A Tree Improvement Programme for Pinus contorta

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WITH the necessity for increased production to supply the demands of an ever expanding market all aspects of forest management are being improved. Foremost in this improvement field is the campaign for better seed. The world forestry authorities are conscious of the importance of good seed for it is known that "good seed does not cost, it pays". Conferences have been held, draft schemes and recommendations have been drawn up with the aim of achieving a world wide conception of what is good seed. Having once decided to follow such a scheme it will be possible to guarantee to users that production from better seed will be increased. Good quality seed is, however, of no great value unless the added consideration of correct provenance is also taken into account, this being particularly so for *Pinus contorta.*

In the importation of *Pinus contorta* seed to Ireland over the years many different provenances were bought. They ranged from Bella Coola in British Columbia, a point opposite the lower tip of Queen Charlotte Islands to the Olney region on the north Oregon coast, a range covering 10 degrees of latitude. Inland the range was from Kamloops in B.C. through the states of Montana, Nevada and Utah. This resulted in very variable growth. Those from the interior were not vigorous enough to overcome completely the native vegetation and in addition they retained their natural habit of thin stems and light crowns. Those from the coastal regions, particularly from Washington, proved more suitable to conditions in Ireland; their heavy crown characteristic enabling them to overcome the competing vegetation. In addition they gave a much better volume production per acre.

From these earlier plantings it became apparent that the coastal form was the more suitable for Irish conditions and having this evidence the obvious step was to perpetuate and improve this strain for the production of better seed to cover future growing programmes. This reduced to some extent the necessity for importing further lots of seed from North America. The question could be asked why not return to the parent stand of this good provenance and collect further lots of seed. This can be easily answered: (1) The exact location of these original stands is not known; (2) the previous stand may have long since been felled and (3) if new lots were collected it would take at least another 30 years to prove whether they were suitable for Irish conditions. It would therefore seem pointless to have all this doubt about future lots when proven provenances are already growing excellently here.

The question of how to perpetuate these good stands now arises. There are two methods available, one short term and the second long term. The first is seed stands, a stop gap method which tides one over the period in which seed orchards are being established. Though they

are composed of phenotypically better trees there is no definite guarantee that the seed produced will have improved genetically. This arises partly from the fact that the male parent is not known. However this is overcome, in as far as it is possible, by removal of inferior trees in the stand during thinning operations. It is, however, probable that seed produced in a seed stand is much superior to that produced in a stand not managed for seed production. Seed orchards on the other hand are more under the control of the tree breeder as only trees with superior phenotypic characteristics are represented in it.

Seed Stands:

Firstly a survey of all the potential seed stands is carried out in which 1/10 acre plots are examined. Within each plot the number of potential seed trees is recorded. The result of this sampling places the stand in one of four groups—(a) where at least 75% of the dominants are acceptable as seed trees—this type being designated a Plus Seed Source (b) where more than 50% and up to 75% of the dominants are acceptable—an almost Plus Seed Source (c) where more than 25% and up to 50% of the dominants are acceptable— a Normal Seed Source and (d) where more than 75% of the dominants are not acceptable—a Minus Source (Faulkner 1962). It is recommended that this survey should not be made in very young stands where the trees may not have developed mature characteristics. Depending on the species the result of the survey will vary considerably. In, say, Sitka spruce, many stands would fall into the plus or almost plus category due to the uniformity of the species. Pines, on the other hand, being more variable in form tend to fall into the normal category. Size of the seed stand chosen is also very important for too small an area could be influenced by invasion of foreign pollen from inferior stands close by.

Having chosen the potential seed stand areas, they are managed for seed production by (1) thinning (2) fertilizing and (3) any other ameliorative measures as may be thought necessary. Before thinning is commenced a selection of seed trees is carried out. It is from these selected trees that all future seed collections will be made. Each potential tree is subject to a three point examination

(1) Vigour and place in the crop;
(2) Stem form;
(3) Crown form.

Vigour:

This characteristic immediately makes it eligible for selection or lack of it rejects it. It should be in a dominant position in the canopy. On rare occasions a co-dominant is acceptable if it is exceptional in all other characteristics.

Stem Form:

The stem should be free from all major defects. In very exposed sites the trees may all be leaning so that seed trees may be selected here

which have a slight lean. When eliminating for this characteristic the effects of environment should always be taken into account.

Crown form:

A long narrow type is the ideal here and the selection is based on this standard, care being taken to ensure that they are not too rough or untidy. If a tree has all the required characteristics it is classified as a seed tree. In selecting seed trees reasonable distance should be left between any two selected trees to allow full development of the crown.

