A PILOT TRIAL OF SOIL STERILISATION IN A FOREST NURSERY

I. J. THULIN, G. M. WILL, and C. BASSETT*

Summary

A soil sterilisation trial with chloropicrin and formalin on a light textured pumice soil resulted in a significant reduction in seedling mortality and an increase in growth. Plant analyses indicate an improvement in the availability of nutrients, particularly potash. In this respect the chloropicrin was the more effective. Species used in the trial were Pinus radiata, P. nigra, Pseudotsuga taxifolia, Larix decidua *and* Picea sitchensis.

INTRODUCTION

Heavy mortality in tree seedlings, raised for the establishment of provenance trials, has been experienced in the nursery at the Forest Research Institute, Rotorua. Particularly heavy losses occurred in larch, Douglas fir, Corsican pine and *Abies* spp. due to root rot caused by a species of *Pythium.*

In view of the high experimental value of the seed available for sowing in 1957, it was decided as a precaution to sterilise the sowing area of 15,000 sq. ft. to a depth of six inches with chloropicrin.

Partial soil sterilisation is common practice in horticulture and has been used in forest nurseries overseas, but not as yet in New Zealand. Therefore, a pilot experiment was laid down to test the effect of partial soil sterilisation, by chloropicrin and formalin, on the survival and growth of tree seedlings on a pumice soil. A preliminary report is given below of the results obtained from this trial during the first year.

METHODS

The trial was located in a section of the nursery with a low humus content and low nutrient levels. Very heavy mortality had occurred in tree seedlings, growth had been poor and green crops of lupins and oats had failed. The soil is a sandy silt loam.

Three beds, 157 ft long and four ft wide, were laid down parallel to each other, 12 ft apart. Each bed was divided into 21 equal sections. Radiata pine forest duff at the rate of one bushel per 22 sq. ft was worked into two sections, one of them prior to sterilisation of the soil and the other after sterilisation. A mixture of Douglas fir and larch duff was similarly applied to two further sections. Fertilisers in various combinations and at various rates were applied to six sections immediately prior to sowing. The remaining eleven sections received no treatment.

* Forest Geneticist, Soil Chemist and Forest Mycologist, respectively, Forest Research Institute, Rotorua.

One of the three beds was sterilised with chloropicrin at a rate of 11 lbs (0.52 gal.) per 1,000 sq. ft by injection of three ml. per sq. ft to a depth of six inches.

Formalin was applied as a drench to a second bed; 10 gal. of commercial 38% formalin in 120 gal. of water, per 1,000 sq. ft.

The third bed was not sterilised and was left as a control.

Stratified seed was sown early in November, five weeks after sterilisation. Five species were sown in drills in each bed at the following rates:

Radiata pine, 180 grams per 150 ft of drill.
Corsican pine, 200 grams per 150 ft of drill.
Douglas fir, 100 grams per 150 ft of drill.
European larch, 85 grams per 150 ft of drill.
Sitka spruce, 35 grams per 150 ft of drill.
(28 grams equal 1 oz.)

No subsequent treatment was applied against disease. Surrounding weeds seeded on to the beds during the time between sterilisation and sowing, so it was not possible to check the effect of sterilisation as a weed control.

COSTS

Based on the sterilisation of 15,000 sq. ft, the injection of 11 lbs of chloropicrin per 1,000 sq. ft can be done in four man-hours. It is estimated that the application of 130 gal. of diluted formalin might also be done in four man-hours.

Chloropicrin costs 6/- per lb and formalin 9/- per gal. i.e., £3/6/- and £4/10/- respectively per 1,000 sq. ft. at the application rates used.

RESULTS

Germination and survival:

There was no difference in the numbers of seedlings germinated in each bed, suggesting that pre-emergence losses in the unsterilised bed were negligible.

Accidental mortality occurred when the radicles of germinating seedlings were forced from the ground by mass germination. Warm conditions withered the exposed root tips which were then unable to extend, although the seedlings lived on for some time. This caused up to 10 per cent. loss in Corsican pine, less in larch, and practically none in the other species. No pathogens were associated with these deaths, although damping off fungi inevitably overtook some that lay on the soil surface for several days. These losses were evenly spread over the three beds.

Subsequent survival of seedlings was markedly high in the sterilised beds; survival in all fertiliser and duff treatments did not differ from that in the controls.

Damping off began immediately after germination and caused heavy losses over the first four weeks. It occurred in all three beds, but was by far the most severe in the control bed. The main pathogen was *Rhizoctonia solani*, the vegetative stage of *Pellicularia filamentosa*.

