EFFECT OF MOLASSES AND FORMALIN ON THE SOIL STRUCTURE AND PRODUCTION OF FOREST NURSERY SEEDBEDS

By T. J. BECKMANN, B.Sc., A.R.A.C.I., Chemist, Chemical Laboratory, Division of Plant Industry.

SUMMARY.

Application of molasses to selected forest nursery soils improved soil structure. The improvement was reflected in growth of seedlings and the proportion of plantable stock obtained. The increases in growth were greater than those obtained with partial soil sterilization.

I. INTRODUCTION.

Forest nurseries producing seedlings for reafforestation in Queensland have been worked under monoculture for a number of years. In some nurseries producing *Araucaria cunninghamii* (hoop pine), a gradual decline in the growth of seedlings was noticed, despite the fact that adequate fertilizer was supplied. This suggested the necessity for examining other factors, such as soil structure, which might influence growth.

Nurseries at Yarraman and Benarkin, on the Blackbutt Range in south-eastern Queensland, were selected for investigation. The Yarraman nursery soil is a lateritized clay developed from andesite. The Benarkin nursery soil is a clay presumed to be developed from hardened shales.

Chemical analyses showed no unbalance or great lack of the major nutrients. Analyses of the two nursery soils (0–9 in. depth) are given below.

	Yarraman.	Benarkin.
pH (2 : 5 soil/water suspension)	6·2	5·7
Available P_2O_5 p.p.m. (soluble in N/100 H_2SO_4) ..	256	152
Repl. Ca^{++} (m–equiv. per 100 g.)	6·3	6·3
Repl. Mg^{++} (m–equiv. per 100 g.)	6·4	7·1
Repl. Na^{+} (m–equiv. per 100 g.)	0·41	0·16
Repl. K^{+} (m–equiv. per 100 g.)	0·56	0·31
Total N (%)	0·18	0·18

Experiments carried out at Yarraman by the Sub-Department of Forestry showed that the application of trace elements gave no increase in production, and NPK trials with and without animal manure topdressing at each nursery showed that the greatest growth followed the manure topdressing.

In both nurseries tilth was poor in spite of the presence of sawdust in the soil. This fact, together with the results obtained with manure, led to consideration of the soil structure as a possible cause of low productivity. This idea was supported by preliminary tests which showed that the soil had very poor aggregation. However, because of the many years of monoculture the possibility of a stagnant soil microbiological population could not be ruled out.

With respect to the latter, partial sterilization with formalin followed by re-inoculation with soil from a forest plantation was tried. Treatment with some substance high in easily available carbohydrate so as to give an impetus to the microbiological population was also planned. Since it has been shown by Martin and Waksman (1940, 1941) that the microfloral population in the soil is responsible for a large degree of the aggregation, the second treatment was expected to improve the soil structure. Shortly after the experiment was begun it was shown by Swaby (1949) that fungi in particular exerted a great effect on the aggregation of soil particles. Browning and Milam (1944) showed that sucrose is an excellent material for improving the soil structure. As molasses is a readily available form of sugars and has been applied with good results in sugar-cane soils, it was used in these experiments.

The normal practice for the production of hoop pine seedlings in Queensland nurseries is as follows:—

Plants are grown from seed in high-shade nurseries which provide half shade. Seed is sown by hand in drills 8 in. apart, aiming at eight plants per foot of drill. A cover of $\frac{3}{4}$ in. of hoop pine sawdust is added after sowing, which is done in September. Thinning is done during the first winter following sowing. In the February before lifting—i.e., approximately 18 months after sowing—the seedlings are root-wrenched. Cultivation and weeding are done plot by plot. At the end of the 2-year period, plants are lifted, measured and classified for suitability for planting stock (tubing stock).

II. COMPARISON OF MOLASSES AND FORMALIN.

The following technique was used in comparing the effects of molasses and formalin on the growth of hoop pine seedlings.

Plots were laid out as a randomised block, with five replications. The gross plot size was 5 ft. x 5 ft. with 1-row isolation strips around each of them. Formalin was applied at the rate of 14 gal. of 2 per cent. formaldehyde solution to the appropriate plots, which were then covered with sacking for three days, after which they were uncovered and allowed to stand for 10 days. Inoculating soil was then dug into each plot, which was then raked smooth. Molasses was applied evenly over the surface of the soil at the rate of 14 lb. per plot. The treated plots were allowed to stand for one week, and then lightly watered with 2 gal. of water per plot. After another standing period of one week the soil was dug over to a depth of 9 in. and raked smooth. The normal sowing and tending practices of the nursery followed.

As it became evident after the first trial that the molasses treatment was superior to the formalin treatment, the latter was discontinued and those plots also treated with molasses.

Plant heights were recorded at 3 in. intervals, and the number tubed and the number discarded as unsuitable were also noted. Water-stable aggregates in samples taken from the plots before the seedlings were lifted were determined by the Downes and Leeper (1940) modification of the method of Myer and Rennenkampf.

