V. Plantation and Management Techniques: Chinese Experience

Seabuckthorn, as discussed earlier, has vast potential to support high value commercial activities, meet the biomass needs of the people, and perform resource-conservation upgrading functions. However, the level and quality of the above gains can be substantially raised by the scientific propagation and management of seabuckthorn plantations.

This section discusses these issues by drawing on Chinese experiences. This may involve some unavoidable repetition of issues raised in the preceding section.

Although seabuckthorn has been used for centuries, no plantations existed for industrial purposes in China until the 1980s. From the end of the 19th century until the beginning of the 20th, seabuckthorn was introduced into most of the botanical gardens of Europe (e.g., Finland, Sweden, Norway, England, Germany, and Russia). Since that time, many horticulturists have introduced seabuckthorn into their gardens as an ornamental plant or as a fruit tree. Until the end of the Second World War, there was almost no modern plantation in any country. In the 1950s, Soviet scientists, led by M.A. Lisavenko, collected more than 20 varieties from natural forests. After analysing the chemical compositions of the fruit, five of the best were identified from this collection and were given a variety of names: Altai News, Katuni Gift, Golden Spike, Vitamin Seabuckthorn, and Oil Seabuckthorn. In the 1960s, these five varieties were cultivated in Altai, Menovo, and the Novosiberian States; perhaps they were the first batch of plantations in the world.

In the 1940s, seabuckthorn was planted for soil and water conservation and for firewood in some places in northern and northwestern China. In China, currently, most seabuckthorn products are made from wild fruit collected from natural forests that extend over more than 670 thousand hectares. However, the existing, natural seabuckthorn forests cannot satisfy the needs of the processing industries because of lack of management and low yield per unit area. Apparently, on one hand, artificial plantations with high yield and of good quality need to be established in order to provide stable raw materials for processing industries and, on the other hand, the existing natural seabuckthorn forests should be transformed into higher yielding forests so as to tap the production potential.

Transformation of Natural Seabuckthorn Forest

Natural seabuckthorn forests exist not only in China and the former USSR but also in many of the countries of Eurasia, especially in the Hindu Kush-Himalayan Region in the countries such as Afghanistan, Pakistan, India, Nepal, Bhutan, and Burma. Ecologically, these natural seabuckthorn forests are generally distributed along river banks. In some places they are concentrated on the wider river beaches and form mass forests. Therefore the use and transformation of these mass seabuckthorn forests into semi-cultivated forests is of universal significance. A series of experiments on the transformation of natural seabuckthorn forests have been conducted by the Beijing University of Forestry, Yuyu County, Shanxi Province, and the results have been successful and inspiring. The major points relating to their achievements are discussed below.

Measures for Transforming Natural Seabuckthorn Forest

Intermediate Strip Cutting. This is suitable for seabuckthorn forests that are neat and have plants from young to middle age. According to design, the reserve strip should be 2m wide and the intermediate space should have a width of 2 to 2.2m. In the reserve strip, other trees that are not required, male seabuckthorn trees, and the dead and diseased plants should be dug out completely. By strip cutting and pruning the trees should be spaced about 1m apart. In addition, each strip should contain a male-female mix in which there should be a male plant as a polliniser every 4 to 5m, so as to make up a male-female ratio of 8:1. In the reserve strip, if seedlings are missing, large seedlings should be planted in these empty spots. In order to avoid growing coppice shoots, the roots of the felled trees should be dug out and then the hollows should be levelled.

Intermediate Strip Cutting and After-Planting. This is suitable for agglomerate seabuckthorn forests since there are

areas of seabuckthorn growth within agglomerate forests. Intermediate strip cutting and chopping can be carried out on lands with seabuckthorn forests. To carry out operations after planting in these areas, the large seedlings should be planted out following the model of intermediate strip cutting as described above. The distance between the trees and the rows should still be 1m and the ratio of male-female 8:1. Usually, the size of the planting pit is about 40x40x40cm, the height of the big seedling 2m, with a root system of 30x30x30cm. After seedlings are planted, 25-50 per cent of the crown of the tree should be pruned.

Wide Intermediate Strip Cutting. This is suitable for tall and old seabuckthorn forests. Cutting above the root collar and improvement cutting are the two measures adopted. The reserve strip has a width of 4 to 8 m. In the reserve strip, most female plants are kept with a distance between the trees of 1m. Where there are no female plants some male plants should be reserved. In intermediate places, the seabuckthorn trees are cut above the root collar without digging out the stumps. After turions grow out of the collar, they should be cut, maintaining a distance of 1m.

