Some nursery men have used the same organic residues for three or more extractions with fairly satisfactory results. If such repeated treatments are practiced, it must be realized that after the first extraction the organic matter will be nearly saturated with bases and ammonia, and, therefore, a much higher proportion of the fertilizers will come through in the solution. Consequently, in preparation of suspension the content of salts must be proportionally decreased.

The application of liquid humates is a very expensive treatment and should be limited primarily to the stock seriously upset by malnutrition or injured by chemical, climatic, or biotic agents. On the other hand, liquid humate treatment is the most efficient means of stock recovery available at present to the nursery manager.

References


CHAPTER XXXI

GREEN MANURES

Selection of Crops Suitable for Nursery Purposes

The practice of raising transitional crops of rapidly-growing species is used in forest nurseries for a triple purpose: to enrich soil in organic matter and nutrients by plowing under the succulent tissue of green-manure crops; to prevent the loss of soluble salts by leaching by incorporating them into the tissue
Figure 85. Preparation and application of fertilizers in forest nurseries: (a) Shredding of peat and duff for compost; (b) Concrete pit provided with conveyor to facilitate the stratification of compost; (c) Distribution of fertilizer by rototiller; (d) Application of liquid fertilizer by means of the Wisconsin multiple-use sprayer.
of catch crops; to protect exposed soil from erosion and weeds by cover crops. Both cover and catch crop are usually used as green-manure.

Whenever the conditions permit, green-manuring is accomplished with leguminous plants which enrich soil in nitrogen. Various species of lupine, soybeans, and cowpeas are commonly used. Satisfactory results have also been reported with a number of other leguminous crops, particularly vetch, beans, clover, serratella, Lathyrus clymenum, and Medicago lupulina. If high cost of seed or soil acidity do not favor raising legume crops, they may be replaced by less exacting non-legumes. The choice of these latter crops is largely limited to rye, oats, and buckwheat.

The selection of suitable green-manure crops is usually dictated by local conditions, but in general preference is given to rapidly-growing species having abundant and succulent tops. In most nursery soils the pH value confines the selection of crops to soybeans, yellow lupine, and non-legumes.

Advantages and Short-Comings of Green-Manuring

The use of green-manures has a strong appeal to a nurseryman. This method of soil fertility maintenance does not involve particular difficulties or danger of burning the stock. However, among many beneficial effects that have been attributed to green-manuring only few are undisputable under conditions of nursery soils.

Green-manuring improves physical properties of the soil, especially its structure and water-holding capacity. It exerts a conserving influence on the soil nutrients, and, in case of legume crops, augments the supply of nitrogen. The liberation of carbon dioxide and organic acids by decomposing tissues are said to increase the availability of nutrients, such as phosphorus, potassium and calcium.

On the other hand, the gains in organic matter and base exchange capacity due to green-manuring are too small to satisfy requirements of most nursery soils. At best, on sandy soils with artificial irrigation green-manure crops may help to maintain the level of these basic fertility factors. Consequently, the practice of periodic rotations of nursery blocks with green-manure as a transitional crop is seldom justified.

The toxicity of green-manure crops to the seedlings, danger of white gruél infestation, and encouragement of damping-off disease appear to be greatly exaggerated. In most instances these ill effects are brought about by untimely seeding or plowing under of soiling crops, or seeding of nursery stock. The high carbon-nitrogen ratio of non-legume crops is likely to be the condition responsible for inhibited growth of seedlings under unskilled management.

Catch Crops

As recent studies have indicated, green-manures attain their greatest importance in forest nursery practice serving as "catch crops" for commercial fertilizers (Cady; Brener and Wilde).
A comparison of available nutrients determined by analysis with growth data and the results of plant tissue analyses has shown that a considerable fraction of applied commercial fertilizers is temporarily fixed by green-manure crops as difficultly soluble organic compounds. These compounds, however, become gradually available in the course of plant tissue decomposition and benefit the growth of forest seedlings or transplants. From the standpoint of nursery stock production, this conversion of mineral fertilizers into slowly acting and less dangerous organic compounds is just as important as the reduction of fertilizer losses through leaching.

In localities where peat is not available, a catch crop is about the safest and most suitable method of fertilization. Under average conditions, 200 to 300 pounds of 20 per cent superphosphate and 100 to 200 pounds of 50 per cent muriate of potash per acre may be suggested as suitable applications ahead of seeding legume crops. In raising non-legumes, these fertilizers should be supplemented with 100 to 200 pounds per acre of ammonium sulfate. The state of available nutrients in soil, however, may considerably modify the amount of fertilizers required.

Tables 37 and 38 illustrate the effect of non-legume green-manure upon the state of fertility of a sandy nursery soil and the development of white ash seedlings. Table 39 presents data on the development of red pine in sand cultures with and without green manure.

The most serious objection to the use of catch crops is the loss of one growing season.

