphratica* stretches across the three continents of Europe, Asia and Africa and the species is present in twenty countries around the Mediterranean Sea. It is also found in the arid and semi-arid desert area in northwestern China and the People's Republic of Mongolia. Significant characteristics of its distribution are the discontinuance of distribution areas and the corridor-shaped natural forest belt along river banks.

There are many methods for propagation of *P. euphratica*. Under natural conditions, main methods are natural seeding and root-sucker regeneration adopted by most of the countries. Stands established this way are mostly uneven.

To protect and expand the *P. euphratica* resources, it is necessary to master the nursery and field planting techniques for afforestation programmes.

### Seed collection and storage

Seed maturity of *P. euphratica* varies with climate and locations. The appropriate time to collect seed is when the capsule's colour turns from green to yellowish green, and a few capsules split and the seeds become red. To collect seed, use scissors to cut the fruit spikes from the tree, spread them on a mat and turn them frequently to prevent mildew. When the seeds begin to grow villi, beat the seeds lightly and use a sheller or screen to separate seeds from shells. Thereafter, they need to be exposed to sun to reduce the moisture content to around 10%. The seed is now ready for allocation and transportation. During transportation, great attention should be paid to ventilation and shading from the sun to prevent the seeds from losing vitality. According to the experience in Ningxia Province, seeds collected in the current year and sown in July-August, were easily damaged by summer storms. Also, their growing season was too short and the seedling's wintering survival was low. The seedlings need to grow in the nursery for three years before planting. If the problem of seed-storage can be solved, summer sowing in the current year can be changed to spring sowing in the following year. This way the seedlings need only two years to grow in the nursery. Therefore, seed storage is a key technical problem for *P. euphratica* (Wang, X, 1986 and Wang, J. 1987).

### Technology for sowing and seedling culture

#### Seeding

For viable seed of 90% germination, seed should be sown at the rate of 4.5 kg/ha. Before sowing the seeds are soaked in cold water for 2

hours then soaked in a solution of 0.1-0.5% potassium permanganate for 10-20 minutes. Thereafter, rinse them in water, and soak in water again for 8 hours. Since the seeds are small, it's not easy to sow the right amount with precision. Therefore, fine sand of 20 times the volume of the seed is mixed thoroughly with the seeds. Sowing is done on raised beds with irrigation water in the channels 2/3rd upto of the bed height. Sow the seeds in the sowing belt, which is 3-13 cm above the water line. Most of the successful departments advocate that it's not necessary to cover the seed with soil; the key point is to irrigate the ditches frequently so as to keep the sowing belt moist all the time.

### **Irrigation and sun shading**

The seed of *P.euphratica* germinates quickly; the cotyledon appears in 1-2 days after sowing. During this period, irrigation is the key point for success. The irrigation water must not be higher than the place of seeding belt, if the wind blows hard, the water level should be a little bit lower, so that the seeds or tender seedlings should not be washed away by water waves. When the seedling begins to grow the first true leaf 10-15 days after sowing, irrigation may be applied once every 2-3 days. Later on, with the development of the young seedlings is necessary to control the water content of the soil to enhance rooting. Though high temperature is favourable for seed germination, it may be desirable to have suitable shading after germination. It is recommended to have complete shade for the first 7 days, 50% shade for the next 7 days, and then remove the shade. On the other side, some people think it unnecessary to have shading to obtain fine seedlings (He, 1987, Liu *et al.* 1987 and Wang, X. 1985).

### **Fertilization**

Fertilizer should be applied one month after sowing. For this purpose, irrigate to submerge the

sowing bed, spread urea uniformly at the rate of 4.5 kg/ha once a week, the amount of fertilization increases with the growth of the seedlings. Sometimes combine fertilization with weeding and soil-loosening. Stop fertilization in mid-September and control irrigation to enhance the lignification of the seedlings to overwinter safely (He, 1987, Liu *et al.*, 1987 and Wang, X. 1985).

### **Weeding and soil-loosening**

During the first year, hand weeding is the main method for the small seedlings. Weeding and soil-loosening should be conducted in time lest the growth of the seedling is suppressed. During the second year, weeding by herbicide may be done. Nitrophen should be applied at a rate of 15 kg/ha before the leaves flush, and again in the middle of the season. This will control almost all the weeds in the nursery.