Cutting Above the Root Collar. This is suitable for seabuckthorn forests that are accompanied by other trees and have a neat form. All the trees should be cut above the root collar. The stumps of non-seabuckthorn trees are dug out. Once the seabuckthorn stump shoots sprout out, and the shoots grow up to be trees that can be identified as male or female, in order to maintain the proper ratio of male and female plants, some of the plants should be weeded out and a number of male plants reserved as pollinisers. Generally, the sprouted seabuckthorn trees bear fruit during the fourth year. This measure is especially suitable for the regeneration of old seabuckthorn forests.

Improvement Cutting. This is suitable for seabuckthorn forests with neat form, of middle age, and accompanied by other trees. First, the other trees and the male seabuckthorn trees have to be cut down and the females spaced out 1-2m apart (depending on the size of canopy and density of seabuckthorn). Second, care should be taken that the female plants are well distributed, i.e., without missing any plants after intermediate cutting. Because the original seabuckthorn forests are not altered very much and there already exist trees of fruit-bearing age, these forests can produce high yields the year following their transformation. The disadvantages of this measure are that these forests are difficult to establish and to manage on a large scale because there are no roads going through the seabuckthorn forests and it is difficult to carry the felled branches out of the forest.

Effects of Transforming Seabuckthorn Forests

Over a period of four years, 13.3 ha of transformed forests have been established; among these most have been established by adopting intermediate strip cutting. Remarkable economic benefits have been obtained through these experimental plots. In 1987, investigations on 3.3 ha of transformed seabuckthorn forest, set up in 1986, were carried out and it was discovered that compared to the yield of 402 kg/ha of non-transformed similar forests, the yield of the transformed forest, at 3,375 kg/ha, was 8.4 times higher. In August 1989, investigations were carried out on all the experimental plots and the results are shown in Table 19. From Table 19 it can be seen that the yield of the transformed seabuckthorn forest reached 4,761.6 kg/ha four years after adopting intermediate strip cutting. The yield from non-transformed forest was 765.0 kg/ha. The former was 6.66 times that of the latter. Adoption of different measures brought forth different results in the yields of the transformed forests. This can perhaps be explained by the fact that the reserved number of seabuckthorn trees per unit area and the age of trees were different in each forest. It seems that the yield from the forest, transformed by adopting wide intermediate strip cutting, was the highest; it reached 14,808.8 kg/ha.

Analysis of the Economic Benefits

The following are some of the reasons that explain why the yields of transformed forests increased: the ecological conditions were improved, the canopy of seabuckthorn trees was widened, and the ratio of female and male was regulated to 8:1.

Transforming natural seabuckthorn forests into seabuckthorn orchards is the fundamental method for obtaining fruit for commercial purposes. Experiments have proved that it does not require much investment, and the returns can be obtained rather quickly. According to calculations, the total investment for 3.3 hectares of transformed seabuckthorn forest was 2,528 *yuan* (535.6 US$) or 766 *yuan* (160.2 US$) per hectare.

In the first year, intercropping can be carried out on the space of land in between the strips. Because the soil of the

land where seabuckthorn was grown before is fertile, and there is enough sunshine, the intercrops grow well and give a good harvest. For example, if potatoes are planted on those pieces of land, the output value of the potatoes will compensate for the cost involved in transforming the seabuckthorn forest.

The intercrops can still be grown in the second and third years, however the yields would decrease gradually. From the fourth year onwards the yield of seabuckthorn fruit would increase substantially. Concrete examples of increase in yields by 3.32 times, and in output value by 735.55 to 7177.90 *yuan*/ha (155.8-1520.7 US$/ha), make it apparent that transforming the natural seabuckthorn forests is profitable for the farmers who live in the mountain areas where massive natural seabuckthorn forests exist.

The intercropping not only increases economic benefits but also prevents the growth of weeds and sprouting of root turion seedlings which normally occur in seabuckthorn forests.

