CULTIVATION OF FAST GROWING TREE SPECIES IN ITALY

by

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Summary.

Cultivation and management techniques of poplars, conifers, eucalypts and willows as practised in Italy, have been discussed in this paper. Whereas, the multifarious research problems are being attended to by the institutes especially established for the purpose under the patronage of an autonomous body (E.N.C.C.)., the farmers are making full use of the recommendations of experts by putting large areas under fast growing tree species, employing the most modern and scientific techniques. Through consistent effort, the best mothods of growing and managing these species have been developed over a period of time,. Since enough state land is not available to practise poplar cultivation with intensive agriculture, the farming community has been encouraged and persuaded to grow this tree on their land in the form of widely spaced compact blocks or row plantations. The targets which to many looked rather ambitious in the beginning, have fully been achieved through proper planning, execution, and above all, cooperation between the growers and the consumers to the benefit of both the sides. In view of the chronic shortage of raw material to feed the pulp and paper industry in Pakistan, planting of fast growing species in irrigated forest plantations, extensive practice of agri-forestry and involvement of private enterprise in such projects of national importance has been recommended.

Introduction.

Like Pakistan, Italy was also once suffering from chronic shortage of raw material to feed its woodbased industry, especially that of pulp and paper. The indigenous forests comprising of poorly managed coppice were neither suitable nor sufficient for the purpose. The bare requirements continued to be met through imports from other countries till it was finally realised that a serious effort ought to be made to grow lightweight hardwoods within the country. The first to attract attention were the poplars due to their numerous intrinsic qualities, such as, ease of propagation, fast rate of growth and yield of multi-purpose wood over a comparatively shorter period of time. Although the tree had been grown by the farmers for quite sometime, the effort was a little haphazard, resulting in

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irregular, short supplies. The farmers were not fully conversant with the modern methods of its propagation, cultivation and management.

In order to boost up and streamline the whole programme of fast growing tree species on national level, the National Agency for Pulp and Paper (E.N.C.C.) was created with its headquarters in Rome. This autonomous body was directed to take suitable measures to improve the supply of requsite raw materials. Within a few decades of its establishement, this organization has done a great service to the cause of fast growing tree species on one hand, and has made the pulp and paper industry almost self-sufficient, on the other.A constant liaison is being kept with the farming community by establishing deomonstration plantations, providing well-grown nursery stock and requisite technical know-how together with phyto-sanitary services. These objectives are being fully achieved with the help of a set of well-knit central and peripheral services which carry out the multifarious activities all the year round.

Simultaneously, the important role which fundamental and applied research can play towards further improvement and development of fast growing tree species programme has not been lost sight of by the E.N.C.C. The research institutes, in Rome and Casale Monferrato carry an international stature. The former known as "Centro di Sperimentazion e Agricola e Forestale" was established in 1953. Here special attention is being paid to eucalypts, certain fast growing conifers and poplars. Investigations involve plant ecology, biology, microbiology, tree improvement, cultivation techniques, wood technology etc. The Casale Monferrato Institute, "Istitutto di Sperimentazione per la Pioppicoltura" is exclusively devoted to studies on poplars and intensive research is being carried out on cultivation techniques, breeding, pathology, entomology and economics etc. Recently, work has been started on willows as well.

1. POPLARS

American black poplar (*Populus deltoides*) was introduced in Italy in the 18th century as an ornamental tree. Natural hybridization between this exotic and the indigenous *Poeulus nigra* gave origin to progenies of many hybrids. Since these hybrids were showing better rate of growth and wood quality, the farmers just through intuition selected these trees themselves for planting in and around their fields so much so that by the end of the last century, they were already using what are now internationally known as "Euramericana" hybrids.

Sponsored by S. P. A., Cartier Burgo, modern phase of reserach work on poplars started in 1928. Considering that there was unlimited scope for research, but means and resources were hardly adequate to achieve the desired results, foundations of an Institute to deal with various aspects of research on poplars was laid in 1937 at Casale Monferrato. After the second world war, modern facilities were made available to expand the area of work still further.

