NITROGEN FERTILIZER INJURES PINE SEEDLINGS IN ROCKY MOUNTAIN NURSERY

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Chlorosis and dwarfing of lodgepole pine seedlings occurred when high levels of nitrogen accumulated from rapid release fertilizer applied to cool, heavy soils.

Figure 1.—*Chlorotic dwarfed 2—0 lodgepole pine seedlings in Block 5, Mt. Sopris Nursery.*

The eastern half of Block 5 at the USFS Mt. Sopris Nursery, Carbondale, Colorado, has chronically failed to produce merchantable lodgepole pine (*Pinus* contorta var *latifolia* Engelm.) seedlings. At the request of nurseryman R. W. Ellis, this problem was investigated during the summer of 1974. The stand of pine was in its second year of growth and exhibited sparse stocking, chlorotic foliage symptoms, and generally poor growth (figure 1). Initial observations disclosed no obvious symptoms of pathogenic fungi or insects. Nursery treatments were comparable to other nursery beds; the nurseryman had not noticed any unusual circumstances.

An interim report was prepared during 1974 on the basis of 1974 sampling results (1). The symptomatic seedlings in Block 5 did not reach merchantable size

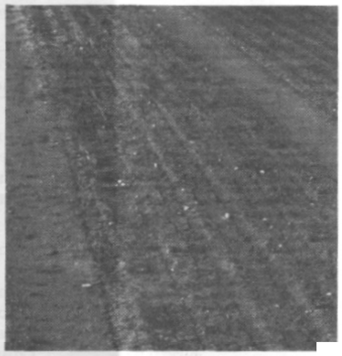

Figure 2.—*Recovered 3—0 lodgepole pine seedlings in Block 5, Mt. Sopris Nursery.*

by the end of the second growing season. Because the land was not needed for planting the next season, the surviving pines were left in the bed during the summer of 1975, receiving no treatment except standard irrigation. During the summer, these seedlings were observed to recover from their symptoms of the previous year. By the end of August 1975, the 3-0 lodgepole pine seedlings were healthy in appearance and had reached or exceeded commercial size (figure 2).

The purpose of this investigation was to diagnose factors responsible for the seedling symptoms expressed during 1974 and to explain the apparent recovery of the seedlings during the 1975 season.

Methods

In addition to visual observations, seedlings from Block 5 were sampled for pathogenic fungi. Soil cores were extracted at random points in the problem areas for chemical analysis during both the 1974 and 1975 growing seasons. Foliage samples were also collected for mineral nutrient tests. For comparison, duplicate samples of pine foliage were taken from symptomatic seedlings and healthy seedlings.

Chemical tests on the first year samples were conducted at the Soils Laboratory at Colorado State University and the other samples were analyzed by Agricultural Consultants Laboratory of Brighton, Colorado. Soil samples were analyzed for standard physical and chemical parameters. Foliage samples were analyzed for established plant nutrients.

A chronological history of treatments applied to Block 5 was obtained from nursery records. The timing and rate of application of each treatment were recorded for each of the three growing seasons, including the year before the symptoms appeared.

Photographs of the problem trees were taken during sample collection to document the physical appearance of the diseased and recovered seedlings.

Results and Discussion

Tests for soil pathogenic fungi revealed that propagules of *Fusarium* spp. were present in the problem area. Population levels of this pathogen, however, were not considered high enough to be of prime concern. This fungus is ubiquitous in forest nurseries and is not considered dangerous unless predisposing conditions exist.

Records of block treatments showed that during the first growing season, the pine seedlings were normal in appearance (table 1). At the end of the 1-0 season, nothing unusual was observed and the seedlings went into the first winter in good condition. Problems were first evidenced at the beginning of the second growing season. Seedlings were chlorotic and this was interpreted as typical nitrogen deficiency. To remedy this situation, applications of fast-acting nitrogen fertilizer were applied to the bed at monthly intervals. Instead of alleviating the chlorosis, the symptoms became more acute and stunting became evident toward the end of the season (figure 1). Due to this poor growth, many seedlings did not reach shipping size within the normal 2 year growing period.