Table 19: Comparison of Fruit Yields of Transformed Seabuckthorn Forests by Different Measures (August 1989)

Measures of Transformation	Age of Tree (year)	Area of Exper. (m^2)	Yield of Fruit (g/tree)	Yield of Fruit (kg/ha)	Increase (times)
Intermediate strip cutting	8-10	396.0	396.0	4761.6	6.66
Intermediate strip cutting and after planting	8-10	312.8	546.8	2186.1	3.06
Wide intermediate strip cutting and cutting above root collar	10-13	122.0	1050.6	14808.8	32.09
Improvement cutting	10-13	264.0	998.4	4538.3	10.02
Cutting above root collar	10-13	147.8	422.8	2285.1	5.04
Intermediate strip cutting (1988)	10-13	284.0	651.6	2019.0	4.46
Contrast	8-10	112.0	114.9	715.0	-

Source: Kou Jilie et al. 1990

Artificial Plantation

Demand for seabuckthorn fruit, and especially for seabuckthorn oil, is increasing year by year. Establishing new seabuckthorn plantations to meet the demand of industries is an urgent task. From the 1960s, the former USSR began to set up artificial plantations, and, by now, more than 6,000 ha of artificial seabuckthorn orchards have been established; among these 3,000 ha are distributed in the Altai Border Region. Some European countries, as well as China, are only just beginning to set up artificial plantations. Therefore, experiences gathered from the former USSR are very valuable for these other countries. Discussed below are some points in reference to establishment of new artificial plantations.

Plantation Establishment

Plantation Site Selection. Based on the distribution of natural seabuckthorn forests, it can be stated that river banks are most suitable for setting up plantations on a large scale. If plantations are to be established in arid areas a good water supply has to be assured. On river banks, seabuckthorn can

tolerate inundation because flood water contains oxygen, however shallow kettle holes, where rain and snow are easily gathered, are not suitable for establishing seabuckthorn plantations. In addition, places where the groundwater level is less than 0.5m are also not suitable for seabuckthorn. Sand soil and loamy, rather than clayey, soil are preferable for seabuckthorn plantation because, in these soils, the plants survive longer but in the latter they do not. In the former USSR, black earth and sod-podzol soil were found to be the best for growing seabuckthorn.

Land Preparation. Before planting seabuckthorn, some necessary measures have to be adopted in order to increase the organic matter content. Generally, sowing perennial herbs and green manure crops and applying large amounts of organic fertiliser are common measures that ought to be taken.

The land should be kept in dead fallow for 1 to 2 years before planting. During this period, the land should be ploughed deeply and harrowed. Perennial weeds with deep root systems should be destroyed by using herbicides such as sodium trichloroacetate, dalapon, and ammonium 2,4-D.

It is recommended that in order to ensure the fertility of the ploughed land, 100 to 150 tons per hectare of compost or barnyard manure should be spread on the land. If the content of humus in the soil is more than 4 per cent, the amount of organic fertiliser spread on it can be reduced by 50 per cent. In the absence of organic fertiliser, green manure can be used instead. Sowing green manure crops continuously for two years can provide 400 to 500 tons of green organic matter to the soil and this is equivalent to 800-1,000 tons of semi-decomposed dung.

If the soil is acidic, lime should be added into the soil in order to raise the efficiency of mineral fertiliser. The seabuckthorn plant is very sensitive to the increase of phosphorus in the soil, and, further, it does not activate the plant in anyway. Therefore, it is better to apply 600 to 800 kg per hectare of calcium superphosphate to the soil before ploughing it deeply.

Planting Time. Seabuckthorn is one of those plants for which autumn is not a suitable planting period because of the constraining feature of the roots. It has been proven that the survival rate of seedlings planted in autumn is much lower than of those planted in spring. Most seedlings planted in autumn die over the following winter. Even if seedlings are dug out in autumn, temporarily planted over winter, and dug out again for planting in the field next spring, the survival rate is still low. A high survival rate is ensured only when the seedlings are dug out and immediately planted in the field during early spring before the seedlings start sprouting. If the time taken for temporary planting in spring or the time for transporting seedlings from the nursery to the field is too long, the survival rate decreases. The roots of seabuckthorn are sensitive to wind and sunshine and drying should be avoided. It is good to place the roots in muddy water before planting.

Disposition of Pollinisers. Seabuckthorn is a typical dioecious plant. The number and disposition of pollinisers directly influence the yield of the plantation. The Siberian Institute of Horticulture, of the former USSR, established 311.5 ha of experimental plantation between 1962 to 1963 in order to assess the relationship between polliniser and yield. The disposition of pollinisers is shown in Figure 1 below.