1.1. **Cultivation Practices:—**

For the last few decades, a departure has been made from the conventional planting of poplars as a forest tree, in favour of intensive cultivation techniques. This form of poplar cultivation is carried out on fertile agricultural land. It is done with or without agricultural crops but the former system is preferred as it helps recovery of heavy initial expenditure, which is normally possible to do within a period of 3-4 years. The agricultural crops such as maize, wheat, soyabean and many vegetables are cultivated for a number of years in between the poplar rows. Their harvesting pays early dividends and the farmer has not to wait for returns upto 10-12 years, the age at which the poplars are usually felled. As is evident, such poplar cultivation has, however, lost the characteristics of forest plantations and taken its own agricultural peculiarities. These stands are established on well prepared soil which is normally ploughed upto a depth of at least 3 feet. It is later levelled and harrowed properly. One to two or even three years old second stage nursery plants are planted at various spacings involving 100 to 400 plants per acre. Planting is done in 3 feet deep pits dug out with machinery, specially designed for the purpose. Farm yard manure upto the extent of 10 tons per acre is often used to keep the soil in a high level of fertility. The soil is annually ploughed and the dose of fertilizer repeated. Where rainfall is insufficient and water available, irrigation is generally practised by flooding or by sprinklers. These plantations are worked on a rotation of 10 to 15 years and on the average 4300-5700 cft. of wood is produced from 120 to 160 trees per acre.

Row plantation of poplars is also quite common. The trees are planted along roads. fields, canals etc. which act as a wind-break and also produce timber. They are spaced 10 to 18 ft. apart and woked on a rotation, varying from 10-30 years.

Planting of poplars although as a forest tree is strongly influenced by environmental factors, the use of intensive cultural methods, which provide excellent site conditions has mitigated this influence to a great extent, thereby making poplar cultivation possible over a wide ecological range. This has inevitably led to many investigations on the techniques of planting, silvicultural requirements like soil working, pruning, spacing and rotation, and selection of vigorous and disease resistant clones etc.

1.2. **Research Studies:—**

1.2.1. *Tree Improvement.*

Breeding and improvement of poplars has remained mainly confined to "Aigeiros" (Black poplars) section which includes the deltoides, nigra and euramericana hybrids. This is due to the fact that these poplars have so far given the best results and there are sufficient prospects for their further improvement. Establishment of comparative arboreta and slection of arboreta has been one of the most important parts of poplar research.

Main objective is genetical improvement of poplars through different methods such as locating the plus trees, sowing of seed from such trees or use of seed from artificially pollinated trees produced either in the glass house or in the field and selection of suitable clones over a period of time. Testing of the clones already selected by other agencies, introduction of breeding material from abroad and making artificial mutations is complementary to that. The material thus obtained goes further intensive selection by establishment of seedling nurseries, propagation nurseries and comparative arboreta etc.

While making selections, following criteria are kept in view :—

1, *Maximum volume production.* Capacity of the tree to produce maximum height, diameter and volume growth over a short rotation under intensive cultivation is an important indication for selection on merit.

2, *Capacity of adaptation to environment.* A full measure of the different requirements of temperature, moisture, light and site has to be taken. The point at which temperature becomes a limiting factor has to be specially considered.

3, *Growth habit.* It includes shape and form of stem, branching, their number. thickness, angle, taper of the crown etc. Round cylinderical form is considered better than oval. Similarly, knots, irregular annual rings, large heartwood etc, are a disqualification in poplars.

4, *Characteristics of bark.*—Smooth and light coloured bark is preferred over dark bark with ridges. On the other hand, thick bark is more resistant to frost, hail, fire and even insects.

5, *Vegetative Propagation capacity.*—It is important not only for proper propagation of the material but also from breeding point of view. All poplars can be vegetatively propagated but there are marked differences in their ability to do so.

6, *Root system.*—Deeper root system is always considered better as compared to a superficial one. This is a strong guarantee against wind damage.

7, *Resistance to diseases and other adverse factors.* This attribute strongly influences the selection or rejection of a clone. However, selection processes are easier as compared to time consuming breeding programme and have given good results.

8, *Quality of wood.* Keeping in view the special requirements of wood-using industry, histological, physical and chemical features are taken into account. As a matter of fact specific requirements of wood-based industry are not known and whatever the present requirements are, even these are likely to change

within a short period due to methodological advancement in the use of wood. Genetic studies to improve the quality can not keep pace with the technological advances in wood utilization.

Just to have an idea of the extent of work being done in this particular direction, it may be mentioned that in the northern and cental regions alone, 115 experimental arboreta covering an area of about 450 acres and involving a total number of more than 60,000 trees are under observation. Further extension in such projects is made every year.