These lodgepole pine seedlings remained in the beds during the third growing season and received no further treatments except normal irrigation. During the third year, the chlorotic symptoms subsided and the foliage returned to a healthy dark green. By the end of the third season, the remaining lodgepole pine were healthy in appearance and normal in size.

Table 1.—*Seedling condition and fertilizer application timetable Block 5, Unit 9, Mt. Sopris Nursery, Carbondale, Colorado*

Seedling Age	Date	Seedling Condition	Treatment
			(Per acre)
1–0	April, 1973	Before seeding	50# ammonium sulfate
	June, 1973	After emergence	100# ammonium sulfate
	August, 1973	Normal	100# urea
	End of Growing Season	Normal	
2–0	Beginning of Growing Season	Chlorotic	
	May, 1974	Chlorotic	100# ammonium nitrate
	June, 1974	Chlorotic-drawfed	100# ammonium nitrate
	July, 1974	Chlorotic-drawfed	100# ammonium nitrate
	End of Growing Season	Chlorosis-stunted noncommercial size	
3–0	Beginning of Growing Season	Chlorosis	Irrigation only
	End of Growing Season	Healthy-recovered-commercial size	

Nutritional analyses of the pine foliage revealed some interesting data (table 2).

Samples taken from chlorotic and healthy pine seedlings at the end of the first growing season showed major differences in plant nutrients. Potassium did appear to be low enough to cause deficiency symptoms. Other ions were slightly higher in the diseased seedlings, notably iron. The principal difference was in the nitrogen level because total nitrogen was higher in the chlorotic seedlings. Apparently, nitrogen deficiency was not causing the chlorosis.

Following the nitrogen fertilizations of the second year, additional samples of diseased

Table 2.—*Nutritional Status of Lodgepole Pine Foliage, Mt. Sopris Nursery, Block 5, Unit 9*

Seedling condition	Seedling age	N-Total(%)	$N\text{-}NO_3$(%)	P (%)	K (%)	Ca (%)	Mg (%)	$S\text{-}SO_4$ (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Analysis performed by
Chlorotic	1-0	1.99	–	0.18	0.37	0.56	0.23	–	375	110	80	10	–	Colorado State University Soils
Control	1-0	1.75	–	0.18	0.42	0.40	0.16	–	185	80	65	6	–	Lab
Chlorosis-Dwarfed	2-0	–	0.059	0.18	0.88	1.30	0.26	0.30	1200	173	425	11	34	Agricultural Consultants Lab. Brighton,
Control	2-0	–	0.006	0.17	0.61	0.56	0.15	0.08	610	410	380	5	23	Colorado
Recovered	3-0	–	0.020	0.15	0.61	0.75	0.23	0.11	530	230	330	7	36	Agricultural Consultants Lab.
Control	3-0	–	0.009	0.17	0.33	0.64	0.14	0.05	380	703	270	6	51	Brighton, Colorado
Adequate		1.30		0.10	0.50	0.12	0.07		50	100	10	4	10	
	–	–	?	–	–	–	–	?	–	–	–	–	–	
Levels[1]		3.00		0.30	1.60	0.70	0.20		100	5000	125	12	100	

[1] Levels given by Powers, R. F., 1974. Evaluating fertilizer programs using soil analysis, foliar analysis, and bioassay methods. IN: Service wide Silviculture Work Conf. Proceedings, Sacramento, California. USDA-FS, Division of Timber Management, Washington D.C. p. 124 – 151.

and healthy pine foliage were taken. The diseased seedlings contained high concentrations of several nutrients: nitrogen, calcium, sulfur, and iron. Calcium, iron and sulfate were high, but the levels were not critical. However, nitrate nitrogen was 10 times as great in the diseased foliage. Based on these results, excessive nitrogen was implicated as a damaging tactor (1).

At the end of the third growing season all nutrients that were in high concentrations the previous year had deceased. When considered in conjunction with the recovery of the remaining seedlings, it appeared that excess nitrogen fertilizer applications had caused the disease symptoms.