### **Insect and disease control**

Incidence rate of rust disease, the main disease of *P.euphratica* seedlings, is rather high and contagious. It is important not to have too high a seedling density because that will result in poor aeration. When the young seedlings are 50 cm high, at the time of weeding and soil-loosening, remove the leaves on the stem below 20 cm to prevent the disease. Once the disease occurs, it is necessary to spray a 1:50 dilution of sodium p-amino benzene sulphonate or a 1:2000 dilution of 0.5% carboxin (Wang, S. 1989 and Wang, Y. 1982).

Psyllid is the main insect pest of *P.euphratica*. It attacks both the seedlings and new shoots of big trees. The overwintering eggs are deposited on the branches and induce swellings on them. Omethoate and 1:2000 fluoroacetamide can be used for control (Wang, X. 1984 and Wen, S. 1987).

## Culture of transplanting seedlings

If seed germination is high, the seedling density will be very high, which will depress growth in the second year. In that case, the seedlings will need thinning in the spring of the second year. The thinned out seedlings can be transplanted in the nursery or transported to other places for field planting.

Table 1. Comparison on the growth of two types of seedlings (introduced from Gyo Quizhi *et al.*)

Type of seedling	Seedling height (cm)	Ground diameter (cm)	Root system			Incidence rate (%)		Survival rate (%)
			Main root length (cm)	Fibrous root length (cm)	Weight of fresh root (g)	June 18	July 16	
Transplanted	109.1	0.66	76.5	594.5	484.0	1.2	55.2	88.1
Control (seedling left in bed)	108.0	0.61	158.6	103.4	26.3	31.5	89.4	79.2

The method for transplanting young seedlings is to lift the seedlings and cut the main roots to a length of 18-20 cm. Use a "setting rod" to insert the seedlings into the soil vertically, and set the seedlings' whole root neck into the soil. Another method of transplanting is to plant the seedlings in ditches with a row spacing of 50 cm. After transplanting, press the soil lightly and then irrigate thoroughly. Suitable transplanting time is shortly after the soil thaws. It is better to transplant earlier than later, otherwise the survival rate will be reduced significantly (Table 1).

## Seedling culture by cuttings

Seedling propagation by cuttings is the main method for most tree species of Salicaceae. The main advantage is that it retains all the genetic features of the mother plant. The procedure is simple, and the propagation success is high. Even single-bud cutting can be used. However, its unfortunate that Section Turanga is an exception. Rooting is very difficult for its cuttings. In recent

years, small-scale studies were conducted by many countries of which some were partially successful. But the problem hasn't been solved yet.

## Seedling culture by grafting

It is an effective method to solve the difficulty of asexual propagation of *P. euphratica*. In northwest Chin, *P. bolleana* grows fast with a straight stem. Its ecological features are similar to *P. euphratica*. But it is not so saline-resistant as *P. euphratica*. So, grafting, using *P. euphratica* as the stock and *P. bolleana* as scion achieved good success. In Xinjiang, there are teen-age plantations that originated with this kind of grafted stock or were re-established by grafting, that have good growth. It demonstrates that this is an effective way to enhance the stand's productivity.

Grafting methods are the same as for other tree species; such as bud-grafting, split-grafting, casing-grafting, etc. Usually the survival rate of grafting done in April-September is very high. There are obvious differences in survival and especially in growth, when grafting is done in other periods. In Xinjiang, the suitable time for grafting is late March and early April. In Inner Mongolia, late April-early May. According to Lu Wen, the wound of bud-grafting heals the quickest and the survival rate is high. However its increment is less than that of casing-grafting or split-grafting. Survival rate is highly dependent upon Scion diameter. From Table 2, it can be seen that if the scion diameter is 0.8-1.4 cm, its survival rate can reach 100% after 45 days with an average seedling height of 44 cm. After 120 days, the height may reach 130-220 cm. If the bud scales are soaked in 3-5% sucrose solution, survival rate may be 3-4 times higher than that of the control (Lu, W. 1991).

The management techniques required after grafting are: (1) remove the binding to guarantee full supply of water and nutrition for the scion, (2) prevent falling by wind; before grafting it is

necessary to select suitable plots that are protected from wind; after the graft is established it is necessary to prune the branches in time to reduce the crown area, and (3) prevent hare and other animals from eating the plants.