1.2.2. *Cultivation, rooting and grafting.*

A large number of studies are being carried out in the two institutes on cultivation and management techniques with significant results. To quote a few, it has been found that soil working for at least 4 to 5 years is highly imperative to get the best growth of poplars. Similarly, studies with planting of 2-year old plants upto the depth of 3 to 10 ft. were conducted. It was found that rooting percentage increased when planting was done at the depth of 2 feet. Special machinery has been developed for such studies.

Since quite a number of deltoides clones like '1-63/51', 'I-69/55' '1-90/60','I-45/51' etc.are giving much better performance as compared to hybrids but on the other hand show poor rootability, great emphasis is being placed on finding out the reasons for that inadequacy. Studies on this subject have mainly taken into consideration the presence or absence of inhibitors, effect of environmental conditions like soil, light, moisture and evaporation, position of cuttings on the tree and age of the plants from which cuttings are taken etc. In spite of intensive research, no clear cut indications responsible for poor rooting in certain cases have been found out. However, one thing is clear that planting should be done when the plants are dormant and very little time should elapse between uprooting of the poplars and their planting in the field. Another important factor which has to be taken note of, and which clearly indicates as to why February planting of poplars was successful in Pakistan was that root initiation should start much earlier than the sprouting of buds so that when the buds sprout, plant is already in a position to draw upon the soil and water nutrients available at its new site. This also explains for the large scale failure of poplars in this country when planting was undertaken in the end of March and early April.

Grafting of poor-rooting deltoides clones on good rooting ones such as '1-214' and *P. nigra* has been taken up with the same end in view. Comparative studies laid out from the materaial thus raised have shown the usefulness of such techniques. It is a very interesting study and the methods applied in Italy can be easily adopted in Pakistan

Growth studies of different clones in comparative arboreta is one of the most important programmes of work. These indicate the usefulness and superiority of some clones over the others, under different climatic conditions.

1.2.3. *Spacing and roating*:—

Poplars have been planted from a very close spacing of 2 x 2 ft. upto 30 x 30 ft. in different parts of the world. This has been conditioned partly by the uses to which the material is ultimately put and partly owing to lack of knowledge with regard to growth pattern of the tree. In spite of lot of controversy about spacing, the cultivators have agreed to one fundamental principle ; that the poplars do require sufficient growing space as any other fast growing species would do, because of the rapid and extensive development of the crown and root system and the exacting nature of the plant in so far as water and nutrient requirements are concerned.

Since spacing is intimately connected with rotation, a number of studies have been carried out in Casale Monferrato to correlate the two under different climatic conditions and to determine the rotation of maximum volume production and the financial rotation. It has been found that highest income under all kinds of soil and good irrigated conditions is from averagely dense (300 to 400 sq. ft. per plant) and widely spaced (400 to 500 sq. ft. per plant) stands.It has further been proved that since there are no substantial differences in technical and commercial quality of the wood thus obtained, a higher revenue is obtained from average spacing (120 to 160 trees per acre) with 10-12 years rotation as there are more number of trees per acre.It has been found that high yields are obtainable from dense plantation (100 -225 sq. ft. per plant) in early years but with the passage of time wider spacings give better results. However, in very close spacing. wood for only pulp and paper is obtainable but from wider spacing, timber for a number of uses such as veneer and peeling industry including plywood, match boxes, saw milling and board making industries, etc. becomes available.

Although it has been fully established that the highest returns are obtained when poplars are grown at a wide spacing of at least 18′ x 18′ in view of the acute shortage of raw material for pulp and paper in Pakistan, poplars may for the time being be planted at a comparatively closer spacing (12′ x 12′) and worked on a rotation of 5 to 8 years. Research carried out in foreign countries and the studies conducted by some pulp and paper mills in Pakistan, have indicated the use of even one year old material. For production of veneer logs,wider spacing (18′x 18′) and longer rotation of 11-15 years will have to be adopted anyway. In view of that, it will be quite appropriate to set aside separate areas to raise poplars for specific end-uses In the meanwhile, management studies may be continued using different clones, planting distances and cultural techniques

