TUNG OIL*

[The information contained in the article appearing below has been extracted from a paper by Dr. L. A. Jordan, of the Research Association of British Paint, Colour and Varnish Manufacturers, which was published in Vol. XII, No. 107 of the Journal of the Oil and Colour Chemists' Association.—Ed., *T. A.*]

INTRODUCTORY

Tung oil is an essential raw material of present-day varnish manufacture, and in fact its unique properties render it indispensable for certain types of varnish. Until comparatively recently, China has satisfied the world's demand for tung oil, and will, it is considered, continue to remain the chief source for some years to come. The oil is derived from two species of *Aleurites, Fordii* and *montana,* of which the former is the chief source. It was Wilson, a naturalist in Western China, who in 1915, after a study of the species of *Aleurites*, solved the question as to the true origin of tung oil. *A. Fordii* has its habitat chiefly in western and central China whilst *A. montana* is found more to the south. Tung oil, also termed China wood oil, was known outside China about 1760. It was first introduced into the United States in 1896, into Germany in 1897, and soon afterwards into England. Little notice of it was taken commercially in England until after the outbreak of War, when special water-resisting varnishes were required for aeroplane work. Thereafter, on the recommendation of the Raw Material Committee of the Imperial Institute, growing experiments (Wilson having stated that he considered the trees could be grown in South Africa, East Africa, Australia, Algeria, and Morocco) were started in India, Ceylon, Malaya, Burma, Kenya, Tanganyika, Hongkong, and South Africa.

NATURAL HABITAT AND GROWTH OF TREE

In China the tung oil trees, with reference principally to *A. Fordii,* occur abundantly and grow luxuriantly mostly in a region between latitude 26° and 34°N., and in hilly country up to 2,500 feet in altitude, especially in the upper reaches of the Yangtze valley. *A. Fordii* favours the northern and *A. montana* the southern parts of the area, but there is no strongly marked division in the distribution of the species. They are ornamental trees and rapid growers producing fruit, from which the oil is extracted, in and after the third year—though it is safest to calculate on a first crop as from the fifth year. In China the trees generally grow 20 feet to 25 feet in height, with a trunk of about 10 inches in diameter. But individuals are said to attain 50 feet to 60 feet with a canopy 60 feet in diameter. The trees have a low branching habit and pruning is necessary to prevent a low straggling cover. The fruit is about the size and appearance of a russet apple and ripens in October. The blossoms are very sensitive to early spring frosts, and young trees, until established, are subject to frost.

Rainfall and Temperature.—A main consideration in the culture appears to be the absence of frost and a sufficient rainfall, which should not be less than 30 inches but preferably 50 or even 70 inches. The *A. montana* species require rather more rainfall than *A. Fordii.* According to Wilson, in China the tree requires a minimum rainfall of 70 cm. and he states that the tree luxuriates at Ichang where the rainfall averages 75 cm. most of which falls in April, July and August.

* From *Tropical Agriculture,* Vol. VII, No. 3, March 1930.

Also at Ichang the climate is rather one of extremes. The summer is tropical, the shade temperature ranging from 90° to 110°F. The winter generally cold with much snow though the temperature seldom falls as low as 28°F.

Soil.—Tung oil has been tried on almost every type of soil and has been found to grow on practically any soil which is slightly acid with plenty of moisture but still well drained. Apparently the ideal soil is a sandy soil or sandy loam which is underlaid with clay three to eight feet down. This type of soil can be usually drained easily but remains fairly moist. This does not mean, however, that the tung oil tree cannot and is not being grown successfully on other types of soil. Tung oil trees in Florida have grown on land that ranges from almost pure white sand to heavy clay loam, with excellent growth and yields on all. The observations show that slightly acid soil, well drained but with plenty of moisture, is safe to use for tung oil. Alkaline earth is fatal to the growth of the tree.

METHODS OF CULTIVATION

Propagation.—So far as is known, the principal methods of reproducing the tung oil tree is by seed propagation, although it has been determined that the trees can be readily budded and grafted with tung oil seedlings as stock.

Planting.—In Florida the best time to plant is in middle February when the soil is warm and maximum growth can be expected. Great variation is found in germinating power, particularly if the seed is old, and the plants tend to come up irregularly. Some 60 days are usually required for germination, but seed has been known to lie in the ground three months before sprouting.

Single seeds (not the whole fruit) should be planted three or four inches deep and from eight to twelve inches apart in the nursery row. In heavy soils the seed should not be planted at a greater depth than two inches. Nursery rows should not be less than three feet apart to permit of ample cultivation between them.