The results of the first trials are summarised in Table 1, which shows the mean heights and percentages of stock tubed. The aggregate analyses will be discussed later.

Table 1.

SUMMARY OF RESULTS OF FIRST TRIALS.

Treatment.	Mean Height of All Plants. (in.)	Mean Height Tubed Stock. (in.)	Percentage Plants Tubed.
Yarraman.			
Control	5·10	7·07	37·53
Formalin	5·47	7·27	42·32
Molasses	6·28	7·88	54·30
Benarkin.			
Control	7·06	9·67	16·77
Formalin	8·46	10·75	45·30
Molasses	10·42	12·64	61·70

The figures from Yarraman show no significant differences at the 5 per cent. level for the mean height of tubed plants. The mean height of all stock and the percentage of plants tubed show that the molasses treatment produced significant differences at the 5 per cent. level. Better results were obtained at Benarkin, where both the molasses and the formalin treatments are significantly higher than the controls at the 5 per cent. level. Furthermore, the molasses treatments were significantly better at the 1 per cent. level than the control and formalin plots.

III. MOLASSES EXPERIMENTS.

The trials using molasses were repeated for two additional growing seasons, but as mentioned previously the formalin treatments were discontinued and these plots also treated with molasses. For ease in tabulation the molasses plots are designated C treatments and those which were treated with formalin originally are designated B treatments.

Fig. 1 shows the distribution of aggregates for each treatment at Yarraman and Benarkin. The ordinate shows the mass of aggregate minus grit on each sieve.

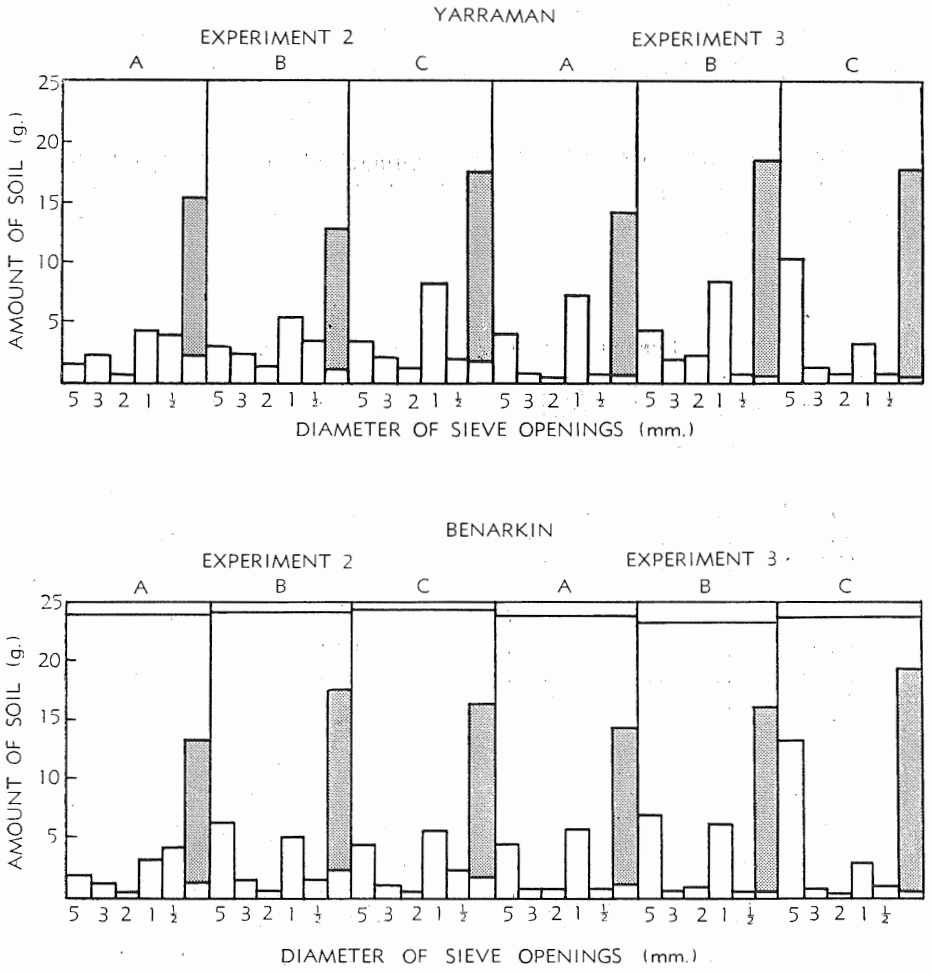

Fig. 1.

Distribution of Aggregates in Experiments 2 and 3. The shaded portion represents the total aggregates retained on all sieves. The portion underneath this represents the quantity retained on a 70 IMM sieve. The horizontal lines at the top of the histograms represent the quantity of oven-dry soil used in the determination.

The change in disaggregation for the different experiments is summarised in Table 2.

Table 2.