When the seed trees have been selected and marked permanently, ameliorative measures are put in hand; the first of these is thinning. The object of thinning is to liberate the crown of the seed tree to allow its fuller development. This liberation of the crown is most important on the southern or sunny side. Following the removal of the competing trees those next to be removed are trees of inferior form which, if left, could be the producers of inferior pollen. These need not necessarily be removed all at once, particularly where there is a danger of wind blow.

During and subsequent to thinning operations every precaution should be taken to reduce the incidence of damage. Felling should be carried out by the forest staff and extracted to ride side so that damage in the form of barking both to stems and roots may be reduced. Creosoting of stumps to prevent, or at least reduce the incidence of *Fomes annosus* is also necessary immediately after felling. Time of felling should be taken into account both to avoid the period of worst storms and the emergence of *Myelophilus piniperda.* If carried out in late winter the danger of the latter may be avoided, as all large timber will have been removed and the lop and top will no longer be sufficiently fresh to attract this beetle.

Following completion of the thinning operation another very important ameliorative operation is that of fertilizing. It has been shown by tree breeders and others that the application of nitrogen, phosphorus and potash increases the fruiting of forest trees. The ratio used in Irish stands is 2N : 1P : 2K (Faulkner 1962) and is used at the rate of $4\frac{1}{2}$ cwts. per acre sulphate of ammonia, $3\frac{3}{4}$ cwts, ground mineral phosphate and 2 cwts. muriate of potash. Ideally an area equal to one and a half times the spread of the crown should be manured around each seed tree. In practice it is spread over the total area of the stand resulting in not only the seed being manured but also non seed trees.

Seed Orchards.

In conjunction with the seed stand programme the establishment of seed orchards can be carried on. This programme is divided into three phases (1) Selection of Plus trees (2) Establishment of the seed orchard and (3) Progeny testing.

Stage 1.

Selection of Plus trees. During the survey of seed stands the selection of plus trees can be carried out. For plus tree selection the examination is much more critical and intensive thus ruling out many

trees that would be suitable as seed trees. In Ireland so far, the examination is based only on the tree's external characteristics, no account being taken of the tree's timber characteristics—ideally these should be taken into account at this stage. However, these tests can be carried out at a later stage.

This examination of the trees is carried out under 4 headings

(1) Vigour and relative position in the crop;
(2) Stem form;
(3) Crown form
(4) Branch form.

Dealing with each heading in turn will demonstrate the exacting nature of the examination.

Vigour and relative position in the Crop.

This point is taken first since it is by its performance in this category that a tree is considered worthy of examination or not. The question of how to measure vigour is a very controversial one, size alone being considered by many not to be the correct criterion. Lack of competition from neighbouring trees may account for a tree appearing more vigorous than its neighbour. As yet there has been no definite method developed to measure vigour. Consequently the method used for vigour in selection of *Pinus contorta* plus trees is that of size relative to other trees in the stand. Since vigour is relative to the other trees in the stand the standard varies from stand to stand. A tree that appears to be superior in both height and girth growth to its neighbours can be considered suitable for selection. To achieve a standard for each particular stand, the surveyor covers its total area to accustom himself to the potential of the stand. Having set his standard for vigour, a number of potential plus trees are selected on this basis and these are then subjected to a rigorous scrutiny.

Stem form.

To achieve ease of examination each stem is considered under three sub-sections—butt, main stem and upper stem, each of which must be, in as far as it is possible, free from defects. Like the question of vigour, freedom from defects is once again relative to the general conditions in the stand. This does not, however, allow any laxity in standards. Within the butt region the points sought are straightness, freedom from butt swell and freedom from fissures. With *Pinus contorta* many of these points must be examined with a critical eye on local environmental conditions. Most of the *Pinus contorta* stands are on very exposed sites and this fact, plus their very rapid early growth, has resulted in many fine stems having slight to moderate basal sweeps. Where this fact is very prevalent in a stand, a potential plus tree, in which this fault occurs, may be included, provided the fault is not too severe. The presence of butt swell and fissuring will rule a stem out.

Crown form.

This is the next section which is given close scrutiny. Points sought are a long narrow crown which is free from all insect and fungal attacks.

Branch form.

