A WHITE PINE SEED ORCHARD LAYOUT

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INTRODUCTION

In spring 1961, the State of New York Conservation Department and the College of Forestry at Syracuse University established the first white pine (*Pinus strobus*) seed orchard in New York, at Gick Road, three miles northeast of Saratoga Springs, as part of a larger clonal seed-orchard program under way since spring 1960. This seed or chard program is a cooperative project between the two above mentioned agencies as reported in last year's Proceedings (2). The College of Forestry is responsible for the selection of suitable trees, their vegetative propagation by means of grafting and the preparation of planting plans. The Conservation Department, in close contact with the College, provides planting areas, does the outplanting of the grafts and is responsible for the management of the orchards.

GENERAL CONSIDERATIONS

In designing a seed orchard several theoretical considerations have to be recognized and contemplated before outplanting can be soundly accomplished. In 1957, Lars Strand (6) reviewed some of the problems pertaining to pollen dispersal in clonal seed orchards. Briefly they include the following items.

1. A real extent of the seed orchard.
2. Distance to, and the size of surrounding native stands which may serve as a source of contaminating pollen.
3. Possible differences in clonal flowering times in the orchard.
4. Prevailing wind direction during flowering time.
5. Clonal positioning to avoid as much self-pollination as possible.

Langner and Stern (5) discussed the various possibilities which might be considered for the arrangement of the clones in an orchard. They give preference to a system called 'balanced, single-tree mixture". This system requires an equal number of clones in each orchard block, individually distributed to avoid as much self-pollination as possible and arranged to provide an equal opportunity for all combinations to occur with about the same frequency. Langner (3) established the fact that trees in a stand tend to cross with their nearest neighbors. This follows Wright's (7) findings based on known pollen sources in open dispersal areas. Generally, pollen concentrations from small, individual-tree sources were greatly reduced with a short increase in dispersal distance. Thus, as pointed out by Langner (4), there should be a maximal average distance maintained between individuals of the same clone to reduce selfing.

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SPECIFIC CONSIDERATIONS

In recognizing the above mentioned general items, special attention had to be paid to more specific considerations as they relate to our white pine orchard. These can be listed as follows:

1. Fifteen white pine clones, all from the Adirondack Mountain region, were to be planted in a five-acre area, as a regular seed orchard wind pollinated type (1). In a 15-clone orchard, using the formula n(n-1), there are 210 possible cross combinations.
2. A triangular spacing with staggered rows (figure 1), as recommended by Langner, was considered to be the best arrangement.
3. Spacing within the orchard was to be 15 by 20 feet, i. e. , the rows 20 feet apart and the ramets 15 feet apart in the rows.
4. The area available and the spacing chosen made it possible to plant 30 ramets of each clone, a total of 450 grafts.
5. The prevailing winds during the time of flowering are westerly.
6. The possibility of fire had to be considered, (New York Route 50 is less than 200 yards away,) This and other considerations necessitated a block arrangement surrounded by a fire lane.
7. Isolation strips were not considered necessary because the nearest stand of white pine is more than a mile away.