1 3 **Losses caused by Insects and diseases.**

In Italy, colossal damage to plantations leading to enormous reduction in wood yields is caused by both the insects and fungi. Stem borers, aphids and defoliators amongst the insects, and root/stem rot causing fungi together with those causing premature defoliation are putting the country to an annual loss of millions of rupees. This is in spite of the facilities available in direct control methods, Great emphasis is now, therefore, being placed on breeding of resistant clones. The fungus *Marssonina brunnea* is taking a heavy toll of poplar plantations by causing premature defoliation. It has been estimated that losses caused by this fungus alone, account for about 16% decrease in poplar wood production in the country, so much so that cultivation of clones like 'I-488', 'I-262, B.F., CBD etc. which previously were planted on a large scale on account of their good growth, is no longer economically possible.

So far as insects are concerned, borers are considered to be much more serious pests as compared to the defoliators because the former destroy the stem portion which fetches three times more price than what is obtained from other parts of the tree. *Saperda carcharias* is the major pest of poplar plantations in Italy. Tunnels made by larvae degrade the logs from veneer and plywood class to paper and package grade with consequent loss of value upto 60% This insect is significant also at very low population densities. The newly hatched larvae are being controlled by trunk sprays with parathion, methyl parathion, phenthoate, trichlorphone etc. containing 0.4% of the active ingredient. *Pygaera anastomosis* is the common skeletonizer and is of considerable concern because of its very high reproduction potential. Fortunately it is naturally controlled by numerous parasites like *Theridion tepidariorum* and *Allotrobium fuliginosum* which are predators of its eggs, and *Apenteles liparidis* which devours larvae. Since *Pygaera anastomosis* is also responsible for defoliation of poplar plantations in Pakistan, it will be worthwhile to start research studies on its biological control.

One virus popularly known as 'Leaf mozaic' was first observed in Italy in 1959. The usual symptoms are large and small spots, devenation etc. It is more serious on the veins and forms different patterns on the leaves of 'I-214' and deltoides clones. It is transmitted by contact and causes defoliation resulting in decrease in growth rate. No suitable control has been found as yet.

Bacterial canker has not been reported in Italy so far but a disease which is considered more physiological in nature than bacterial, exists and is related to ground water level, density of plantation and its age etc. It causes spots on branches and stem.

There is a general belief amongst the foresters in Pakistan that the fungi and insects attack the plants only when these have already been predisposed to attack due to unhygienic conditions on the ground surface, lack of soil cultivation and shortage of irregular supplies of water. This view gets further support from the fact that plantations raised on rich

alluvial soils, well supplied with canal water and properly maintained under intensive methods of agriculture have so far been comparatively safe from all such calamities. Inspite of the fact that insect pests and diseases of poplar in Pakistan have not yet reached a serious stage and have not assumed an epidemic form, there is no reason to be complacent. With the expected increase in area under poplars, there is every possibility of their appearance and multiplication. It is, therefore, highly imperative to take all the possible steps to control the insects and pests through the use of insecticides and fungicides as well as to strengthen the quarantine measures against incursion from outside.

1.4. **Clones/Species recommended for Pakistan:—**

In spite of the fact that the research workers have selected scores of new clones over a period of time, *Populus* x-*euramericana cv.* '1-214' continues to be the most widely planted clone in Italy. In fact it covers about 75% of the total area under poplars. This clone ows its popularity to higher percentage of success in the field, rapid growth rate and a high volume production on a comparatively short rotation of 11-15 years. It is also quite resistant to a number of pathogens. It may. therefore, be planted extensively in Pakistan as well. Side by side, new deltoides and hybrid clones from Italy, Turkey. Spain, France, Morroco and USA which have shown promise in Italy may be procured and tested under the climatic conditions obtaining in different parts of the country.

In pursuit of the exotics, the indigenous poplars may not necessarily be neglected. Species like *P. ciliata*, *P. alba* and *P. euphratica* need more attention. Work on their breeding, selection and cultivation techniques may be intensified. Researchers from many countries like Italy, Belgium, Canada and USA have shown their keeness to introduce *P. ciliata* to observe its growth behaviour out of the natural habitat of the species in different climatic regions. Studies can be started in collaboration with these workers.

2. CCNIEERS

Two institutes in Italy are conducting research on a number of conifers with a view to finding out some really fast growing species fit for large scale planting under different ecological conditions. Main objective is the production of good quality pulp. One of the institutes is located in Torino in northern Italy and is named "Istituto Nazionale per pianta da Legno" and the other one is the "Centro" at Rome.

