# INITIAL FIELD TESTING FOR FOREST TREE IMPROVEMENT

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# INITIAL FIELD TESTING FOR FOREST TREE IMPROVEMENT

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*Summary*

Initial field testing for forest tree improvement is essentially a comparison of genetic groups whether the level of comparison is of species, provenances, or individual trees.

A good study design should be as economical as possible, for a given precision, and must be accurate. The latter is simply obtained by restricting the study to a specified set of conditions, replicating adequately within those conditions, and randomizing the groups being compared.

Precision is improved by minimizing variation within a sampling unit, by keeping careful, accurate records, and by additional replications.

In Puerto Rico, studies utilize one-tree plots, in 16 contour rows per block, three blocks per location, and four to eight locations on a major soil type, a total of 192 to 384 seedlings of each species under test. This arrangement is believed to give maximum precision and accuracy at minimum costs, under local conditions.

Field testing for improved forest trees is essentially a comparison between genetic groups, regardless of the nature of the genetic category under test. By definition, the broadest category usually considered is the species. A moment's reflection is sufficient to demonstrate that, for most purposes, there is no point in comparing genera. Between *Quercus* and *Carya,* for example; in sites suitable, timber quality, habit of growth, and susceptibility to pathogens there is so much variation within the genus that probably only a taxonomist could conclude that all oaks are more like each other than any oak is like any hickory.

Comparison of one species against another, however, can be very useful and is common practice.

The next finer category, provenance, has received a great deal of attention in recent years; there appears to remain no doubt that provenances, or clines in some cases, are of great importance within some species. Unfortunately there seems to be little real justification for hoping that there is an intrinsically superior provenance of each species, to be isolated by a few research centres and distributed to the interested segment of the forest industry. Rather, there appears to be one or a few provenances which on certain sites or in certain regions are superior in designated characteristics. More often than desired, provenance A grows most rapidly, provenance B is most frost resistant, provenance C has the best stem form, provenance D has the finest branching habit, and provenance E has the straightest grain.

Such results do not illustrate the futility of provenance trials; they illustrate the need for well-designed provenance trials, properly established, and carried through to completion.

The next finer degree of genetic category may be individual tree selection and testing. This is the level of category commonly meant when tree improvement is discussed, but there is no apparent reason for considering it as a separate subject. Neither does there appear to be any reason for a separate way of testing clonal materials, as compared to sexual progeny.

Comparisons of species, of provenances, and of progeny/clones are all stages in tree improvement, not different types of studies.

## BASIC CONSIDERATIONS IN FIELD TESTING

### *Cost*

The one factor limiting all studies, formal or informal, must be cost. The cheapest design which sacrifices neither accuracy[1] nor precision is the best.

### *Accuracy*

The single characteristic which should be common to all studies is accuracy. Any study which yields erroneous results is money wasted, no matter how low the cost. Since the requisites for accuracy are so simple, it is surprising how often they are ignored.

(1) Restrict the study to a particular, defined set of conditions. The narrower the scope of the study, the more chance of an informative conclusion.

(2) Replicate, according to the conditions defined for study. For the type of study being considered here, two replications at each of two locations are the absolute minimum for useful results. Only divine revelation can justify reduction of these figures, in which case no study is necessary.

[1] As used here, *accuracy* refers to whether an answer is free from error; *precision* refers to the exactness with which the answer is defined. See: B. Husch. 1963. Forest mensuration and statistics. Ronald Press Co., New York. pp. 13-14.

(3) Randomize within each replication. The necessity for this step is far less obvious than the first two, which are, in fact, simply common sense. A complete conviction on the final point, unfortunately, requires either a rather thorough grounding in statistical theory or an act of faith. For most of us, the latter is easier to attain.

*Precision*

The required quantitative exactness of the result is difficult to justify at any specified level, on objective bases. It is normally impossible to state that a difference of 10 per cent, for example, is important, but a difference of 9 per cent is not. The specific definition of exactness adopted is simply a matter of judgement, taking all known factors into consideration.

To attain the desired precision and at the same time minimize costs, several procedures are helpful.

One means of increasing precision is to reduce variation of extraneous factors within the sampling unit. In any field study the most obvious way of doing this is to occupy a minimum of ground area; use small plots. This also reduces costs directly.

Another means is to reduce variation within the sampling unit for each of the categories under comparison. Forest trees are normally drawn from a genetically unmodified population; so this step usually requires clonal material or single trees.

A third means of increasing precision is in imposing controlled uniform conditions to the extent practicable. At best, field studies incorporate tremendous differences in environmental factors; certainly all treatments should be applied without bias. And this restriction begins in the nursery, or before.

Unfortunately, our background of knowledge is completely inadequate for anything more than the merest rudiments of following the above suggestion. An obvious illustration is that teak (*Tectona grandis*) grows very well if stumped (trimmed to a 20-centimetre taproot and a 2-centimetre stem) whereas bigleaf mahogany (*Swietenia macrophylla*) does much better if leaves are stripped off, but the stem is left intact. Imposing the same treatment, either stumping or stripping, on both species is biased treatment.