Clonal Distribution

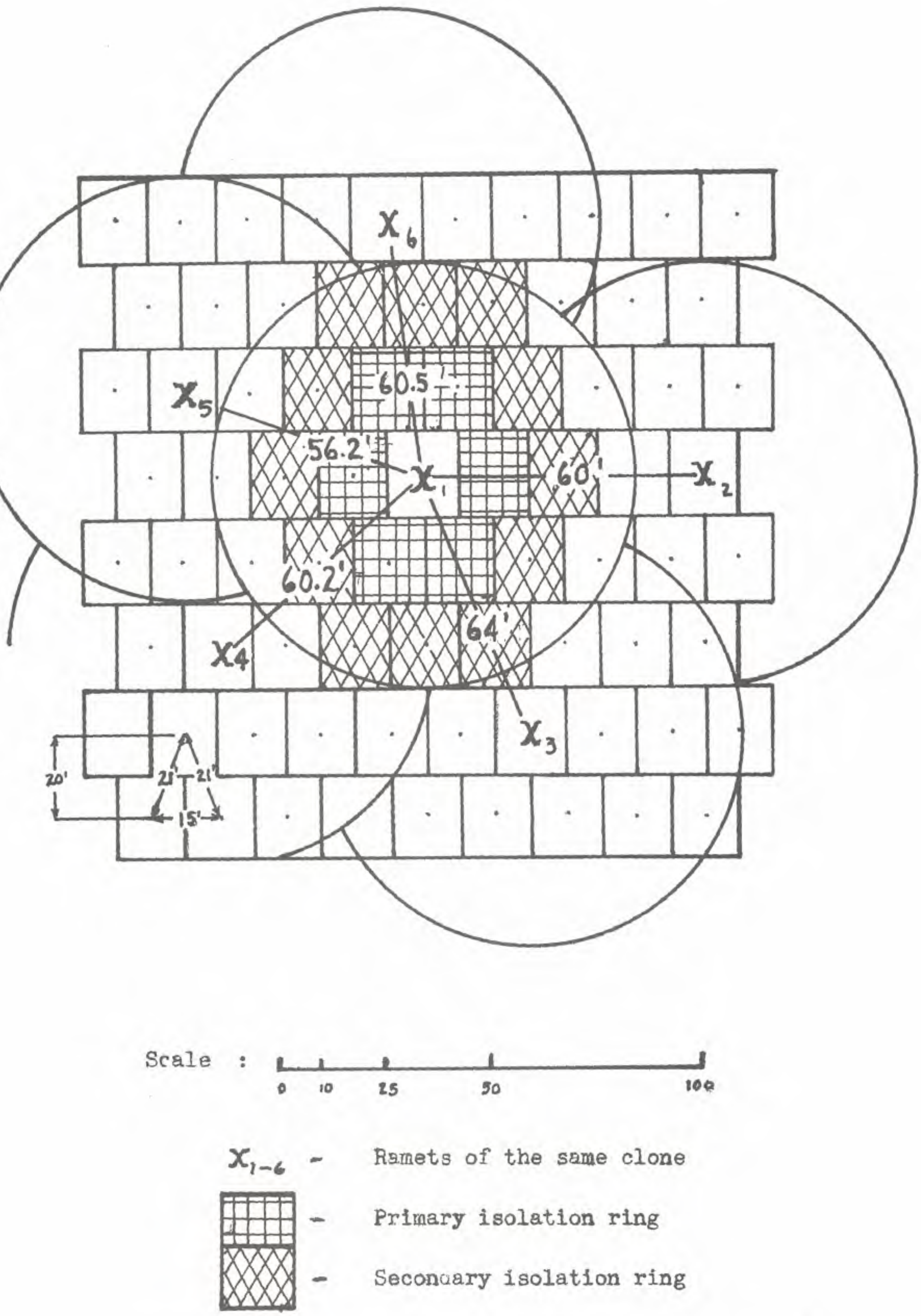
The plantable area was first divided into three equal blocks (A, B, and C). These blocks were alined in an east-west direction, so that prevailing winds from the west would carry pollen from Block A into Block B, and from Block B into Block C. A fire lane 25 feet wide was placed around each block to reduce fire danger. Each block received 150 grafts, ten from each clone, for outplanting.

The next problem to be solved was the elimination of as much self-pollination as possible between a ramet and its genetic duplicate. To accomplish this, a circle was drawn with a predetermined radius around each blank position in the block. This circle became a "restricting zone", in that any clone found in the circle eliminated that clone as a choice for the blank center position. The "X_1" in figure 1, represents a ramet of any clone at the center of its restricting zone.

The determination of the radius of the circle was based on various studies of pollen distribution from individual sources, as well as orchard spacing and number of clones. Wright (7) has shown that more than half of the pollen of *Pinus cembroides* var. *edulis* was dispersed less than 50 feet from the source. In a 15-clone orchard, with a spacing of 15 and 21 feet between individual ramets, the graphic solution for a 50-foot radius resulted in a distribution distance of more than 56 feet between individuals of the same clone (figure 1).