Root rot began to kill seedlings when they were about one month old, the main causal organism being *Pythium ultimum*. Attack began relatively deep in the soil and spread gradually upward, causing a slow decline in health and vigour, indicated by a progressive yellowing of the foliage. Mortality was heaviest in the control bed.

A prolonged hot dry spell in January, after the frames had been lifted, caused quite heavy losses among the spruce and larch. The diagnosis of these deaths was complicated by the presence of root disease; it seems certain that drought and root rot were mutually aiding factors and it was usually difficult to separate their effects. Once again, mortality was heaviest in the control bed.

Tables 1 and 2 summarise the position at the final count when the seedlings were three months old.

TABLE 1

Mortality per cent. of Total Germination

Three months after emergence

Treatment	Radiata Pine	Corsican Pine	Douglas Fir	European Larch	Sitka Spruce	Mean
Control	18.0	58.0	9.5	49.5	48.0	40.0
Formalin	4.5	19.5	3.5	25.5	15.5	14.5
Chloropicrin	5.0	29.5	6.0	24.0	20.0	17.0

TABLE 2

Number of Surviving Seedlings per Bed

Three months after emergence

Treatment	Radiata Pine	Corsican Pine	Douglas Fir	European Larch	Sitka Spruce	Total
Control	3,480	2,580	3,950	1,970	4,490	16,470
Formalin	3,420	5,130	4,160	2,500	8,390	23,600
Chloropicrin	3,800	4,000	4,750	2,480	7,250	22,280

Although the same pathogens caused death in all three treatments, there was a significant reduction of mortality in both sterilised beds. There is always a possibility that pathogens will become more active than ever in a sterilised soil with fewer competing organisms, but that did not happen in this case.

The five species showed a marked variation in their resistance to the different types of mortality. Corsican pine was particularly susceptible to damping off, while spruce and larch suffered quite heavy mortality from the combined effects of drought and root rot.

At the age of four months, all five species in each bed had developed mycorrhizae, regardless of any treatment.

The presence of both mycorrhizal and pathogenic fungi in the sterilised beds may be attributed to one or more of the following: incomplete sterilisation, re-infection by air-borne inoculum, re-infection from the underlying unsterilised soil.