Until we know enough to make reasoned conclusions, the only real alternative is to go by educated intuition and keep complete records.

A final caution on the subject of controlling study conditions: if the care given to the study plants is better than can be attained in practice, the results may lack any real value. Here, as always, sound judgment is highly desirable.

A fourth means of reducing variation, now gaining well-deserved recognition, is to make careful, well-planned measurements. Maintenance of individual tree records on permanent plots may be considered the minimum requirement in this direction.

Once variation within the sampling unit is reduced to the practicable minimum, the only means of increasing precision still further is to add more replication. For a given sampling unit, precision usually progresses in a uniform manner: to reduce sampling error by half, increase the number of replications by four times. That is, if 10 replications give a sampling error of 40 per cent, 40 replications will give an error very close to 20 per cent, and 160 replications are necessary to obtain 10 per cent error. Rising costs tend to have a profound influence on one's attitude toward precision attainable in this manner.

## FIELD TESTING IN PUERTO RICO

Past tests in Puerto Rico have been confined to species comparisons; the first provenance trials are now being outplanted in the same manner, but for simplicity the discussion will mention only species.

### *Restrictions*

Species adaptability tests are designed only to compare growth and development of the various species up to minimum merchantable size, assumed to be about 15 centimetres diameter at breast height.

Under local conditions good early care is considered necessary and justifiable; so all plantings are given intensive weedings during the first three years and occasional weedings to age ten.

Practically all land available for forest planting is either abandoned crop land or secondary brush with no merchantable components; so all study areas are cleaned of the entire overstory before planting.

No pre-commercial thinning is expected in practice; so a relatively wide spacing, 2.5 x 2.5 metres, is used. Since some species fail completely and others are very poorly adapted, the effective growing space for the well-adapted survivors is even more than the 6.25 square metres indicated by the planting espacement.

Species can be selected for good form and branching habit in such open plantings because they will doubtless do as well in stands, but species cannot be rejected because of poor form. The critical test of development in stands is during the spacing studies, which are conducted only with the few most promising species selected in the adaptability comparisons discussed here.

All live branches are pruned if (a) they are on the lower 40 per cent of total height and (b) stem diameter at point of pruning is 7.5 centimetres or more. Dead branches are pruned throughout by termites.

*Replication*

Each major soil type is considered a separate study. On each type, four to eight locations, preferably eight, are selected to obtain maximum variation in rainfall, elevation, and geographic dispersion; if other variables appear to be locally important they are included in location selection. Briefly, locations are selected subjectively to obtain the full range of variation recognized within the soil type.

At each location three blocks are established side by side. Each block is 40 meters long and contains 16 contour rows. Each contour row in each block contains one seedling of each species; therefore, width of block varies with the number of species under test.

The more promising species are tested by planting in at least three calendar years, but no effort is made to replicate every species in time. In point of fact, with the wide replication in space and environmental conditions enforced, no annual differences in species comparisons have been discernible up to the present.

*Randomization*

The position of each species in a contour row is set by drawing random numbers; each row is randomized independently.

*Precision*

The individual seedling is considered to be a plot; this is the smallest possible unit and reduces within-plot variation of microsite and genotype to the absolute minimum.

Each of the contour rows containing one tree of each species also contains the minimum attainable variation in microsite, and rows can be grouped in any desired combinations, or differences between contour rows can be isolated during statistical analysis.

At a few locations, in narrow stream valleys, the contour row has been replaced by a square layout, again to minimize microsite variation. This is less satisfactory both in the field and in analysis; so its use is kept to the absolute minimum.

As indicated above, care is uniform and fairly intensive. Potted seedlings are used throughout, which minimizes variation in nursery treatment. Position in the nursery, for example, is varied during the growing season to avoid any possibility of favoring one species. The best known combination of soil, fertilization, and watering is given each species; this varies between species in some cases.

Records of field treatment are kept by the block, and each block receives the same treatment throughout. Individual tree measurements are made annually for the first five years, at seven years and at ten years. By this age, height of the successful trees is 20 meters or more and diameter is 20 to 40 centimeters; interest has shifted to yield studies of the best few species.

These trees, with their detailed histories, also provide an excellent background for studying either provenances or individual tree selections.

Summarizing, each species is represented by one seedling in a contour row; there are 16 contour rows in a block, three blocks at a location, and usually eight locations on a soil type. Therefore, there are 1 x 16 x 3 x 8 = 384 seedlings of each species. This number has been sufficient for finer precision than is actually of practical importance, and studies are now testing the use of only one or two blocks per location; however, this reduction has not yet been justified. Reduction of locations or contour rows is not possible without sacrificing the range of conditions tested.