Table 37. Effect of Buckwheat Green-Manure upon the Fertility of a Sandy Nursery Soil as Determined by Chemical Analysis. Fertilized Plats Receive 2,000 Pounds of a 4-4-10 Mixture per Acre. Fertility of Soil One Year after Application of Fertilizer and Green Manuring. (Central State Forest Nursery at Wisconsin Rapids, Wisconsin)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Base pH</th>
<th>m.e./100 g</th>
<th>Ca per cent</th>
<th>Replaceable m.e./100 g</th>
<th>N per cent</th>
<th>Organic matter</th>
<th>Total P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;</th>
<th>K&lt;sub&gt;2&lt;/sub&gt;O</th>
<th>Available N per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated soil</td>
<td>5.46</td>
<td>4.73</td>
<td>3.28</td>
<td>.063:43.5:112.4</td>
<td>2.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertilizer alone</td>
<td>5.32</td>
<td>4.67</td>
<td>3.21</td>
<td>.060:60.7:139.0</td>
<td>2.45</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green manure alone</td>
<td>5.24</td>
<td>5.27</td>
<td>3.47</td>
<td>.067:52.0:110.4</td>
<td>1.87</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertilizer and green manure combined</td>
<td>5.17</td>
<td>5.39</td>
<td>3.59</td>
<td>.070:77.5:154.6</td>
<td>2.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 37: Effect of Buckwheat Green-Manure upon the Fertility of a Sandy Nursery Soil as Determined by Chemical Analysis. Fertilized Plots Receive 2,000 Pounds of a 4-4-10 Mixture per Acre. Fertility of Soil One Year after Application of Fertilizer and Green Manuring. (Central State Forest Nursery at Wisconsin Rapids, Wisconsin)*
Table 33. Effect of Buckwheat Green Manure "Catch Crop" upon the Content of Nutrients in the Tissue of One-Year Old White Ash Seedlings

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Weight of an average seedling</th>
<th>( \text{N} ) per cent</th>
<th>( \text{P}_2\text{O}_5 ) per cent</th>
<th>( \text{K}_2\text{O} ) per cent</th>
<th>( \text{CaO} ) per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check</td>
<td>0.94</td>
<td>1.72</td>
<td>0.40</td>
<td>0.69</td>
<td>0.94</td>
</tr>
<tr>
<td>Fertilizer alone</td>
<td>1.43</td>
<td>1.77</td>
<td>0.41</td>
<td>0.92</td>
<td>0.98</td>
</tr>
<tr>
<td>Green manure alone</td>
<td>1.17</td>
<td>1.72</td>
<td>0.40</td>
<td>0.66</td>
<td>0.39</td>
</tr>
<tr>
<td>Fertilizer and green manure</td>
<td>2.02</td>
<td>1.84</td>
<td>0.43</td>
<td>1.22</td>
<td>0.98</td>
</tr>
</tbody>
</table>

Table 39. Effect of Non-legume Green-Manure upon the Development and Chemical Composition of Red Pine Transplants Grown for Five Months in Quartz Sand Cultures

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Average weight of transplants</th>
<th>:Average root :Ave. size of buds</th>
<th>Analysis of tissue per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>grams</td>
<td>mm.</td>
<td>mm.</td>
</tr>
<tr>
<td>Sand treated with 1,000 lbs. of 4-6-10 fertilizer per acre</td>
<td>1.37</td>
<td>0.69</td>
<td>2.1</td>
</tr>
<tr>
<td>Sand treated with 1,000 lbs. 4-6-10 fertilizer per acre and green-manure</td>
<td>2.43</td>
<td>0.77</td>
<td>2.9</td>
</tr>
</tbody>
</table>

Cover Crops

When conditions require a temporary decrease in the production of nursery stock, the fallowed area should be kept under a cover crop or be used as farming land for raising corn, potatoes, or other agricultural products. Such practice helps to protect the soil from water and especially wind erosion, excessive oxidation, leaching, and infestation with obnoxious weeds. The beneficial effect of cover crops is unquestionable.
Seeding and Turning Under Soiling Crops

As a general rule, green-manure crops are seeded in the spring shortly after the nursery stock is lifted. In the years when a large flight of June beetles is expected, seeding must be delayed until the egg-laying period is nearly over.

The success of green-manuring with legumes depends greatly upon careful inoculation of seed with the proper culture of nodule bacteria. Some nursery soils have been inoculated by broadcasting surface soil from a field which previously supported a productive stand of legumes. One hundred pounds of soil is sufficient to inoculate one acre of nursery according to Tillotson. This method, however, is not as reliable as seed inoculation.

The plowing under is done before the crop matures or the tops lose their succulent character. Allowing green-manure to mature may infest nursery beds with an undesirable volunteer crop; this is especially true in raising buckwheat. The decomposition of the hardened tissues with their high carbon-nitrogen ratio may bring about a shortage of available nitrogen.

In plowing under green-manures, the furrow slice should not be thrown entirely over, but rather against and on the adjacent furrow-slice. In this way of plowing the green manure is distributed evenly throughout the whole layer of surface soil. Deep plowing, however, is recommended in nurseries which do not use artificial methods of damping-off control.

The turned under green-manure is left to decompose until the plant remains do not interfere with the preparation of seed beds. Forest seed is planted in fall of the same year or in the following spring. In some instances two crops of green-manure are raised during the same growing season, or green-manure crop is followed by a catch crop of non-legumes, usually rye. The second crop is plowed under two or three weeks before the preparation of seed beds. If cover crop is left over winter, at least two weeks should elapse in the spring between plowing under green-manure and planting of forest seeds or seedlings; otherwise germinating seeds and young plants may be injured by toxic by-products of plant tissue decomposition.

Selected References


CHAPTER XXXII

ADJUSTMENT OF NURSERY SOIL FERTILITY

The Problem of Fertility Maintenance in Nursery Soils

Although the relation of the chemical composition of soil to tree growth was a subject of many investigations in the course of the past hundred years, little reliable information has been obtained (zu-Leiningen). In most of the earlier experiments a number of important conditions were overlooked or misinterpreted. The chemical analysis of soils was performed by the use of strong solutions which extracted not only easily soluble or available nutrients, but also difficultly soluble compounds unavailable to plants. No regard was paid to the distribution of nutrients in different soil horizons. The reactions between the nutrient salts, colloids, and other soil constituents were not considered. The studies dealt largely with specific constituents and disregarded the influence of numerous other chemical and biological factors. The production of dry matter alone was studied in fertilizer trials, but the anatomical and physiological development of the seedlings was ignored. Particular attention was given to the encouragement of luxuriant vegetative growth, but not to the development of vigorous seedlings resistant to