SOIL TESTING AND SOIL FERTILITY MAINTENANCE

C.T. Youngberg

Forest Soils
Consultant Corvallis,
Oregon

The main goal of nursery management is the production of high quality planting stock that has an excellent chance for survival and establishment on widely diverse planting sites. Since soil is the basic resource on which nursery production is dependent, good soil management based on an adequate understanding of the soil system becomes an important factor in reaching this goal.

Although certain basic principles of soil management may be applicable to all forest nurseries, a sound soil management program must be based upon a thorough understanding of the soil system of each individual nursery. Secondly, establishment of a monitoring program: designed to develop management recommendations o fit existing soil conditions at each nursery is essential. It is important to have a good understanding of both physical and chemical conditions of the soil. For example, poor physical conditions may result in poor drainage and aeration, which in turn will influence nutrient uptake. Obviously, this will influence how soil and plant analysis data are interpreted.

Monitoring the changes that occur as a result of tillage practices, root pruning, lifting, and numerous trips by equipment over an area is somewhat difficult. Very few nurseries have a resident soil scientist on their staff. Usually one of the technical staff will be given the responsibility for soil management. In view of the fact that the soil is the basic resource upon which nursery production is based, less expertise is devoted to soil management in proportion to its importance than to other aspects of nursery management.

Monitoring soil organic matter levels and levels of nutrients is a somewhat simpler task than the monitoring of physical parameters. Most nurseries have some kind of a soil sampling program and analytical services are available. Fertilizer recommendations of varying; quality are made from the analytical data or the nurseryman may interpret the data himself.

SOIL TESTING

A soil testing program consists of three parts: (1) sampling, (2) analysis, and (3) interpretation.

Sampling. A soil testing program is only as good as the sampling techniques used. In order to derive the maximum benefits from a

soil fertility monitoring program, careful planning of sampling techniques and record keeping are essential.

For routine monitoring purposes, blocks/compartments should be sampled and designated the same way each time sampled. In order to maintain valid records, a guide to sampling should be prepared, so that when nursery personnel change, sampling techniques can remain consistent.

The actual sampling should consist of a composite sample representative of the area sampled. A 3/4" diameter sampling tube is handy for sampling. Cores should be placed in a clean plastic pail (free of chemicals or fertilizer materials) and thoroughly mixed and a sub sample taken to send to the lab. If distinctly recognized differences in soil conditions occur within a block/compartment, these should be sampled separately. Soil sample bags and information sheets are available upon request for anyone wishing to use the services of the Oregon State University Soil Testing Laboratory.

Analysis. Following the North American Forest Tree Nursery Soils Workshop held at Syracuse, N.Y. in 1980, Steve McDonald, U.S. Forest Service; Ed White, SUNY--Syracuse; Chuck Davey, North Carolina State University; Earl Stone, University of Florida, and I met to discuss how the soil testing needs of the forest nursery industry could be met most efficiently. Based on expertise and labs currently functioning, three labs were designated as possibilities: (1) SUNY--Syracuse for the Northeast, Midwest and Lake States, a lab to be designated for the Southeast, South and Mid-south, and the Soil Testing Lab at OSU for the Western States. This same group also met in December 1980 to discuss standardization of analytical procedures. It was agreed that we would all use basically the same methods for everything but phosphorus (P). Each lab will use different methods for P determination.

The soil testing lab at Oregon State University has done analytical work for private, state and federal nurseries in all of the western states except Arizona and New Mexico as well as in South Dakota and Nebraska. The tests available are shown in Table 1. mechanical analysis and moisture retention determinations can also be done.

For samples received from Intermountain nurseries the method for P analysis is determined after the p11 has been determined. If the soils are alkaline (pH > 7), the sodium bicarbonate extraction method is used. If the soils are acid, a dilute acid-fluoride extraction is used. Other basic tests are done by standard methods for both alkaline and acid soils (Berg; and. Gardner 1978).

Suggested ranges of p11 and various nutrient factors for producing Douglas-fir in forest nurseries are given in Table 2 (Youngberg and Austin 1954). Until more data are available, these same values can be used for other conifer species. Tom Landis, U.S. Forest Service Western Specialist, has developed target ranges for Intermountain nurseries. These values are given in Table 3. It should be emphasized that the values presented in Tables 2 and 3 are only targets to aim for.