In a species such as *Pinus contorta* this is a very variable characteristic. In the inland provenances branches are usually very light. In some coastal provenances they can be quite light and in others very heavy. Even within any one provenance they are very variable. This holds not only for size but also for number. With a potential plus tree the branches per whorl are first counted and if possible they should be between 5 and 8 in number. Inter-nodal branches are not acceptable. Branch diameter is particularly variable within the coastal provenances. Consequently in dealing with this point the general branch diameter pattern should be taken into consideration. Lighter branches are preferable. There is no definite upper limit but consistently heavy branching will rule out a vigorous tree. Another very important point is the angle formed by the branch with the stem. This is also extremely variable. In some cases it may be a right angle while at the other extreme it may be nearer to 30°. The importance of angle is such that it governs the length of knot included in the wood, the steeper the angle the greater the length of knot. What is sought therefore is as near a flat angle as possible. In *Pinus contorta* an added disadvantage to steeply ascending branches is the tendency for the bark to grow out around the branch; this leads to the inclusion of pockets of bark in the wood.

The question then arises whether it would be better to adopt a system for scoring each characteristic. Difficulty would then arise as to the best method and if it were not weighted it might lead to some trees getting a high score on less important characteristics. This would lead to trees with more desirable chacteristics but with lower scores being ruled out. On the other hand with the non-scoring method, personal bias may enter into one's considerations. Since a satisfactory scoring system has not been developed all selection is carried out on a visual basis.

Stage 2.

Following on the selection of plus trees the next step is the establishment of seed orchards. Before the actual laying out of the orchard it is important to plan the size required. The size should be sufficient to allow the production of a specified quantity of seed. The area required will in all probability be greater than is available at any one site. Therefore the area required will be divided over a number of sites each containing material from all the plus trees. This stage of the programme can also be broken into a number of stages (1) selection of site, (2) preparation of site (3) layout of area and (4) grafting.

The selection of a suitable site is most important. The points looked for are fertility, southerly aspect and isolation from any plantations of the same species.

A southerly aspect is stipulated to ensure that the site has the maximum amount of sunlight and the minimum amount of frost. In this country those sites facing any of the southern points of the compass are classified as being suitable. Isolation from plantations of the same species is to ensure that no contamination can occur from foreign pollen. Where there are wide geographic ranges it is of importance to have the orchards in the same regions from which their constituents were collected.

Following the selection of the site, ground preparation is undertaken. At present opinions vary as to which is the best seed orchard floor. There are two possibilities, that of leaving the area fallow or of sowing it with a special grass clover mixture. The former ensures that there is no competition between the ground vegetation and the grafts. However management of such a site is very difficult particularly in a wet climate where difficult underfoot conditions are liable to prevail. In addition, the site would have to be continually rotovated to control new growth. During rotovating there is the danger of the roots of the trees being damaged but this could be overcome by leaving a small area immediately around each tree unrotovated. The alternative, of ploughing the site and sowing with a permanent grass clover mixture, appears most suitable for Irish conditions. Prior to planting of the orchard the erection of a proper rabbit and stock proof fence is essential. At this stage the layout of the future orchard can be marked out on the ground. The distance between grafts is initially 15 ft. and between rows 15 ft. and, depending on the size of the area available, the orchard can contain anything from 400 grafts upwards. The exact location of each tree is first marked on the ground and then an area one yard square is dug over. During the cutting of the sward the dug over areas are mulched with some of the cuttings and are then left unplanted for some time. The stocks may be placed in *situ* prior to grafting or placed there at a later date following grafting but normally grafting is done away from the orchard site, the grafted stocks being brought to the seed orchard site after they have struck.

Scion Collection:

This can be carried out by either of two methods, climbing the tree or shooting. The former is a slow time-consuming job which entails the transportation of bulky equipment and the delay in setting it up. For shooting, on the other hand, all that is required is a shot-gun. The cartridges are of a special type, having 6 large pellets in each. A branch with suitable scion material is selected with the aid of binoculars. It is then shot down severing the branch as close to the stem as required. Position of the selected branch in the crown depends on the prevalence of male flowering shoots. In many cases the middle third of the crown is almost completely male and consequently many of the branches selected have to be in the lower third. The upper crown usually does not possess a branch with sufficient scions on it and in addition many of the available shoots are also male. The upper crown shoots also

tend to be rather vigorous and in many cases are much stronger than the available stocks on to which they will be grafted. The scions are cut from the fallen branch using a secateurs and are usually about 6 ins. in length. During the selection of the scions care is exercised to ensure that no shoots with male buds are included in the selection. The presence of male buds is recognised by a swelling on the basal portion of the bud. Those shoots which have borne male flowers are also unsuited as scion material. Those selected are in every case the most vigorous on the branch selected. Following collection the scions are placed in polythene bags and loosely tied. All these operations must be carried out when the bud is in the dormant state.