2.1. **The Species:—**

The Torino Institute established in 1954 is being financed by Cartier Burgo paper company. It is conducting research in the fields of cultivation of woody species, parasites, soil biology and environment. Laboratory facilities are available. Two farms, covering an area of 625 acres are meant for studies in the field. After experimenting with so many conifers, the work is now ultimately concentrated on *Pinus strobus* and *P. wallichiana*, and their hybrids. These species have grown very well on poor degraded,

calcareous soils. Seed orchards and comparative arboreta are being established with provenances from a large number of countries. The institute also looks after a large number of experimental plantations established in northern and central Italy. Such plantations cover more than 2500 acres. Also special experimental plots have been laid out during the last 8 years to study the growth pattern of many species.

So far, hybrids of *P. strobus* *P. wallichiana* have shown better rate of growth than either of the parents. Grafting of *P. strobus* on *P. wallichiana* and vice versa is quite interesting. Stock is raised in pots. When 2 to 3-year old, 1-year old scions are grafted on it. If successful, these are planted out. There is lot of scope for similar work in Pakistan where scions of fast growing *P. wallichiana* can be grafted on the stock of more hardy *P. roxburghii.*

In the Rome, 'Centro', the main conifers being studies are *P. radiata* and *Pseudotsuga menziesii.* Other conifers under test are *P. halepensis, P. brutia, P. taeda, P. petula, P. elliotti, P. ponderosa, Cupressus macrocarpa* and *C. arizonica.*

Radiata pine is being planted under widely different ecological conditions in forty experimental plots which are distributed throughout southern and central Italy. On the basis of soil and climatic characteristics, ecological maps have been drawn up for this species to get an indication of its suitability.

2.2. **Nnrsery Methods:**—

It has been decided as a rule that all plantations will be planted with large sized well proportioned and healthy nursery stock. To achieve that objective modern scientific nurseries have been established in different parts of the country. Such nurseries are grown in two stages; the seedling nursery and the transplant nursery. In order to achieve the best results, measures like seed refrigeration and stratification, seed treatment against birds, rodents and insects, deep and thorough soil preparation, use of fertilizers, etc. have been adopted. Weeding, hoeing, irrigation and protection are a regular feature. The job has been entrusted to efficient and technically trained staff with a thorough knowledge of different steps involved in nursery raising, starting with sowing of seed on well prepared beds upto the removal of plants. It may not be out of place to mention that 200 to 300 pounds of chemical fertilizers like Ammonium sulphate are added in one acre of the nursery area to keep the soil fertile and productive.

The seedling nursery stays in the first stage for two years before it is transplanted on a wider spacing with 30 x 40 c. m. In this nursery plants are kept for another two or three years before these are ready for planting out. In the period of 4-5 years

for which the plants remain in the first and second stage nurseries, these should attain the height of at least 3 ft., the size which is considered the most appropriate for planting out. This is in very great contrast to the practices in vogue in Pakistan where the plants are hardly 6" in height when these are planted in the field and are expected to survive and grow. The result is large scale failure. However, very recently, 3-4 year old plants of *Cedrus deodara* raised in research nursery, Abbottabad have been planted in Muree Hills with reasonable success. This clearly proves the efficacy of planting well grown nursery stock in the field.

2.3 **Field Plating.**

In Italy, the stock thus grown with a balanced root-shoot ratio is planted in about 2 ft. deep pits. Care is taken that collar is in line with the soil surface or even better, if covered with loose soil . Thorough pressing all around the plant is done followed by irrigation if necessary. The usual spacing adopted is 8.5 x 11 ft. Regarding management techniques of *P. strobus*, nothing has been finalised as yet. Majority of the plantations of this species are not older than 12 years. First thinning has been done in certain cases after 9-10 years when about half the plants were removed. Final felling is proposed to be done at the age of 30 to 35 years depending on the rate growth of the tree. It is expected that one acre will give about 140 cft. of wood annually.

Growth of *P. radiata* is being studied from plots established in 1965. Mean annual increment of 180 cft. per acre has been recorded which is certainly very high for an 8-year old plantation.