PERCENTAGE DISAGGREGATION OF SOILS.

Experiment.	Control.	B Treatment.	C Treatment.
Yarraman.			
1	20·8	20·8*	12·6
2	17·9	13·8	9·7
3	24·0	8·7	7·6
Benarkin.			
1	39·5	39·5*	29·2
2	28·6	27·4	21·1
3	29·2	19·6	11·6

* Formalin treatment.

It will be noted that the effect of molasses treatment is to increase not only the total aggregation but also the aggregate size. This shift from small to large particles is evident in Fig. 1 (Benarkin), which also shows that the shift is in two stages—first, a build-up of 1 mm. size particles, and secondly, a build-up of 5 mm. particles with depletion of the 1 mm. size.

The mean heights of plants in the plots and the percentage of plants selected for planting out (i.e., stock tubed) are given in Tables 3 and 4.

Table 3.

MEAN HEIGHT OF STOCK.

Experiment Number.	Control. (in.)	B Treatment. (in.)	C Treatment. (in.)
Yarraman.			
1	5·1	5·5*	6·3
2	8·3	9·4	9·4
3	8·6	9·4	10·2
Benarkin.			
1	7·1	8·5*	10·4
2	6·4	9·9	9·9
3	6·8	12·1	11·4

* Formalin treatment.

At Yarraman the heights are significantly greater than the control in all except the B treatments in Expts. 1 and 3. The increases in Expt. 3 at Benarkin are not significant; neither is the fall in percentage of stock tubed recorded for the C treatment of Expt. 2 significantly different from the control. The differences in mean height and percentage of stock tubed between the B and C treatments are not significant, but both are significantly higher than the controls.

Table 4.

PERCENTAGE OF STOCK TUBED.

Experiment Number.	Control.	B Treatment.	C Treatment.
Yarraman.			
1	37·5	42·3*	54·3
2	72·8	79·1	70·4
3	70·1	75·1	75·0
Benarkin.			
1	16·8	45·3*	61·7
2	48·2	74·5	87·8
3	54·4	82·6	78·1

* Formalin treatment.

The experiments were complicated somewhat by a severe drought which extended over a period covering the end of Expt. 2 and the beginning of Expt. 3. The effects of the drought were more severe at Yarraman than at Benarkin.

It would appear from Fig. 1 that plant height is related to the amount of 1 mm. aggregates present in the soil but that the quantity of aggregates 5 mm. or greater increasingly exerts an effect contrary to that of the 1 mm. aggregates.

It should be noted that the decrease in disaggregation is the same for Expts. 1 and 2 but that a greater decrease was obtained at Benarkin than at Yarraman.

The differences between the nurseries is due to the different type of clay minerals present in the soils. X-ray diffraction measurements of the clay fractions from the soils were made and powder and aggregate photographs were prepared. The Yarraman clay was found to consist of kaolinite-type mineral with small amounts of montmorillonite and haematite and a trace of quartz. The Benarkin clay was similar but contained approximately 25 per cent. of montmorillonite and approximately 2 per cent. of quartz.

IV. CONCLUSIONS.

Treatment of nursery soils with molasses at the rate of 14 lb. per sq. yd. has been shown to improve the structure of the soils. This improvement in structure is reflected in the increases in height of seedlings grown and in the percentage suitable for planting.

Partial sterilization, although effective in increasing growth, is not as successful a treatment as molasses.

V. ACKNOWLEDGEMENTS.

Grateful acknowledgement is made to the Agricultural Chemist (Mr. C. R. von Stieglitz) for much advice; and to the District Forester and his nursery staff at Yarraman (in particular to Mr. M. A. Cameron, Research Forester) for tending the plots and making measurements. The X-ray analyses were done through the courtesy of the University of Queensland and thanks are due to Dr. Cole, C.S.I.R.O. Building Materials Research Division, for great help in interpretation of the X-ray patterns. The statistical analyses were done by Mr. P. B. McGovern, Biometrician in the Division of Plant Industry.

REFERENCES.

BROWNING, G. M., and MILAM, E. M. 1944. Effect of different types of organic materials and lime on soil aggregation. Soil Sci. 57: 91-106.

DOWNES, R. G., and LEEPER, G. W. 1940. The measurement of soil structure. Proc. Roy. Soc. Vict. 52: 1-20.

KERR, H. W., and VON STIEGLITZ, C. R. 1935. Soil analytical methods employed in Queensland. 5th Congr. Int. Soc. Sug. Cane Tech.: 624-630.

MARTIN, J. P., and WAKSMAN, S. A. 1940. Influence of micro-organisms on soil aggregation and erosion. Soil Sci. 50: 29-47.

MARTIN, J. P., and WAKSMAN, S. A. 1940. Influence of micro-organisms on soil aggregation tion and erosion.II. Soil Sci. 52: 381-394.

SWABY, R. J. 1949. The relationship between micro-organisms and soil aggregation. J. Gen. Microbiol. 3: 236-254.