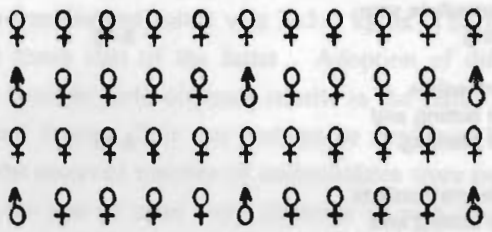

Figure 1: Disposition of Pollinisers

According to this disposition, between every two lines of female plants there is a mixed line . In this mixed line, after every four female plants there is a male plant. This means the pollinisers account for 6-7 per cent of the total plants. Generally, the distance within which the female plant can be pollinated is about 100m. Investigations have shown that as the distance from the female plant to the male plant (polliniser) increases (64m or so), the yield of the female plant decreases. Therefore, for balanced pollinisation, the disposition of pollinisers illustrated above is suitable.

For more effective pollinisation, male seedlings that have different blooming periods, a higher pollen preservation rate, and tolerance of bad weather should be selected as pollinisers. If both the male and female plants are vegetative seedlings, the male plants will blossom at the same time. If the weather is not suitable, concomitantly ripe pollen cannot be spread by the wind, and hence the process of pollinisation cannot be carried out.

Management of Plantations

Irrigation. Seabuckthorn is sensitive to the moisture in the soil. For satisfactory growth and production, supplementary irrigation is needed to ensure profitable production. Experiments on irrigation, conducted by Berry Station in New Siberia, the former USSR, showed that in meadows of chernozem soil and middle clay loam, in conditions where the moisture content in the irrigated plot was more than 71 per cent compared to the moisture content in the non-irrigated plot of 51-65 per cent, irrigation enabled an increase in the crown diameter of seabuckthorn by 56 per cent and an increase in fruit yield by 47 per cent.

The minimum moisture contents permissible for specific soils are as follows: middle clay loam - 70 per cent; heavy clay - 80 per cent; slightly sandy soil - 60 per cent; and sand loam - 65-70 per cent. When the moisture content is lower than the levels mentioned above, especially during the blossoming and fruit- growing periods, irrigation is required. For example, the area of non-chernozem soil needs to be irrigated three times during the growing period (each time 400-500m^3/ha). In areas of East Siberia and Lake Baykal in the former USSR, where rain and snowfall are insignificant, irrigation is very important before the seabuckthorn faces winter, because sufficient water not only increases the temperature of the layer where the roots are distributed but also provides the moisture that the plant requires in the following spring. The average amount of irrigation required in these areas before winter is 500-600m^3/ha and it should be soaked to a depth of about 70-80 cm.

Fertilisation. Like all crops, seabuckthorn needs proper nutrition, but its optimum requirement is unknown at present. During spring, the seabuckthorn which has borne fruit begins to grow quickly by drawing upon the supply from store nutrients accumulated the year before. During the first phase of the growing period, because seabuckthorn needs a good supply of nitrogen, the nutrients are consumed to form roots and branches and to blossom. During the latter phase of the growing period, the branches stop growing and the nutrients are consumed by the formation of the fruit and flower buds. The nutrients then flow gradually from the leaves to the trunk, branches, and roots. During this period, the seabuckthorn plants need phosphate and potash fertilisers (Bukshtenov et al. 1985).

It is recommended that 45-50 tons of organic manure per hectare be applied to the seabuckthorn plantations every 3-4 years. The practice of fertilisation has proved that, under guaranteed water supply conditions, the effect of fertilisation increases substantially.

Form Pruning. By the end of the first four years, seabuckthorn grows up to 2-2.5m and forms its crown based on the growth of its central branch. The aim of form pruning is to make the scaffold branches take proper positions and to keep the crown compact and low in order to make it convenient for harvesting. For this purpose, the crown should be pruned regularly. Usually, the branches that overlap and those that are not in correct positions should be pruned off, and the slim and long branches should be cut short. From the fifth year, the central leading branch stops growing, and the plant no longer increases in height. The branches then grow out from the lateral buds and the pseudo-verticillate body. Meanwhile, the seabuckthorn enters into the stage of mass bearing. If the crown is dense, some branches should be pruned off so as to let sunshine penetrate the crown. During the following spring, all diseased, withered, and very low branches must be pruned. Generally, seabuckthorn begins to bear fruit in large quantities in the fourth or the fifth year. The peripheral branches of the crown grow or bear alternately. In order to prevent seabuckthorn from premature senescence, pruning for rejuvenation should be carried out on three-year old branches.