It should not be assumed that the addition of sufficient fertilizer material to make up the difference between the soil test level and the desired level will necessarily be adequate. As mentioned, these values are a target to aim for. Amounts required to supply needed levels of nutrients will vary among soils having similar soil test values. For example, nursery "A" having a sand textured soil and nursery "B" having a sandy loam soil strongly influenced by volcanic ash may both have soil test values of 10 ppm P. If you wish to raise the level to 50 ppm, sufficient phosphate fertilizer to add the equivalent of 40 ppm night do it for soil "A." On the other hand, with soil "B" the allophanic or amorphous colloids weathered from the volcanic ash component imparts P-fixing properties to the soil. As a result, greater levels of phosphate fertilizer would be required on soil "B" than on soil "B" to attain the desired levels.

At the J. Herbert Stone Nursery phosphate additions to soils with P levels less than 20 ppm have resulted in growth responses. On the other hand, it seems unnecessary to add phosphate to soils with 1' levels greater than 50 to 60 ppm.

In developing a fertilizer management program, it is advisable to obtain soil tests well ahead of the time that a new rotation is being initiated. In this way, it is possible to work in nutrients, such at P, K, Ca, and Mg, that do not move into soil readily when surface applied.

Recommendations have been made to broadcast phosphate fertilizer to stimulate root growth. The movement of surface applied P into the soil is practically nil. Phosphate fertilizer should be either banded at the time of seeding or broadcast and worked in when preparing; the seedbeds.

If soils need liming, it is preferable to apply the lime after a seedling crop has been lifted and soils are being prepared for a cover crop. Cation exchange capacity (CEC) values can be helpful as a guide in determining amounts of lime to be added, or in the case of alkaline soils the amount of acid or sulfur to add to acidify the soil. The data from two nurseries illustrate the use of CF.C data for making a decision on liming.

	Exchangeable			CEC	pH
	K	Ca	Mg		
	-------me/100g-------				
Nursery A	.32	5.0	.37	12.7	6.0
Nursery B	.42	6.0	.35	8.2	6.7

The most economical method for increasing Mg is the addition of dolomitic limestone. One ton of dolomite/acre would add approximately 1 me of Mg. Nursery A with a pH of 6.0 has 7.0 me exchangeable acid so the addition of 1 ton of dolomite would present no problem. Nursery R with a p11 of 6.7 has only 1.4 me exchangeable acid; a ton of dolomite would result in an excess of base and increase the p11 to the point of potential damping off and root rot problems. Some other means of increasing Mg would be called for such as the addition of MgSO4 (Epsom salts) which is more costly.

Since CEC is a function of the contents of clay and organic matter, it is a fairly stable parameter, and it is not necessary to get a CEC determination every time a soil from a given area is tested. If organic matter content decreases over time it can be assumed that CEC will also decrease. This relationship could be used to determine the advisability of obtaining a CEC analysis.

Soil test data can be used to advantage to monitor levels of nutrients, 0M, CEC, and pH over tine and to evaluate the impact of management practices on soil fertility. Consistency in sampling techniques and accuracy of record keeping will improve the efficiency of this use of soil test data. The new format for reporting soil analysis data is shown in Table 4. The format for a system of monitoring nutrient levels over time is shown in Table 5. An individual monitoring form can be used for each sample area represented in Table 4. The next time this area is sampled, the soil test data can be entered on the appropriate monitoring page. Space is also available for appropriate remarks. This information can become a part of the permanent record for a nursery and can be used by new personnel as personnel changes occur.

You will notice that P and K are reported in parts per million (ppm) of the elements rather than lbs/acre of the oxides (P_2O_5 and K_2O). Calcium and Mg are reported as me/100g of soil. Since fertilizer analyses are reported in percent P_2O_5 and K_2O and

limestone is purchased by the ton the following conversion factors may be helpful:

ppm x 2 = lbs/acre

ppm P x 4.6 = lbs/acre P_2O_5

ppm K x 2.4 = lbs/acre K_2O

1 me Ca/100g = 400 lbs/acre Ca

1 me Mg/100g = 240 lbs/acre Mg

MgO x 0.6 = Mg

1 me S/100g = 320 lbs S/acre

The approximate amount of the elemental P, K, Ca and Mg added per 100 pounds/acre of commonly used fertilizer materials are as follows:

Fertilizer applied -- 100 lbs/acre		
Single super phosphate (20% P_2O_5)	P	5 ppm
Treble superphosphate (45% P_2O_5)	P	10 ppm
16-20-0 (20% P_2O_5)	P	5 ppm
11-48-0 (48% P_2O_5)	P	10 ppm
Muriate or sulphate of potash (60% K_2O)	K	25 ppm
Epsom salts ($MgSO_4$)	Mg	5 ppm*
Sul-Po-Mg	Mg	5 ppm*
	K	11 ppm

* 1 me Mg/100g = 120 ppm

Lime applied -- T/acre		
Limestone (calcium carbonate)	Ca	2 me/100g
Dolomitic limestone (Ca-Mg carbonate)	Ca	1 me/100g
	Mg	1 me/100g

FERTILIZER USE

There are a few general rules to follow in order to maximize fertilizer efficiency. Perhaps the most obvious rule is not to over fertilize with N. Seedling tissue analysis data from some nurseries indicate that too much is probably being added. This results in leaching losses and probably has a negative influence on seedling quality.

If slow release fertilizers or materials such as Milorganite are used, they should be worked into the soil in order to enhance the microbiological activity to mineralize the

Surface application of phosphate fertilizers without working then into the soil is a wasted effort. Movement of surface applied P into the soil is essentially nil.

Lime, other Mg carriers and P and K fertilizers should be applied and worked into the soil prior to preparing the seedbeds. Ideally, lime should be added well ahead of seedling conifers, preferably ahead of a cover or green manure crop.

Many western soils, especially, but not only west of the Cascade Range, are inherently low in S. Sulfur bearing fertilizers such as ammonium sulfate, single superphosphate or sulfate of potash should be occasionally included in the fertilizer program.

SUMMARY

Soil testing is a useful tool for developing a program for maintaining soil fertility in a forest nursery. In order for the program to be most efficient, consistency is required in sampling, analysis and record keeping.

The OSU Soil Testing Laboratory offers soil testing services to forest nurseries in the western region. A seedling tissue analysis service is also available to supplement the soil testing program. I am supervising this program and also offer consulting services for sampling, record keeping, data interpretation and management recommendations.

Fertilizer programs, especially the amount and frequency of N fertilizers, are unique to each individual nursery and strongly influenced by soil and climatic conditions.

Consistency in sampling and analytical services used and careful record keeping of analytical data and cultural practices used in a form that can be passed on to your successors is essential for the continuous production of high quality planting stock. You are the initial, and a very important segment in any reforestation program.

LITERATURE CITED

Berg, M.G. and E.U. Gardner. 1978. Methods of soil analysis used in the soil testing laboratory at Oregon State University. Spec. Report 321, Ore. Agric. Exp. Sta., Corvallis.

Youngberg, C.T. and R.C. Austin. Fertility standards for raising Douglas-fir in forest nurseries. J. For. 52:4-6.

Table 1. Summary of Soil Tests Available at the Oregon State University Soil Testing Laboratory.

Test Primarily for Soils with pH ≤ 7
1. pH, P, K, Ca, Mg and LR
2. pH, P, K, Ca, Mg, LR and B
3. pH, P, K, Ca and Mg
Tests Primarily for Soils with pH ≥ 7
4. pH, P, K, Ca, Mg and SS -- Na if pH > 7.4. Test 5 necessary for gypsum requirements
5. Alkali Reclamation (Exchangeable Sodium & CEC for gypsum requirements on sodic soils)
6. Ammonium Nitrogen (NH_4-N)
7. Nitrate Nitrogen (NO_3-N)
8. Ammonium and Nitrage Nitrogen
9. Sulfate Sulfur (SO_4-S)
Tests for All Soils
10. pH
11. pH and Lime Requirement (LR)
12. Boron (B)
13. Soluble Salts (SS)
14. Cation Exchange Capacity (CEC)
15. Organic Matter (OM)
16. Total Nitrogen (TN)
17. Zinc (Zn)
18. Other

Table 2. Range in soil fertility levels recommended for Douglas-fir[1].

Soil reaction	Tot N	Avail. P	Avail. K	Exch. Ca	Exch. Mg.
pH	%	--------ppm--------		------me/100g-------	
5.0-6.0	.18-.23	25-50	80-120	2.0-4.0	0.8-1.5

[1]Using Soil Testing Lab values.

Table 3. Soil productivity targets for Intermountain nurseries.