Table 2. Relationship between thickness of scion and survival rate of grafting\*

Grade	Thickness of scion (cm)	Casing-grafting	
		Survival rate (%)	Increment (cm)
I	> 1.2	100	77.0
II	1.2 - 1.1	100	51.7
III	1.2 - 1.0	100	44.8
IV	1.0 - 0.9	100	38.8
V	0.9 - 0.8	100	33.0
VI	0.8 - 0.7	83.8	29.6
VII	0.7 - 0.6	59.1	19.8
VIII	< 0.6	15.8	5.8

\* Investigation was conducted 45 days later and the number of plants investigated is 210.

## Afforestation

Over most of the world *P.euphratica* forests are being destroyed by people. There are just a few *P.euphratica* plantations; only a small number in Morocco, Iran, Turkey, Pakistan, Spain, etc. Small numbers of individual trees or plantations have been cultivated for gene conservation or other purposes. China is an exception. Since the 1950's *P.euphratica* has been used for afforestation experiments on saline lands. During the large-scale forest conversion for farming in the northwestern area during the founding of PRC, a large area of natural *P.euphratica* forest was destroyed while a few farmland protective forest belts were re-established from the natural *P.euphratica* forest. During that period, experiment-demonstration-extension work

for planting *P.euphratica* was carried out. According to report in the 29th Fair of Agriculture, 2nd Infantry Division of the Bureau of Agricultural Reclamation, Xinjiang-1500 ha of *P.euphratica* plantation had been established for farmland protection. In Gansu Province, there are 133 ha of *P.euphratica* plantation, accounting for 8.9% of the total (1500 ha) in the Province. There were similar successful afforestation activities in other areas of Xinjiang and Inner Mongolia (Sun *et al.* 1992, Que *et al.* 1984 and Wu *et al.* 1990).

## Afforestation method

*Euphratica* plantations are established by two methods: planting seedlings and direct sowing.

### Planting seedlings for afforestation

Except for areas where the underground water level is too high, no matter if it is arid or saline land, the best method for planting *P.euphratica* is digging ditches and deep planting. Its advantages are: saving water, preserving soil moisture and preventing soil from accumulating salt. Generally, the distance between ditches is 2.5-3 m, depth of ditches 0.5-1 m, and width of ditch base 0.4-0.6 m. The *P.euphratica* seedlings are planted in the ditch base. The salts move along the ditch slope and accumulate on two lateral sides of the ditch, which is favourable for tree survival. According to the investigation No.123 of Farm of Dongpaizhi Reclamation Area, Northern Xinjiang, the amount of salt accumulation on ditch slope was 7 times that on ditch base. The survival rate reached 97% with a current year's height growth of 1.2-1.5 m (Wei, 1988).

### Direct sowing for afforestation

Direct sowing for afforestation can be used in locations where the soil salinity is light and the water regime is adequate. Spring is the best season for sowing seed. Sowing method is the same as for seedling culture. Thinning to a 1×1 m spacing is

done in late autumn or the following spring. According to Wei Qingju (1988) some farms in Tarim Basin, Xinjiang adopted the direct seeding method in 1967 to establish farmland protective forests. At 20 years, the protective forest has a height of about 15 m and a dbh over 20 cm with a strong and healthy growth.

### Planting density

*P.euphratica* is among the species that demand maximum light. If the planting density is too high, natural thinning occurs early which is not favourable for forming a uniform stand. If the planting density is too low, its lateral branches grow vigorously which is unfavourable for height growth and stem straightness. In China's northwestern area, the primary management objective should be the ecological benefit and the secondary objective the economic benefits. A higher initial density promotes rapid stand closure which helps achieve a variety of ecological benefits more quickly (Wei, 1988). Based on the predecessors' experiences, Wei Qingju (1988) developed a table for reference on the planting density for *P.euphratica* afforestation for three kinds of site conditions (Table 3).

For site condition group I: soil fertile, humid with light salinity, a sparse planting density should be adopted; for site condition group II: appropriate density be adopted; for site condition group III: heavy salinity, soil unfertile and arid, soil improvement should be done in advance, the initial planting density should be greater, tree spacing 1 m, row spacing 1.5-2 m.