Propagation

Artificial plantations are established with cultivated seedlings, cuttings, grafted seedlings, and other propagated materials such as the seedlings from root turion or the plantlets produced through tissue culture. But the most important propagation methods are to cultivate seedlings from seeds and to use cuttings from hardwood or softwood trees.

Cultivating Seedlings from Seeds

Cultivating seedlings from seeds is a simple technology and has some definite advantages; it produces a greater number of seedlings, involves lower costs than other propagation methods, and seedlings thus produced survive better and grow faster compared to cuttings. This technology involves the following procedures.

Pre-treatment of the Seeds. Chinese seabuckthorn (*H. rhamnoides L.*, subsp. *sinensis*) seed is medium in size and

one kilo of air-dried seeds contains 130-140 thousand seeds. If the germination rate reaches 80-95 per cent, one kilo of seeds can produce 104-133 thousand seedlings. Before sowing, the seeds should be put into water at a temperature of from 60°C-70°C and stirred constantly until the temperature drops to from 10°C-20°C. Then the seeds should be soaked for two days. When the seeds have expanded sufficiently they are taken out and dried for sowing.

Seedbed Preparation. Seedbeds should be established in a place close to the expected plantation plot. This place should have convenient transportation and irrigation facilities. Before the seedbed is prepared, sufficient barnyard manure should be applied to the land, then the land should be ploughed under to great depth (about 20-25 cm) and meticulously broken up. Generally, the seedbed is 10 metres long and 1 metre wide. This size is convenient for operation and irrigation.

Sowing. As the temperature of the soil (5-10 cm depth) rises to 15°-20°C in spring, it is suitable for sowing. Ditch and drill seeding is commonly practised in northern China. The drill furrow is 4 cm in width and 2.5 cm in depth. The drill spacing is 20-25 cm across the seedbed. The seeds are sown in the drills evenly and covered with 1-2 cm of soil.

According to experience, seabuckthorn seedlings are weak in springing up from the soil, so seeds should not be sown deeply. After 12-18 days, most seedlings sprout. Then the key period follows, if the ground surface becomes dry and hard, the seedlings cannot sprout properly and will curl and suffocate under the surface of the ground. After the seedlings sprout, strong sunshine will hurt the young tender seedlings and sometimes they can die from branding. At this time, timely cultivation of the soil and breaking up the hard ground surface to avoid the temperature of the soil rising is necessary to decrease the likelihood of dead seedlings. In addition, seedlings should be covered with a mulch of straw to conserve moisture, or covered with a shade to protect the young seedlings.

After Care. When a seedling sprouts 3-5 pieces of microphylla, the seedling is not likely to die. From this period, weeding should be carried out frequently, otherwise the weeds will inhibit the growth of the seedlings. Insects living underground can also damage the young seedlings. Insecticides such as gammexame and dylox can be used to control these pests. When the growth is at 3-4 cm, excessively dense seedlings should be thinned down and weeds pulled out. During the rainy season (July and August), the seedlings should be 5-7 cm in height and more attention should be paid to draining the seedbed. If the accumulated water floods over the top of the seedlings, they will die when the water recedes and the sunshine comes out again. In order to promote speedy growth, supplementary chemical fertiliser is applied to the seedbed before or after rain. This measure may be carried out in combination with cultivating and weeding. To produce a seedling which is suitable for transplanting will take 6-18 months in a nursery (Li Ruzhi 1990).

Hardwood Cutting

Seabuckthorn is a dioecious, wind-pollinated plant. The seedlings propagated by seeds cannot maintain the fine biological characteristics and economic properties that are genetically identical to the selected mother plants. Among the seedlings there are usually more males than females, and it is difficult to distinguish males from females before flowering and fruiting. Cutting propagation can produce scion- rooted seedlings with the same genetic properties as those of their mother plants in a short time, and these can bear fruit 1-2 years earlier than the seedlings. This is an important technology for propagating improved varieties, for introducing and acclimatising new species of seabuckthorn, and for building artificial plantations.