This hypothesis was reinforced by the soil chemical tests (table 3). At the end of the second growing season, the nitrate (N03-) level was more than six times greater than at the end of the third growing season. Nitrite (N02-) was eight times higher when the seedlings exhibited disease symptoms. Changes in other nutrients were attributable to the irrigation during the third summer. Calcium and magnesium increased because they were prevalent in the irrigation water whereas phosphorus was leached together with the nitrogen.

Consideration of the chemical tests together with the disease symptom pattern strongly implicates excess nitrogen fertilization as a causal factor.

Table 3.-Soil *Analyses of Block 5, Unit 9, Mt. Sopris Nursery*

Seedling Age and Condition	Texture	pH	CEC(meq)	Salt (Mmhos cm^{-1})	Na(meq)	Lime (%)	O.M. (%)	NO_3 (ppm)	NO_2 (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Zn (ppm)	Fe (ppm)
2-0 Diseased	Silty Loam	6.5	15	0.3	0.5	0.0	4.6	25	1.6	22	110	1400	210	25	50
3-0 Recovered	Silty Loam	6.4	17	0.3	0.5	0.0	4.2	4.0	0.2	12	110	2100	250	25	50

Analyses performed by Agricultural Consultants Laboratory, Brighton, Colorado

Soil factors probably compounded the problem of nitrogen accumulation. The silty texture at Mt. Sopris and low soil temperatures tend to inhibit normal nitrogen cycle processes. Cool soils depress microbial conversion of soil nitrogen whereas heavy soils inhibit drainage, and thus slow down leaching of nitrogen.

Soil nitrogen exists in several ionic forms, some of which may have caused the disease symptoms. Nitrite nitrogen is an extremely toxic ion that results from incomplete microbial oxidation of ammonium ($NH4+$) ions. Nitrite is known to accumulate in cold soils and may cause poor seed germination and seedling chlorosis. Paul and Polle (2) reported that ammonium nitrate applications produced stunted and chlorotic lettuce plants; these symptoms gradually disappeared with time.

Nitrate and ammonium are the principal forms of nitrogen used by plants. At normal levels these ions are not considered harmful, but some reports of toxicity have been reported Urea fertilizer, which only provides ammonium, has been implicated as the cause of damage to jack pine (P. *banksiana* Lamb.) seedlings (3). Chloroplast structure may be adversely affected under conditions of ammonium toxicity (4).

The form of fertilizer used may also have contributed to the problem. Ammonium nitrate is a fast-acting fertilizer that rapidly breaks down into ammonium and nitrate ions. Applications on cool, poorly drained soils accumulated high levels of soil nitrogen.

Summary and Conclusions

The evidence suggests that heavy applications of nitrogen fertilizer can cause chlorosis and stunting of lodgepole pine seedlings. Rapid release fertilizers such as ammonium nitrate may lead to excessive soil nitrogen levels, especially in cool, poorly drained soils. Either toxic nitrite or normally beneficial nitrogen forms may cause injury at high levels in the rhizosphere.

Foliage symptoms should not always be used as the sole criteria for fertilizer applications. Chlorotic needles can be caused by several plant nutrient deficiencies, as well as other factors. Such symptoms should be the signal to use other diagnostic techniques. Nutritional analysis of seedling foliage should be the ultimate criterion for fertilizer amendments. An annual program of seedling foliage analysis has been implemented at Mt. Sopris Nursery and all chemical

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plantations on a 40-year rotation with an average annual increment of not more than 1 cord per acre.

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amendments will be based on the results. Nutrient reference standards are available for many species, although such standards should be developed for each nursery site.

In developing fertilization schedules, soil factors, such as texture and temperature, must be taken into consideration. The type of nitrogen fertilizer is also important because release rates are variable. Any fertilizer, especially nitrogen, should not be applied merely as a matter of policy. Over-fertilization is a real possibility and can have serious direct and indirect effects on tree seedlings.

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