In another study laid out to compare the rate of growth *P. radiata* with other conifers, young plantations of *P. radiata*, *P. pinea*, *P. halepensis* and *P. canariensis* established from 1957 to 1963 were measured. It confirmed *P. radiata's* marked higher rate of growth over the rest of the species.

2.4. **Other Scientific Studies.**

Although a large number of studies are being carried out on the different aspects, like growth pattern, and behaviour, drought resistance, soil plant relationship, nutritional requirements, microbiology and tree improvement, only some of these can be touched upon in this paper. These include the influence of physical characteristics of the soil on *P. radiata* seedlings where in it has been established that very definite correlation exists between growth and physical properties of the sub-soil; the effect of fertilizers to see the development of resistance to insects which is not very indicative yet; relationship between the roots of *P. radiate* and mycorrhiza etc. Also investigations on correct seeding time, pretreatment of seed and the optimum age of *P. radiata* seedlings for planting out are being conducted.

2.5. **Species recommended for trial in Pakistan.**

The foremost, of course, is *P. radiata*, but others like *P. pinea* and *P. pinaster* which grown very well in southern Italy and Sicily may be tried. *P. elliotti*, *P. canariensis* and *P. brutia* have already been introduced with success and need extension under different ecological conditions. *Cupressus arizonica* which too has been grown in arboreta in low rainfall zones may also be given due attention.

3. EUCALYPTS

Eucalypts were introduced in Italy at the end of 18th century. Large scale plantation of the genus has, however, been taken up only in the last 30 to 40 years, particularly in the reclamation works in Latium, Sardinia, the plain of southern Italy and Sicily.

3.1. **Nursery and planting techniques.**

These are almost the same as being practised in Pakistan except that in Italy the whole process is very smooth and streamlined. Seedlings are transplanted in perforated black plastic bags, filled with stream-sterilized soil. Transplanting in the bags is semi-automatic. controlled by electrically operated machines. Sprinkler irrigation system is quite sophisticated with permanently fixed high and low showers having controlled sprays upto very fine mist. In certain large nurseries irrigation system is even more modern. There sprays are controlled automatically according to the requirements of seedlings, fluctuating with the change in the air humidity and temperature. Field planting is done in one foot deep pits with one year old planting stock. Soil is kept well cultivated and clear of all weeds and rank growth.

3.2. **Research Studies.**

Although desired number of eucalyptus plants can be easily raised from seed, methods of promoting rooting of eucalyptus cuttings are being intensively studied This has helped multiplication of a number of promising species and provenances. Similarly, grafting of some compatible species has been successfully done with the same end in view. Other studies cover growth pattern, spacing and wood properties etc.

3.2.1. *Rooting and Grafting.*

For rooting of cuttings, one year old shoots are taken either from the coppice of an old tree or a coppiced young sapling. It is mostly done in 90% humidity and an optimum temperature of 18-20°C. Success ranges from zero to 90%. January to March is considered to be the best period, the second best being July to August. *E. camaldulensis* and *E. trabutii* which is a hybrid of *E. camaldulensis* and *E.botryoides* are being used, as test species.

Full cleft grafting method is used for grafting of *E. camaldulensis* on *E. trabutii*, the latter being an excellent stock. While the stock is normally always 2-year old, scion can be one year old depending on its size. Although grafting is possible with scions from 4-5 year old plants, rooting is successful only with, at the most one year old cuttings. A method to successfully root the cuttings from older plants is to graft 4-5 year old plant scion on the stock and then make cuttings out of the sprouts for rooting.

3.3. **Management Studies.**

3.3.1. *Growth pattern.*

Seasonal diameter growth of 9-year old *E. camaldulensis* and *E. viminalis* has been measured. It was observed that pattern of growth was the same for the two species. starting in March, going to the maximum in April and gradually decreasing in June. Second growth period occured in the beginning of July and terminated in the end of December. Individual growth patterns to be mainly related to temperature variations. The early summer interruption of cambial activity could tentatively be related to leaf development. No influence of rainfall distribution on radial growth periodicity was shown, since tree roots had reached the sub-soil water table and were drawing the required quantities from there.

3.3.2. *Spacing.*

Different planting distances have been tested including 7 x 7, 10 x 10, 12 x 12, 14 x 14 14 x 16 and 16 x 16 ft. Preliminary data indicate that the most satisfactory results could be obtained with 10 x 10 and 12 x 12 ft. spacing.