### Planting mixed forest

If *P.euphratica* is mixed with other tree species, there are a lot of advantages:

- space is more fully used
- soil fertility is improved

- there is an opportunity to form a double-layer crown to increase the ecological protective effect;
- it can reduce or prevent insect and disease pests.

The method of establishing mixed plantations is mainly adopted for the planting of protective plantations. The tree species adopted are: *E.angustifolia*, *P.bolleana*, *P.nigra* var. *thevestina*, *Ulmus* spp., *Salix* spp. and *Tamarix chinensis* etc. Mostly *P.euphratica* is mixed with *E.angustifolia*, *P.bolleana*, *P.nigra* var. *thevestina* or *Tamarix chinensis*.

*P.euphratica* mixed with *E.angustifolia*: This type of mixed stands are often planted in the reclamation area of the upper reaches of Tarim River, Xinjiang.

Table 3. Planting density for *P.euphratica* afforestation on different sites

Area	Site condition	Planting density		No. of trees for felling (trees/ha)	Felling age (year)
		No thinning	With thinning		
Southern Xinjiang desert area	Group I	2050-3300	3300-4950	165-2700	30-40
	Group II	3300-4950	4950-6600	2700-3300	
	Group III	4950-6600	6600-10005	3300-4950	
Northern Xinjiang, Gansu, Inner Mongolia	Better soil	3300-4950	4950-6600	2700-3300	30
Semi-desert and desert area	Common soil	4950-6600	6600-10005	3300-4950	

Site condition group II: lightly salinized desert soil with intermediate fertility. Site

condition group III: salinized desert soil, heavy salinity, unfertile soil, needs improvement.

These are row-mixed or individual tree mixed plantations with double crown canopies. *P.euphratica* crown is on the upper layer and the *E.angustifolia* crown in the middle and lower layers, which increase the ground coverage and is favourable to prevent wind and salt accumulation of soil. The root-system of *P.euphratica* is deep and that of *E.angustifolia* shallow, so they can absorb soil nutrients and water from different soil layers respectively. Besides, there is a large amount of nodule bacteria growing on the root-system of *E.angustifolia*, which can fix nitrogen to promote *P.euphratica* growth.

*P.euphratica* mixed with *P.nigra* var. *thevestina* or *P.bolleana*: This type of mixed stand often established on lightly saline soils. The initial growth of *P.bolleana* or *P.nigra* var. *thevestina* is faster than that of *P.euphratica*, which makes *P.euphratica* an understorey. Later, after 7-8 years, the root-system of *P.euphratica* is fully developed and its height growth accelerates and grows quicker than its competitors and forms a straight stem. In the Tiganlike Reclamation Area, of southern Xinjiang, there was a 20-year-old mixed plantation with a mean tree height of 13.2 m, dbh 20 cm, and volume of 0.1939 m<sup>3</sup> for *P.euphratica* and 13.4 m, 12.6 cm and 0.0751 m<sup>3</sup> respectively for *P.nigra* var. *thevestina*.

*P.euphratica* mixed with *Tamarix chinensis*: Mixed natural forest of *P.euphratica* and *T.chinensis* is a good natural mixed-model. There is little doubt that a satisfactory result can be achieved when this kind of mixed type is adopted for plantations, especially when a wind-break or sand-fixation shelterbelt is established. This is because it will increase the ground coverage and canopy roughness, which is favourable for wind protection and sand stabilization.

## Tending management

The method of tending *P.euphratica* is the same as that for other poplars. However, the method for pruning is different. The branching ability of juvenile *P.euphratica* is strong, and its sprouting ability high. Therefore timely pruning is necessary to produce a uniform crown. Pruning principles are:

1. Prune only competing branches in 1-3 year-old juvenile stands. Don't prune other branches lest it decreases growth, or the trees are damaged by livestock.
2. It is better to prune lightly rather than heavily. The best pruning height is no more than 1/3 of the tree height.
3. For juvenile stands on better sites, the intensity of pruning can be greater. In contrast, the intensity of pruning should be less on poor sites. As for juvenile stands on heavy saline land, pruning may not be warranted.
4. When big branches of 3 cm diameter or larger are pruned, apply a coat of surphuric compound to prevent infection.
5. It is better to prune in spring or early summer, so that the wound heals quickly.

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