Although hardwood cutting propagation technology has been widely used by agriculturists and horticulturists as well as by foresters, for example, in poplar cultivation, a large amount of research on seabuckthorn has shown that this plant easily takes root through cuttings, but the rate of rooting is very uncertain, so hardwood cuttings have not been widely used in nurseries. Because of the susceptibility of rooting to the environmental conditions in different regions, with different facilities, and different management levels, detailed study is necessary in order to increase the reliability of cuttings. From 1986 to 1988, a systematic and thorough research on the technique for using hardwood cuttings of seabuckthorn was conducted by Beijing Forestry University at Dabaoxiang Nursery, in Zhuolu County of Hebei Province. A series of techniques is summed up below.

1. The adventitious roots of hardwood cuttings of seabuckthorn usually strike above the leaf scars in a scattered manner. Each cutting has 3-5 roots which grow from the epidermis of the stem. Microscopic observation shows that the root initials originate from vascular rays and cambium. Although the cuttings take

root easily, the rooting is unstable and sensitive to changes in environmental conditions.

2. Dabaoxiang Nursery is located in a cold region (the annual average temperature is 4.6°C) at an altitude of 1,300 masl. By adapting large, plastic film canopies and small, plastic film canopies, the hardwood cuttings can be planted earlier, 30-40 days before plantation in the open field. Covering with straw screens at night can increase temperature, retain moisture, and protect the cuttings from frost. The cuttings begin to sprout roots eight days after being planted, when the accumulated temperature (equal to or above 10°C in 5cm depth of land) reaches 121.6°C. The cuttings take root in large numbers by the fifteenth till the twentieth day when the accumulated temperature reaches 315-317°C. After 30 days, a complete, semi-woody root system with lateral roots and nodules is formed. At this time, seedlings of the hardwood cuttings can be transported to nurseries for further cultivation.

The second batch of cuttings can then be raised (these cuttings are selected and stored in wet sand at a low temperature). Both the first and the second batches of the seedlings of hardwood cuttings reach the required standard during late fall.

3. Adequate aeration and water permeability in the soil are required when hardwood cuttings form adventitious roots. A man-made medium can ensure the needed temperature, moisture, and adequate aeration for rooting. Comprehensively, considering the rooting rate and survival rate, the better ratio for the medium should be - sand: humic soil: the soil under seabuckthorn vegetation - 5:3:1. In addition, all the cuttings of different ages have the capacity to form adventitious roots. Among them, the three year old cuttings have the highest percentage of root formation (see Table 20). Full use should be made of these characteristics in asexual propagation of seabuckthorn.

Table 20: Investigation of Rooting Rate 30 Days after Planting

Replication	1				2				3				4			
Media / Rooting rates (%) / Shoots' ages	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
A	33.3	44.4	88.9	77.8	33.3	55.6	44.4	33.3	55.6	33.3	66.7	66.7	22.2	44.4	44.4	33.3
B	88.9	55.6	77.8	33.3	66.7	55.6	88.9	44.4	66.7	88.9	66.7	44.4	77.8	55.6	88.9	44.4
C	100	22.2	77.8	88.9	100	44.4	55.6	77.8	88.9	33.3	88.9	88.9	100	11.1	77.8	77.8
D	77.8	22.2	33.3	60.0	88.9	77.8	55.6	100	77.8	33.3	77.8	75.0	55.6	66.7	66.7	88.9

Source: Huo Shuhua et al. 1989

Notes: ratios of media are: I. pure sand; II. sand: humic soil = 1:1; III. sand: humic soil: under seabuckthorn vegetation = 5:3:1; IV. sand: soil under seabuckthorn vegetation = 1:1, ages of shoot are: A. one-year-old; B. two-year-old C. three-year-old; D. four-year-old.

4. Three years of experiments have shown that the best time to take cuttings from mother trees is from October to January. The cuttings should be stored in wet sand at low temperature in a moist dark environment. Another good time to take cuttings from mother trees is middle or late March, and these cuttings should be immediately planted under a canopy. Standard cuttings should be taken from the base of a 2-3 year old shoot, 10-25 cm in length, and 0.8-1.5 cm in diameter.

5. Before planting, the bases of the cuttings are soaked in running water for a day and a night, or immersed into a container filled with water for one or two days (the water should be changed once or twice every day). When the bases of the cuttings are given a quick dip in 300-500 ppm NAA (naphthylacetic acid), the rooting rate is raised. If the cuttings are immersed in 50 ppm NAA solution for 24 hours, the same effects can also be achieved (Huo Shuhua et al. 1989).