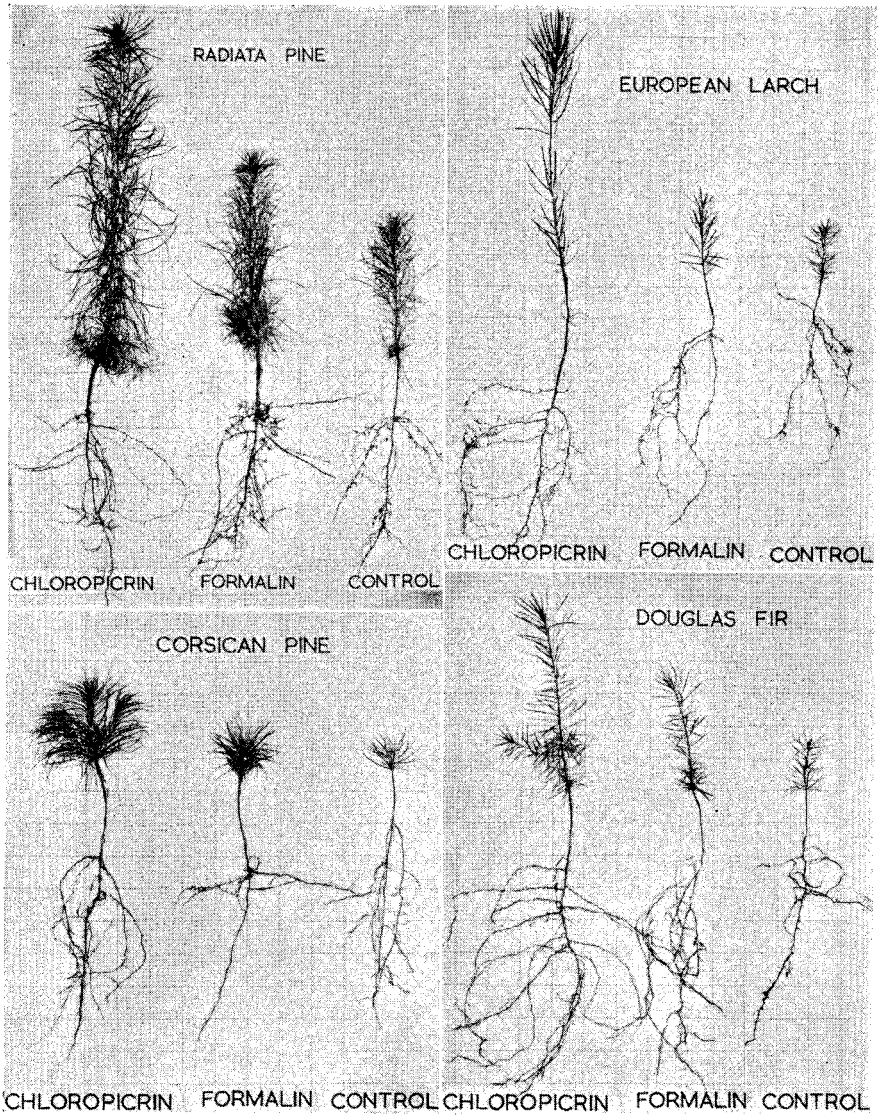

Figure 1

Average seven month old seedlings from each bed.
(Photographed against a one inch grid)

Growth

About three months after sowing, increased height growth of seedlings in the sterilised beds became noticeable. Towards the end of the season, small height differences were also observed in the sections which had received the heaviest fertiliser treatments and the duff treatments but these differences were confined to the non-sterilised bed. Table 3 gives the increases in the height of each species attributable to the soil sterilisation and to the fertiliser and duff treatments.

TABLE 3

Comparative Heights of Seedlings in Various Treatments. Age 7 Months
Heights of Controls = 100

Treatment	Radiata Pine	Corsican Pine	Douglas Fir	European Larch	Sitka Spruce
Control	100	100	100	100	100
Duff 1*	100	145	150	145	105
Duff 2*	110	130	155	165	100
Fertiliser**	140	100	125	260	110
Formalin	140	140	235	205	140
Chloropicrin	240	260	375	455	250

* Duff 1—Radiata pine duff—control bed.
* Duff 2—Douglas fir plus European larch duff—control bed.
** Superphoshate 3 cwt/ac., Sulphate of potash 1½ cwt/ac., Sulphate of ammonia 1 cwt/ac.—control bed.

Increases in the weights of seedlings were in proportion to the height increases. Table 3 shows that the increases found in seedlings from sterilised beds greatly exceeded those found in seedlings from beds treated with fertilisers or duff. In the cases of Corsican pine and European larch, it should be remembered that, although formalin, fertiliser and duff treatments gave similar height increases, the formalin resulted in much lower mortality.

With the increased height growth there was some increase in the shoot/root ratio—for radiata pine the figures were: unsterilised bed 4.2 to 1, formalin treated bed 4.4 to 1 and chloropicrin treated bed 6.5 to 1. However, as can be seen from Figure 1 all seedlings had good root systems and there is no reason to believe that the increase in size has resulted in a less desirable type of seedling.

Nutrient Uptake by Radiata Pine Seedlings

The chemical analysis of seedlings has shown that the quantity of calcium (lime), nitrogen, and phosphate per seedling increased approximately in proportion to the increase in weight. However, while the weight of an average seedling from the chloropicrin bed was a little more than twice that of one from the untreated bed, the potash content per seedling was nearly three times as great. Seedlings from th formalin bed also showed an increase in the concentration of potash but it was smaller than the increase in the chloropicrin bed.

Table 4 gives the equivalent quantities of commercial fertilisers removed by one-year radiata-pine seedling crops grown in unsterilised

TABLE 4

Equivalent Quantities of Fertilisers Removed from a Nursery Soil in One-Year Radiata Pine Seedlings

(lb/acre; 50,000 trees per acre)

	Lime	Sulphate of Potash	Sulphate of Ammonia	Superphosphate
Unsterilised soil	10	25	120	25
Sterilised soil (chloropicrin)	20	70	210	55

soil and in soil sterilised with chloropicrin. These figures are based on the production of half a million seedlings per acre.

CONCLUSIONS

We would emphasise that this experiment was a pilot trial only, with no replications, a single rate of application of two chemicals and covering one soil type—a light textured pumice soil of low fertility.

With these reservations, the following conclusions can be drawn:

1. Soil sterilisation significantly reduced mortality.
2. A marked increase in growth resulted from soil sterilisation, chloropicrin giving the greater increase.
3. Indications are that the availability of some nutrients, particularly potash, is increased by soil sterilisation.
4. Results confirm overseas experience that, in certain circumstances, soil sterilisation can be economically justified in forest nurseries.

Replicated trials are planned using different application rates of soil sterilants. These trials will be carried out in nurseries representing a range of soil types and climates.