Grafting:

Grafting follows next but is usually at a later date to that of scion collection if it is carried out in the open. If it is indoors the collection of the scions can be synchronised with the commencement of growth of the potted stocks in the greenhouse. Stocks are those plants on to which the scion shoot of the plus tree is grafted. These are usually 2 + 1 or 2 + 2 transplants of the same species which have good form and are of vigorous growth. It is essential, particularly with *Pinus contorta,* that the stocks be from the same provenances as that of the plus trees. Before grafting these stocks must be undisturbed for at least one growing season. For open air grafting this is usually in transplant lines at a wider spacing than normal between the plants. For greenhouse work the plants are potted the Spring before grafting is to be carried out. The potting medium is a mixture 7 parts of loam, 3 parts of peat and 2 parts of sand (Lightly and Faulkner 1963). To this also is added some compound fertilizer. The potted stocks are left in the open until the following winter when they are placed in a greenhouse and subjected to higher temperatures to induce early growth. The temperature may be raised by either soil or space heating or both. In this way the grafting season may be extended over a longer period thus increasing the output. Once the stock has commenced growth the dormant scion is grafted on to it using the side veneer graft. The grafted stock is allowed to remain in the glass house for some time to permit the proper union of scion and stock. In mid summer it is placed in the open still in the pot, but is not planted out in the orchard until the following autumn. Correct and careful labelling must at all times be carried out during this phase of operations. Prior to the final laying out of the orchard the exact location of each scion with the correct identity tag is marked on the ground. The potted grafted stocks are transported to the orchard site where they are carefully removed, care being taken not to injure the roots. Greenhouse grafting usually give a much higher proportion of sucessful grafts than outdoor grafting.

Lay out:

The size of orchards varies considerably, but it is belived that one should contain not less than 20 clones, a clone being material grafted

from a particular plus tree. Too small an orchard is undesirable as inbreeding is liable to occur thus leading to a decrease in vigour. The layout is usually square but it can be any other shape depending on the size of the area available. Its size is normally designated by the number of clones represented in it. A 20 clonal seed orchard is one having 20 rows and 20 grafts each row having a representative of each plus tree in it. The layout is such that somewhere within this square each graft is along side every other graft represented in the orchard. The initial spacing of 15 ft. × 15t ft. is to ensure that in the early life of the orchard sufficient pollen will be produced to fertilize the female flowers. When the grafted stocks have reached full development every second tree will be removed thus giving the required spacing of 30 × 30 ft.

Stage 3.

The final proof of whether the plus trees selected are of superior potential comes from progeny tests. If they should be shown to be inferior their representatives in the seed orchard must be removed. The simplest form of progeny testing that can be carried out is the one parent test. Here seed is collected from the parent plus trees and sown in the nursery. The resultant development of the seedling can be watched and any inferior characteristics noted. There is however, one big draw-back to drawing conclusions from this test and that is that only one parent is known. The more reliable form of test is where controlled pollination is carried cut in the orchard. The procedure followed is to collect pollen from a number of clones represented in the orchard and with it pollinate the developing female flowers. During this operation great care is taken to ensure no foreign pollen is allowed to enter and pollinate the flowers. Each flower is protected by a bag made from a weather proof material. It is placed over the flower sometime in advance of its being receptive to pollen. At the correct time the pollen is injected into the bag in a cloud, some of which fertilizes the ovules. When the seed has developed fully it is collected and sown. These progenies are observed carefully and any lack of vigour or other bad characteristics are noted. These characteristics can be related back to their original parents. These trees are then removed from the orchard at the first thinning. In this way only those trees of proven characteristics remain in the orchard and subsequent seed produced can therefore be classified as genetically superior.

The area of seed orchards will depend on the annual requirements of *Pinus contorta* seed and the expected seed yield per acre of this species. In the case of seed stands the annual yield is estimated at about 10 lbs. per acre. At present our annual requirements range from 400 lbs. to 600 lbs. To supply this demand would require an acreage of 1,500 acres, this figure being increased to allow for the periodicity of seed years. The quantity of seed produced in an orchard is not as yet known for *Pinus contorta.* For *Pinus sylvestris* a yield of 10-15 lbs. per acre has been estimated abroad. The advantages of the seed orchard

is the case with which collection can be made and most of all the fact that the seed produced can eventually be guaranteed to be of superior quality.

References:

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