In China, two seeds are planted in a dug over spot three to five feet in diameter, and the soil kept in loose condition. If both seeds germinate one is removed. Transplanting is generally not very successful. Under favourable conditions in China plants will make three feet growth in the first season.

Site of Nursery.—A well-drained but fairly moist location should be chosen. The moisture content of the soil, particularly during the spring dry season, is of prime importance, as, if the seedlings are supplied with adequate moisture during this time they will not suffer from a set-back in growth which would be caused by droughty conditions. At the same time, the soil should be well enough drained that no water will stand between the rows for any length of time during the summer rainy season, which has a scalding effect on the young seedlings.

Nursery Cultivation.—Regular shallow cultivation should be given throughout the growing season so that a good dust mulch is always present and the nursery free from weeds or grass at all times. Because of the shallow rooting habits of the plant, deep cultivation should be strictly avoided after the first few weeks.

Transplanting.—When the time comes to transplant trees from the nursery to the grove, the methods commonly used in transplanting fruit trees are employed. The work should be done whilst the trees are dormant, and care should be taken to prevent injury to the root system.

As with all plants, exposure to sun or wind should be avoided, and at no time should they be allowed to become dry. Trees should be planted at the same depth as they stood in the nursery row. Deep planting is highly injurious. When seedlings are transplanted they should be cut down to a stub 12 or 14 inches above the ground. When established, no further pruning of young trees seems to be needed other than cutting off the tip of the plants; this may be done to cause more lateral branching close to the ground. In this connection the question of the distance to plant out the trees presents itself.

Orchard Distances.—The best size ordinarily attained by tung oil trees in China is about 25 feet by 20 feet spread under ordinary circumstances. They are frequently found about 11 feet apart. Growing the trees under orchard conditions, it would seem that 20 feet each way would be sufficient space for the proper growth of the canopy. However, as it seems that the cultivated plantation trees in Florida bid fair to exceed in size the average Chinese tree, distances of 25 feet by 25 feet, 25 feet by 30 feet or even 30 feet by 30 feet are suggested.

It has been suggested that trees should be planted in parallel rows, 12½ feet between trees in the row, and 30 feet between the rows. After the seventh year alternate trees should be removed which will leave 25 feet between two trees in the same row and each tree will be 32½ feet diagonally removed from its nearest neighbour in adjacent rows. It is calculated that the extra yield of fruit before the alternate trees are removed is sufficient to justify this practice. This arrangement finally bears 60 trees per acre.

Fertilisers.—The fertiliser needs of the tree have not been fully determined except to prove that young trees respond quickly to light applications of nitrate of soda or of Peruvian guano up to 1 lb. per tree. Cultivation between the trees by leguminous cover crops is recommended to keep the soil rich and moist.

Harvesting.—In China it is usual to knock the fruits off the trees before they are perfectly ripe. The husks are then removed by parching the fruit in iron pans over a fire or by collecting the fruit in heaps and allowing fermentation to take place to loosen the husks. Alternatively the fruits may be harvested at leisure after having fallen to the ground as they do not deteriorate through lying on the ground for a few weeks, and they are not eaten by cattle because of the disagreeable taste. The seed proper, after being removed from the husk, can be stored in any dry place for an indefinite period. However, if the seed is to be used for planting it should only be removed from the husk immediately before planting, and should not be carried over from one season to another. Seeds should be planted during the winter following the autumn in which they drop from the trees.

YIELDS AND PLANTATION COSTS

Chinese trees yield from one to five bushels of fruit per season according to their age. The kernels form approximately half of the weight of the fruit and contain 58·3 per cent. of oil by analysis, the usual yield in practice being 40 per cent. A tree should yield its maximum crop in the ninth or tenth year and may be expected to have a useful life of about 30 years.

Little information is available on costs, but experience shows that $200 per acre is a safe figure to cover the cost of planting and carrying plantations with the necessary cultivations and fertilisation for a period of five years. Of this sum, $50 is allowed for the cost of land and cleaning. Up to the fifth year there would be no income worth speaking of but it is estimated that five-year-old trees would yield $100; rising gradually to $200 at ten years of age.

AMERICAN PRODUCTION

As has been said, the world was dependent on China for the oil. The United States, the post-War consumption of which went up by leaps and bounds, were the first to realise the position and to take steps to obviate a total reliance on one source of supply and country. In 1914 the U.S.A. imported 61 per cent. of the total Chinese exports, in 1918, 77 per cent., and in 1925, 80 per cent. The American consumption is now 40,000 tons per annum. The oil is used to a considerable extent for domestic purposes in China, and the increasing world demand will encroach more and more on the stocks required for home use, which will mean that they will only be parted with at an increased price. The methods of collection and extraction of the oil in China are crude and wasteful, yet the crop is regarded as a most profitable one by the Chinese.