In Pakistan, a controversy regarding spacing of eucalypts has been going on for quite sometime. In a number of working plans it has been prescribed to plant at 5 x 5 ft. against the usual practice of 10 x 6 ft. In a way, smaller spacings are going to be very helpful in eliminating the weeds which are a constant source of trouble. However, the conventional system of planting on trenches which is employed to economise on irrigation water will have to be changed to plot system as digging of trenches at such a close distance does not leave enough space in between the lines to pile up the dug out earth. If the trenches are too close, this earth keeps on drifting back, thereby filling the trench, and necessitating repeated expensive reopenings.

In 1968, a spacing study on *E. camaldulensis* was laid out in Peshawar involving both the trench and flood methods of irrigation. Spacings of 3 x 6 ft., 6 x 6 ft., 6 x 10 ft., and 10 x 10 ft. and 3 x 3 ft., 4 x 4 ft., and 6 x 6 ft. were adopted for the two methods respectively. Interim results indicated no significant differences in height and diameter but basal area differed significantly at 1.0% level in flood irrigation plots with

the lowest spacings. For the time being it is obviously due to comparatively larger number of plants per acre. Different results should be expected when severe competition for growing space nutrients, light etc. sets in at a later stage.

3.3.3. *Pruning.*

Prunning test on different eucalypts are under way in Italy. Pruning after 2-3 years of planting has shown excellent results in that country. In Pakistan, although repeated warnings against heavy pruning have been given, there is a tendency to prune the plants even in the first year, which not only affects the rate of growth to a very great extent due to loss of leaves so essential for photo-synthetic activity but also makes the plant whippy and prone to wind damage. Pruning at this early stage also encourages weed growth. This practice, therefore, has to stop forthwith. Removal of forks if any, can be undertaken leaving only one growing shoot. Also cutting of the lower most straggling branches can be done judiciously.

3.4. **Wood Quality and Technology.**

From the pulping point of view, the proportion of fibrous tissue is of great importance because of its relationship to pulp yield. For an economic return, a fibre volume of at least 50 to 60% is required. In a study with species like *E. botryoides, E. camaldulensis, E. globulus, E. gomphocephala, E. maidenii, E. resinifera. E. trabutii, and E. viminalis,* it was found that all the species investigated gave more than 50% fibre volume. *E. maidenii* and *E. botryoides* exceeded even 60%, with 61.5% and 64.2 % respectively.

Examination of different materials in eucalypts is showing a remarkable varibility of wood structure within the species. As there is every reason to believe that wood structure characters are genetic in nature, selection work for the required properties should be useful in improving them.

It would be of interest to mention that the whole cellulose technology had developed only around softwoods. The same technology, therefore, can not be applied to hardwoods, especially eucalypts. Also the Australians who reported unsatisfactory results used old eucalypts for pulping. On the other hand, it has been proved now that the output of pulp both in quality and quantity is entirely different, if young trees of 10-14 years age are used. Although the fibre length is short in young trees but wall thickness is definitely lower due to larger diameter of lumen, resulting in strong bonded pulp sheets.

It is believed that deformation in eucalypt wood is caused by internal stresses. Investigations have been carried out to find the possibilities of reducing it by girdling. *E. camaldulensis* at the base, six months prior to felling the tree. 50% reduction in deformation has been indicated by removing the whole sapwood with girdling.

3.5. **Recommended Species.**

E. viminalis and *E. bicostata* which can grow over a wide climatic range and can stand cold temperatures may be given more attention in the foothills of Pakistan, Besides that *E. trabutii* and *E. dalrympleana* and *E. rubida* may be introduced. *E. camaldulensis* and *E. globulus* have been considered the best performers in Italy. These too may be planted extensively.

4. WILLOWS

4.1. Casale Institute is engaged for the last 15-20 years in research on willows with particular emphasis on selection, nursery practices and cultivation methods. About 200 clones have been selected so far. Quite a few of these were considered suitable for different purposes e. *g*.. SI-2-61, SI-8-62, SI-9-62, SI-14-62, SI-48-62 are good for veneer and are grown on wider spacing. Some others grow well whe planted at close distances and are good for pulp. Similarly, a few with regular bends and crooks are only of ornamental value.