This distance between ramets of the same clone, becomes most effective if there are ramets of different clones intervening. The effect is two-fold: the interposed ramets act as pollen filters, which isolate ramets from pollen of the same clone; the interposed ramets produce quantities of pollen themselves, this lowers the relative

Figure 1.--Seed orchard spacing and distances showing "restriction zone" and "isolation rings".



percent of pollen from the same clone. There are two rings of different clones isolating ramets of the same clone as shown by different cross hatching (figure 1). The ramet, "X_1", within the rings has six different neighbors in the "primary isolation ring", 12 ramets in the "secondary isolation ring" and ten additional ramets in an incomplete third ring.

Block A - Basic or Standard Block. Using the above-mentioned spacing method several distribution models were developed which satisfied the previously mentioned distribution restrictions in regard to self-pollination. They differed considerably in the number of combination frequencies between their nearest neighbors. As an example, the cross combination 12 x 13 and its reciprocal occurs more frequently than 12 x 15 and 15 x 12. To find the best model it was necessary to tally all possible combinations between each central ramet and the six adjacent ramets in the primary isolation ring. Extremes in the frequency of any cross are undesirable, as a "balanced mixture" denotes equal crossing opportunities. Therefore, a redistribution of some ramets was necessary to narrow the range. The frequency range of Block A (figure 2) ranges from 2 (such as 3 x 5) to 16 (such as 12 x 13); this range must be considered very large. Further redistribution of the various ramets is time consuming and, because of the limited number of clones, becomes impossible without changing the size of the basic restricting zone. It became clear that another way to balance the combination frequencies was desired.

Block C - Mirror Image Block. For ease and simplicity the same design chosen for the standard, Block A, was used again in Block C. Some concern was given to the effect of prevailing winds at the orchard site. The possibility of pollination is greatest from a windward clone. If all blocks were identically oriented, any prevailing wind during the period of pollen shed would favor those combinations from the same windward pollen parent. With the use of a mirror image the positional importance of a ramet in one block was reduced, in that the reciprocal cross is favored in the other block, For example, the 1 x 8 cross in the top row of Block A becomes an 8 x 1 cross in the top row of Block C, assuming a prevailing wind from the left (figure 2), It may be pointed out that correction for prevailing winds in only two directions has been achieved, Future layouts could, by rotating the standard block 180 degrees, correct for any prevailing wind direction

Block B - Correction Block. The unequal combination frequencies found in the first two blocks lead to the development of this block. It was designed to favor those combinations only occasionally found in the standard and the mirror image block, at the expense of the most frequent combinations. After tallying all adjacent combinations in both Block A and Block C, the crosses appearing least frequently were placed in favorable positions in the correction block. The correction block contained the same number of ramets (10) of each of the 15 clones, as well as the same size restricting zone used in the other blocks.

Final Distribution Design. The final distribution design of the white pine seed orchard is shown in figure 2. The total cross-combination frequencies between all adjacent ramets are given in table 1. The range of combination frequencies is 14 to 32 when only the crosses within the primary isolation ring are considered. If however, the crosses in the secondary isolation ring are added the range is narrowed still further

1	8	4	11	15	2	3	9	11	4
2	14	10	7	1	6	8	7	15	10
3	6	13	9	5	4	13	12	1	3
4	12	11	15	3	10	14	2	6	4
5	2	14	8	1	7	9	8	5	7
6	10	9	13	6	11	4	13	1	3
7	4	3	12	5	15	14	12	10	15
8	11	2	1	10	9	3	6	2	5
9	5	15	14	7	8	11	4	1	9
10	13	3	6	12	13	5	10	14	7
11	7	8	2	4	1	15	6	12	13
12	15	5	10	14	11	7	8	9	11
13	9	1	6	3	12	2	4	5	14
14	7	2	8	15	9	10	6	13	12
15	3	12	5	13	14	1	11	8	2