It was these considerations which led the Americans, very soon after the War, to take up the question, added to the fact that they were reluctant to depend for their supplies on a foreign country. They began to study the possibilities of establishing a domestic industry and with a period of high prices in 1923 brought matters to a head, by forming the American Tung Oil Corporation. Its object was primarily to demonstrate what could be done with tung oil trees in the hope, which has been fulfilled, of encouraging farmers to cultivate the tree on a large scale upon a commercial basis.

Judged from the manner in which this work is developing over a very wide area in the Southern United States, and also in Hawaii and the American Pacific Islands, it has become evident that the farmers have responded to the efforts of the Corporation. In 1923 all the information available in America was that a few tung oil trees had been successfully grown here and there in various parts of the Southern United States, the oldest of these trees being about 14 or 15 years at that time. The Corporation acquired land adjacent to the Agricultural Experiment Station of the University of Florida, and the first seedlings were planted in 1924. By 1926, 2,500 acres had been planted up, representing about 200,000 trees. Distribution of one-year plants raised in nursery centres is made on very favourable terms to *bona fide* farmers. In the autumn of 1926 the Corporation had half a million seedlings in the nurseries available for distribution. The Corporation is assisted by the U. S. Department of Commerce, and everything is being done to stimulate the independent planting of the tung oil trees. Seed is now being sold from the nurseries to large land-holders, and several hundred pounds of seed were shipped in 1927 to New Zealand, Jamaica, the Virgin Islands, the Philippines, and to England for Colonial purposes. In the Report for 1928 the area under tung oil trees amounted to 4,000 acres, whilst another 1,000 acres was projected in Florida during 1929.

Experiments have been made as to the best machinery for crushing the seed, 30,000 lb. seed being experimented upon in 1928. In January, 1929, the first large-scale tung oil mill came into operation, capable of expressing about 50 gallons of oil per hour; thus marking the commencement of activities on a commercial scale. As yet but a small percentage of the trees grown are old enough to produce fruit; it is considered, however, that in a few years a considerable supply should become available. It is estimated that an area of 100,000 acres would be required to supply the present American demand. The quality of the American oil is said to be better than the Chinese and purer from impurities.

EMPIRE PRODUCTION

Turning now to the activities in this direction in the British Empire, it is apparent that they fall far short of the American. Prior to 1927 they were almost negligible. It has been stated that experiments were started

in various Colonies in 1917, though the amount of available seed was small. Kenya had a record planting at 5,500 feet in 1922, seed from the trees being sent to the Imperial Institute in 1927. India carried out experiments at the Forest Research Institute at Dehra Dun. In 1924 trees of *A. Fordii* were fruiting at six years old but the seed germinated badly. The work, however, was still in an experimental stage.

The last two years have witnessed a real movement. It was in 1927 that the Research Association of British Paint, Colour, and Varnish Manufacturers took the matter up when considerable interest and enthusiasm on the subject was stimulated in many parts of the Empire by Dr. Jordan's first pamphlet. The Research Association then took the step of purchasing 700 lb. of selected seed of *A. Fordii* of the 1927 American crop and distributed it to privately owned farms and estates, government agricultural stations, and forest officers over the widest possible area. The General Manager of the American Tung Oil Corporation rendered invaluable help in this matter, not only with seed but also with advice; "for the American view is that beyond a certain point they must ultimately look to British Empire production to augment their own supplies." The distribution of the seed by the Research Association was effected with the help and advice of Sir William Furse, Director of the Imperial Institute, and Dr. A. W. Hill, Director of the Royal Botanic Gardens, Kew, who heartily co-operated.

The seed was sent to Middle and East and South Africa, India, Nilgiris, Malwa Plateau, C.I., Behar and Orissa, Bengal and Assam, the latter province being regarded as the most promising), Malaya, Ceylon, and Burma, where *A. montana* is indigenous. Seven tea estates have taken up the matter in Assam. All of them report approximately 50 per cent. germination. One estate reports trees averaging four feet in four months after transplanting; three reported six feet reports as the rate of growth from seed in one season.

Cyprus is experimenting with the seed, and work is being carried out in the West Indies, Palestine, Australia and New Zealand. Reports as to progress are insisted upon from all recipients of seed; so far those received are mostly favourable. As far as Africa is concerned, tung oil plants of the 1927 seed are now being watched everywhere from Kenya to the Cape—in Nyasaland, Tanganyika, the Rhodesias, Transvaal, Natal, Cape Province, and in Nigeria.