In the case of willows too, first and second stage nurseries are planted on the same lines as poplars. In the field planting a comparatively closer spacing of 12 x 12 ft. has been recommeded for willows as their crowns are not large and also there is natural pruning which is further helped by close spacing obviating the necessity of repeated prunings as required in the case of poplars. Also planting of stem cuttings in the nursery gives better results than planting rooted cuttings which is more expensive and time consuming.

4.2. It will be of interest to mention here nursery and plantation methods employed in England.

4.2.1. *Nursery Stock.*

The age old-method of planting well-grown sets is still being practised with considerable success. The plants from which sets are to be obtained are planted at 4 x 4 ft. in the nursery. These are cut one foot above ground level every year till these are strong enough to produce the sets. When the sets are 2 to 3 years old and 12 ft. in length, these are cut from the stool for planting in the field. After proper grading, only well grown and straight ones are used; the rest are rejected and destroyed.

4.2.2. *Planting.*

The area where willows are proposed to be planted is thoroughly ploughed. After that 2.5 ft. deep pits are dug. Since it is difficult and expensive to dig such a deep pit by hand, a hole about 15 inches square and 15 inches deep is dug in the first instance. It is then further deepened with a crow bar to the required depth of 2.5 ft., diameter

of the lower portion of the pit being 6 inches. The base of the set is firmly pushed down the hole and the bottom tightly rammed to make it secure against wind-blows. The top 15 inches of the soil is then replaced and trodden down firmly but not rammed too solidly. After a few weeks, another round of the plantation is made to make sure that the sets are still firm and if found necessary in some cases, more soil is put around the base of the pits. Generally, such plantations are raised at a spacing of 36 x 36 ft. When planted in rows, plant to plant distance is 25 x 27 ft.

4.2.3. *Maintenance.*

The sets are kept clean of side shoots, The buds are rubbed off at least twice a year to discourage unwanted branches. As a matter of fact, the side shoots are not allowed to develop upto the stage when it would become necessary to cut them off with a knife. The bole after planting is kept clean upto a height of at least 9 ft. 4 inches that is four bat lengths, of 2 ft. 4 inches each. However, no pruning is done above 7 ft. of stem until the third growing season. This is to provide a good top to the tree for normal growth. On a reasonably good site the willows thus planted reach maturity in 10 to 12 years.

In Pakistan Forest Research Institute, a start has been made for collection of good willows stock from different sources. The first and second stage nurseries have been raised from cuttings. In addition to that a small plantation with 11 different willow sources has also been started. Stools of these plants will be used for producing sets of desired size in the years to come.

5. CONCLUSION

Chronic shortage of light-weight hardwoods has been met in Italy through a sustained effort over a period of time. The country which once was dependent entirely on import of woody raw materials, has now become not only almost self-sufficient in pulp and paper but is also in a position to export huge quantities. Pakistan is facing the same difficulties which the Italian industry had to overcome about 4 or 5 decades back. In this country the annual yield of 10 million cft. of timber from the government forests is totally inadequate to meet even the existing requirements. The inevitable result is that the wood-based industry has become despondent and disillusioned as sustained supply of raw material is not in sight. On the other hand, the country continues to be deficient in food grains. Agriculture has, therefore, to be given precedence over forestry ruling out the possibility of setting aside more areas for afforestation in the foreseeable future. One way to get out of this predicament is to convert some of the low yielding irrigated forest plantation into intensively managed and highly productive estates by planting fast growing trees. This measure will handsomely contribute towards increasing the yield per unit area. Side by side, the farmers should be provided suitable incentives to encourage the practice of agri-forestry in order to subsidise the government effort with supplies of wood from farmlands. It is also necessary to make the private enterprenaur interested in fast growing tree species projects in view of the huge present and future

requirements of raw material as it would never be possible to meet the entire demand from government forest land. Learning a lesson from the Italian strategy, the industrialists should endeavour hard to get good agricultural land on hire/purchase basis and start plantations of fast growing tree species so that they are not totally dependent on the meagre supplies from the state forests.

Acknowledgements

Dr. Silvio May, and a large number of other technicians in Casale Monferrato and Rome institutes extended full cooperation and support by arranging field trips, prompting on the spot discussions and by providing requisite reference material. Without their help, it would not have been possible to acquaint the Pakistani foresters with the magnificient job the Italian researchers and farmers are doing to keep their country well supplied with the woody raw materials.