Block A - Standard

Fire Lane

8	2	11	7	8	9	10	6	11	13
1	13	3	5	12	4	15	14	1	2
12	14	4	6	1	13	2	5	12	8
2	9	15	11	8	10	7	11	6	15
10	5	13	7	12	4	14	3	13	9
12	6	14	1	5	9	15	1	10	2
4	9	15	3	11	6	2	7	5	11
13	7	8	10	12	4	8	14	3	13
11	2	6	14	1	15	9	10	1	4
3	12	9	5	7	3	11	2	5	8
5	8	10	13	4	12	14	6	7	3
6	7	14	2	15	8	1	9	4	10
15	9	11	5	6	3	13	5	12	15
10	3	13	1	12	4	14	11	8	7
4	6	14	15	7	2	9	10	1	3

Block B - Correction

Fire Lane

4	11	9	3	2	15	11	4	8	1
10	15	7	8	6	1	7	10	14	2
3	1	12	13	4	5	9	13	6	3
4	6	2	14	10	3	15	11	12	4
7	5	8	9	7	1	8	14	2	5
3	1	13	4	11	6	13	9	10	6
15	10	12	14	15	5	12	3	4	7
5	2	6	3	9	10	1	2	11	8
9	1	4	11	8	7	14	15	5	9
7	14	10	5	13	12	6	3	13	10
13	12	6	15	1	4	2	8	7	11
11	9	8	7	11	14	10	5	15	12
14	5	4	2	12	3	6	1	9	13
12	13	6	10	9	15	8	2	7	14
2	8	11	1	14	13	5	12	3	15

Block C - Mirror Image

N

Prevailing Winds →

CONCLUSIONS

In designing a seed orchard certain basic requirements have to be fulfilled to prevent as much self-pollination as possible. The greater the number of clones, the less the chance of self-pollination when the orchard is properly designed. All the possible cross combinations have to occur with about the same frequency. This, as well as possible fire danger, prevailing winds during pollen shed, and for reasons of management, favor the use of a block design for larger orchards. At present, clonal distribution designs are very time consuming. The college, in cooperation with Syracuse University, has begun a program using electronic computors to find an easier and perhaps a standardized solution (combination tables) to the problem.

We are aware that this design has not solved all problems in the best possible way. In addition to the preceding considerations, there are others (such as insufficient overlapping in flowering time, quantity of male and female strobili produced, etc.) which may occur and which cannot, or can hardly be controlled by man. Some problems may be solved, however, by proper management of the orchard.

LITERATURE CITED

1. Klaehn, F. U. 1960. Seed orchard classification. Jour. Forestry 58: 355.
2. ------------ and Eliason, E. J. 1961. A seed orchard cooperative project in New York. Northeast. Forest Tree Improve. Conf. Proc. 8(1960): 21-27.
3. Langner, W. 1953. Eine Mendelspaltung bei Aurea-Formen von Picea abies (L) Karst. als Mittel zur Klarung der Befruchtungsverhaltnisse im Walde. Zeit. Forstgenetik 2: 49.
4. ---------- 1953. Die Klonanordnung in Samenplantagen. Zeit. Forstgenetik 2, 119.
5. ----------and K. Stern. 1955. Versuchstechnische Probleme bei der Anlage von Klonplantagen. Zeit. Forstgenetik 4: 81.
6. Strand, Lars. 1957. Pollen dispersal. Silvae Genetica 6: 129.
7. Wright, Jonathan W. 1952. Pollen dispersion of some forest trees. U.S. F. S. , Northeast. Forest Expt. Sta. Paper 46. 42 pp.

Table 1.--Combination frequencies between adjacent ramets in "primary isolation ring."