	Range	Units
pH		
most conifers	5.5-6.5	--
hardwoods and junipers	6.5-7.5	--
Electrical Conductivity (E.C.)		
conifers	2.0	mcmhos/cm
hardwoods	4.0	mcmhos/cm
Organic Matter (O.M.)[1]		
all seedlings	2.0-5.0	%
Cation Exchange Capacity (C.E.C.)		
all seedlings	7-12	m.e./100g
Calcium carbonate equivalent ($CaCO_3$)		
all seedlings	0	%
Major Nutrients - for all seedlings		
Total nitrogen (N)	0.10-0.20	%
Phosphorus (P)[2]	30-60	ppm
	175-350	lbs. P_2O_5 per acre
Potassium (K)	100-200	ppm
	300-600	lbs. K_2O per acre
Calcium (Ca)	500-1000	ppm
	2.5-5.0	m.e./100g
Magnesium (Mg)	120-240	ppm
	1-2	m.e./100g

[1] O.M. determined by Walkey-Black (WB) method.
[2] P determined by Olsen's Sodium bicarbonate method.

Table 4. Computer printout for reporting soil test data.

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Forest Nursery Soil Testing Service

OREGON STATE UNIVERSITY
SOIL TESTING LABORATORY
CORVALLIS, OREGON 97331

OSU Forest Nursery Technology Center

NAME: EVERGREEN FOREST NURSERY
JOHN DOE
Address: RT 2 BOX 257
GILCHRIST OR 97737

Date Sampled: 7/20
Date Received: 7/25
Date Completed: 8/ 2/82

Sample From: East of Cascades XX
West of Cascades

Comments: ACID SOILS - USE BRAY P TEST. SEND RESULTS TO DR. YOUNGBERG.

Sample No.	Lab No.	pH	Bray P ppm	K ppm	Ca m/100g	Mg m/100g	CEC m/100g	OM %	TN %
4-PP	66111	6.0	38	304	4.70	1.90	7.60	0.91	0.04
4-LP	66112	5.9	41	276	4.20	1.60	7.40	1.10	0.05
5-2	66113	6.8	52	319	7.50	2.30	10.2	1.80	0.05
5-5	66114	6.5	54	280	5.00	1.30	9.40	1.20	0.06
5-8	66115	6.4	63	401	7.30	2.00	10.1	1.90	0.07
5-11	66116	6.7	48	331	6.20	1.60	8.30	1.80	0.05
5-13	66117	6.8	45	319	6.00	1.60	8.90	1.60	0.05
6-2	66118	6.5	41	253	5.90	1.90	8.10	1.70	0.05
6-5	66119	9.0	39	245	5.70	1.90	9.30	1.40	0.05
6-8	66120	6.4	39	218	4.90	1.60	7.60	1.60	0.05
6-11	66121	6.3	43	222	5.20	1.70	8.50	1.30	0.06
6-14	66122	6.2	45	234	4.70	1.70	7.50	1.30	0.04
6-17	66123	6.4	45	273	5.70	1.80	10.1	1.30	0.05
7-2	66124	6.2	32	265	5.20	1.80	9.30	1.30	0.05
7-5	66125	5.9	40	280	5.20	1.90	9.00	1.70	0.07
7-8	66126	6.2	33	335	5.90	2.40	10.2	1.90	0.05
7-11	66127	6.3	35	343	6.00	2.70	9.60	1.80	0.06
12	66128	5.9	27	187	4.09	2.09	8.80	1.50	0.05

Table 5. Computer printout for monitoring soil fertility levels.

Forest Nursery Soil Testing Service

OREGON STATE UNIVERSITY
SOIL TESTING LABORATORY
CORVALLIS, OREGON 97331

OSU Forest Nursery Technology Center

NURSERY SOIL FERTILITY MONITORING FORM

NAME: EVERGREEN FOREST NURSERY
JOHN DOE
Address: RT 2 BOX 257
GILCHREST OR 97737

Sample No. 4-PP

8/02/82

Date	pH	Bray P ppm	K ppm	Ca m/100g	Mg m/100g	CEC m/100g	OM %	TN %
09/80	6.2	50	400	4.85	2.10	8.00	0.82	0.03
07/81	5.9	44	325	4.68	1.50	7.10	1.02	0.05
08/82	6.0	38	304	4.70	1.90	7.60	0.91	0.04