Softwood Cutting

Usually, softwood cutting is an effective propagation method needing artificial mist sprays and a plastic film house with other equipment. The basic technique is summarised below.

Selection and Collection of Cuttings. The cuttings from small young shoots have no capacity to form roots, and the cuttings from highly lignified branches have a poor capacity to form roots. Seedlings from such cuttings have difficulties in winter. Both these cuttings are unsuitable for softwood cutting. Experiments have shown that shoots with medium growing power, in the same layer of the crown, of the same age, and exposed to sunshine, are most suitable for cutting. It is better to collect cuttings in the early morning when the leaves are covered with dew.

When the cuttings (15-20cm length) are cut off from the mother trees, they should be immediately put into plastic film bags to prevent them from wind-drying and withering. These cuttings will remain fresh for three days in this condition. The cuttings can also be maintained in water for one week without losing their rooting capacity.

Treatment of Cuttings. Each cutting must be cut into two sections of 7-10 cm lengths. One- third of the leaves on the cuttings should be eliminated from the base of these cuttings. Then the cuttings should be placed in water to stay fresh. Before auximone treatment these cuttings are taken out of the water and bundles of 50 cuttings, bound together with a rubber band, are put into a box filled with solution of IBA (indolebutyric acid) at a depth of 3-4 mm. The concentration of IBA solution is 50 ppm in the box. All cuttings soaked in the IBA solution should be covered with a plastic film to keep the moisture in and the solution in the box should be maintained at a temperature of 20-25°C for 16 hours. The cuttings treated with an auximone like IBA can strike massive adventitious roots. Before planting, these cuttings should to be taken out from the IBA solution and washed in order to remove the auximone.

Cultivating Softwood Cuttings. This needs to be carried out in the plastic film house equipped with an artificial mist sprayer and drainage facilities. The seedbed needs to be made flat and the medium of the seedbed should be of sand and humic soil mixed in a ratio of 3:1. Before cultivation, the seedbed needs to be watered to keep the medium wet enough. Before inserting the cuttings, use a marker to rule small shallow furrows in the seedbed (distance between the furrows should be 7 cm and the distance between the cuttings should be 3 cm). In this way, the cuttings are inserted into the medium at depths of 1.5-2.0 cm. If the placing of the cuttings is too close, they will be damaged by mould. After the cuttings are inserted into the medium, water the seedbed again to make the medium around the cuttings settle down.

Aftercare of Cuttings. The aim of aftercare is to raise the rate of rooting. The rooting of cuttings depends upon the temperature and moisture in the soil and air. When planting begins, the temperature of the soil should be higher than that of the air by 1-3°C. Generally, when the daily average temperature of open land is up to 18.5°C, the average temperature of the soil is up to 19.0°C, and the relative humidity of the air is 40-50 per cent. In the plastic film house the average temperature of day and night should be 19°C, the average temperature of the soil should be 24°C, and the relative humidity of the air should be 88-100 per cent. In order to maintain the humidity mentioned above, it is necessary to spray-mist in time. When the humidity of the polythene film house is sufficient, there is an apparent indicator - water membranes on the leaf surface of the cuttings. If the water membranes disappear, it shows that it is necessary to spray mist until the leaf surface retains water membranes again. When the cuttings have already taken root, the humidity should be gradually decreased and the area should be well ventilated. When autumn is coming, the rooted cuttings need to be gradually tempered. In the beginning, the plastic film is taken off for a short time every day, and this is increased day by day. After 2-3 weeks, the plastic film can be taken off completely. When winter comes, it is necessary to cover the place where the roots have taken with a layer (5-6 mm) of fallen leaves in order to prevent them from cold damage (Elmakov 1985).

Softwood cutting has also been studied by the Beijing Forestry University. There are two types of seedling cultivation equipment adopted by this university. One is a greenhouse which is equipped with an automatic intermittent mist sprayer controlled by an electronic leaf. Another is a small plastic film canopy equipped with an artificial mist sprayer and shaded by foliage. The favourite cutting time is from the middle of June to the beginning of August (in Hebei Province, China). When semi-lignified cuttings are used for softwood cutting, the rate of rooting can be 98 per cent . Both in the greenhouse and under the small canopy, the cuttings will put out massive adventitious roots and grow up to heights of 37-51 cm with average diameters of 0.67-0.92 cm above ground after two years of cultivation (Zhang Zhixiang et al. 1989).