Cross and Reciprocal	Cross and Reciprocal	Cross and Reciprocal	Cross and Reciprocal	Cross and Reciprocal	Cross and Reciprocal	Cross and Reciprocal
1 X 2 - 26	2 X 5 - 24	3 X 9 - 20	4 X 14 - 20	6 X 10 - 24	8 X 9 - 24	10 X 13 - 18
3 - 22	6 - 32	10 - 20	15 - 14	11 - 22	10 - 14	14 - 32
4 - 14	7 - 18	11 - 22	5 X 6 - 30	12 - 30	11 - 18	15 - 18
5 - 32	8 - 28	12 - 22	7 - 20	13 - 18	12 - 22	11 X 12 - 22
6 - 26	9 - 18	13 - 16	8 - 22	14 - 24	13 - 30	13 - 26
7 - 28	10 - 24	14 - 24	9 - 28	15 - 24	14 - 16	14 - 22
8 - 22	11 - 18	15 - 32	10 - 24	7 X 8 - 30	15 - 20	15 - 22
9 - 14	12 - 32	4 X 5 - 22	11 - 22	9 - 28	9 X 10 - 32	12 X 13 - 32
10 - 28	13 - 18	6 - 30	12 - 22	10 - 22	11 - 20	14 - 26
11 - 20	14 - 20	7 - 18	13 - 28	11 - 28	12 - 18	15 - 14
12 - 24	15 - 20	8 - 20	14 - 14	12 - 22	13 - 26	13 X 14 - 32
13 - 22	3 X 4 - 24	9 - 22	15 - 26	13 - 20	14 - 28	15 - 18
14 - 28	5 - 16	10 - 32	6 X 7 - 20	14 - 22	15 - 30	14 X 15 - 26
15 - 24	6 - 26	11 - 22	8 - 26	15 - 28	10 X 11 - 20	105 (total)
2 X 3 - 18	7 - 24	12 - 24	9 - 14		12 - 16	
4 - 22	8 - 24	13 - 22				

DISCUSSION

GENYS - Mr. Hunt, I am somewhat confused about the meaning of the term "seed orchard". Since the establishment of seed orchards yielding superior seed stock with respect to growth rate, resistance to pests, or other desirable traits is the final goal of tree improvement, it appears important to define the "seed testing area", "seed orchard" and "orchard for production of improved seed". Your definition of these three terms would be appreciated.

HUNT - If I may bring you up-to-date on the situation that exists in New York State, we have probably the most populous state, with regard to density in some areas, and yet in other areas, we have a very low population density, Here a great deal of planting has been done and must be continued in order to stock the idle land. This is the project in which we hope to participate in the future. This requires the production of a large quantity of seed. Working in cooperation with the nursery folks at Saratoga, we hope at the year's end to have growing in orchards such species as Scotch pine, white pine, white spruce, Norway spruce and larch. I believe that's a good start. These are the main species that are used in the nurseries„ We are interested in them to varying degrees or for various uses. There are Christmas tree selections and timber selections, all of which seemed free of forest pests. As we start our seed orchard program for white pine, we generally choose the best that we can find in the old native stands of the Adirondack Preserve. We don't necessarily believe these represent the best individuals to be found in the species Therefore, as we progress we will find ourselves doing more and more progeny testing to eliminate negative clones, I hope this clarifies our position.

In regard to your questions, I would like to say that the establishment of a clonal seed orchard is the first step towards the production of improved seed. The degree of improvement depends upon the type of clonal selection employed and the extent to which clones with inferior combining abilities are eliminated. The degree of improvement will become evident through the use of progeny testing plus clonal testing. In the case of untested ortets, we can't certify genetic improvement (only certified as to source). If the seed proves to be genetically improved we may call it, as done by others, elite seed.

COOK - I'd like to ask Ernie Schreiner why he omitted the squirrel as an agent of seed collection. I've got most of my small collections of prize larch seed from squirrel collections.

SCHREINER - I forgot them, Dave. I'll include squirrels with the loggers as a possibility for cheap cone collection.

GERHOLD - I'd like to ask someone from a state organization here what incentive there might be for the state organization to produce genetic improvement in its seedling stock?

ELIASON - In general terms, in New York, we are interested in producing something better if available. The programs that we are working on with clonal orchards and seedling selections are expected to show improvement in our seed over the present method. As Hunt has pointed out, the State has had a big planting program and this will continue. Therefore, if we can improve the situation, the State organization is interested.

KLAEHN - It has been pointed out today that clonal seed orchards are, in Denmark, Sweden, Germany, and other countries, considered to be at the present time the most productive way to obtain somewhat improved seed material for reforestation purposes. We feel that the situation in New York State, as far as the seed supply is concerned, is as urgent as it can be. Everyone knows that the present practice for obtaining needed seed is very unsatisfactory. In many instances it is impossible to obtain complete information on seed sources. You also are familiar with the practice of seed collection in the woods where the early flowering and bushy trees with a high seed setting are very often the sources from which seeds are collected. This situation demands a radical change as soon as possible! Here, the most logical way to overcome this situation, is the establishment of clonal seed orchards. From the theoretical point of view some people feel that seedling seed orchards (as suggested by various workers) have genetical gain advantages over the clonal orchards. Whether this will really be true is still unknown. If this is actually true, how much time will be involved before we get the seed material required and this in sufficient quantity? It may be that in 30 or 40 years we still lack what we want!

On the other hand, everyone who has traveled through Europe and seen the highly productive seed orchards in Germany, Sweden and Denmark, where large companies own vast orchards of clonal material, is amazed by the productivity of these orchards and soon becomes convinced that this approach, as far as seed quantity is concerned, is a certain one. It is possible to walk or drive around in a truck and obtain a high number of cones from almost every graft. I have pictures which demonstrate this point very clearly, and it seems doubtful to me that a seedling will produce this amount of seed at such an early age.

There is also another point that I would like to make. It seems to me that it is quite difficult to prune seedlings onto shape them in order to stimulate flower production and to facilitate seed harvest. In clonal orchards (composed of scion wood from mature trees normally less vigorous) it is much easier to do this The productivity of clonal seed orchards begins much earlier and is much higher.

To date no seedling orchards of the suggested types exist and it will take quite a while before we will have one of good production. We need better seed as soon as possible. This is the main reason why I believe highly in clonal orchards. I am continuing this business and feel that I have to do this, I also am convinced that 99 percent of my European colleagues would do the same in my position.

SCHREINER - Fred, I don't dispute the fact that our European colleagues are recommending clonal seed orchards, but I wonder whether some of them, particularly the younger men, may not change their minds when the pros and cons begin to permiate the literature. How much exact information do we have on the superiority of grafts over seedlings for earlier and heavier fruiting? In a five-year-old Christmas tree plantation of Scotch pine seedlings in Pennsylvania I saw more cones than I did in Sweden on 5-year-old grafts. I don't think we can today generalize that we will surely get more seed from grafted trees at an earlier age; in fact Goddard and Brown dispute that assumption. But Fred, let us not forget that there are three sides to this question, your side, my side, and the correct side.

KRIEBEL - I think the species involved makes some difference here. The time factor that Fred mentioned is of some significance in the near future. The ultimate objectives may be different from the immediate objectives. In the case of sugar maple, for example, we can get flowers in a very few years, while in seedlings it is a long term proposition. In propagating for sugar content we would like to get seed as soon as we can, but ultimately the seedling seed orchard might be the thing. So the species factor and the time factor are two considerations that should enter in.

KLAEHN - Here in the Northeast, State Nursery people are becoming more and more interested in starting a program similar to our New York State Cooperative Seed Orchard program. The visitors who came to discuss this matter asked me about the paper of Goddard and Brown. Just where the interest in this phase of our work was growing, enthusiasm deadened. They became uncertain about spending immediately effort and funds on the clonal orchard approach and postponed their plans. The establishment of seedling seed orchards in the prescribed way is out of the question for most of them as it requires too much time. In summary, I believe we should encourage people, stimulate interest wherever we can and be glad that they are willing to participate actively in our work. We should not discourage or confuse them with theoretical considerations which have as yet not been proven. Anyway, I did my best to convince them and I hope I talked them back into my line which as you know, is clonal seed orchards.