

Nitrogen Fixation by Root Nodules of Western Mountain Mahogany

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The ability of leguminous plants to fix nitrogen has long been known as a phenomenon of great importance in agriculture. Of increasing interest to wild-land managers is the fact that many shrubs and trees, both leguminous and non-leguminous, also have root nodules with nitrogen fixing ability. Among the species which have been reported to fix nitrogen by means of root nodules are the following: deerbrush (*Ceanothus intergerrimus*), snowbrush (*C. cordulatus*), bush lupine (*Lupinus al-bifrons*), deerweed (*Lotus scoparius*), scotch broom (*Cystis scoparius*), chaparral pea (*Pickeringia montana*), alder (*Alnus* spp.), and redbud (*Cercis occidentalis*).

This report deals with a study of nitrogen fixation by nodule-dated roots of western mountain mahogany (*Cercocarpus betuloides*, Fig. 1).

Experimental Methods

Seeds of western mountain mahogany were germinated in sand flats and three months later the seedlings were transplanted to 10-inch pots filled with Holland soil. This soil was transported from a ponderosa pine forest near North Fork in Madera County, and had been shown by previous work (Table 1) to be acutely deficient in nitrogen and phosphorus.

The soil was fertilized with P_2O_5 in the form of monobasic calcium phosphate at the rate of 300 pounds per acre, and one-half of the pots were fertilized also with 200 pounds per acre of

nitrogen added as ammonium nitrate. The pots were irrigated with distilled water as needed and painted clay saucers were used to prevent the loss of nutrients by leaching.

Table 1. Relative yields of lettuce and barley on Holland soil in greenhouse fertility test.

Fertilizer treatment	Lettuce	Barley
	--- (Percent) ---	
NPK	100	100
PK	21	18
NK	7	22
NP	91	100
Check	4	14

At the end of the first year the plants with N + P were about

twice as large and much greener in color than the plants with P alone. The plants were allowed to grow for a second year because previous experience with seedlings of deerbrush had shown that nodule development was greatly enhanced during the second year. At the end of the second year the plants receiving N were still the largest. Among those without added N, there was a variation in size and depth of green coloration of the foliage. The plants were harvested at this point and the roots carefully washed free of soil. Dry weights were taken of shoots and roots.

Results

The measurements and observations made on the shoots are given in Table 2. The plants with N + P weighed the most and their leaves had a dark green color. A close examination of the roots of these plants failed to show the presence of any nodules. Seedlings with P alone were divided into three

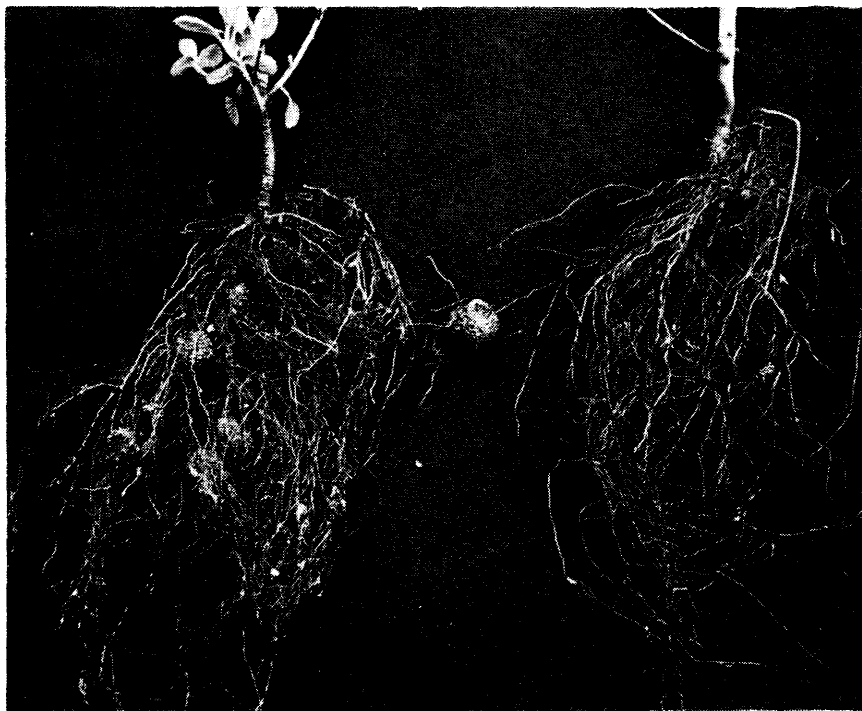


FIGURE 1. Plants of western mountain mahogany with large root nodules capable of fixing nitrogen.

Table 2. Leaf coloration and dry weights of two-year old western mountain mahogany seedlings.

Treatment	Root nodulation	Leaf coloration	Average weight per shoot (Grams)
N+P	none	dark-green	11.2
P	trace	yellow-green	0.8
P	slight	pale-green	2.1
P	moderate	green	8.3

categories on the basis of size and color. The largest seedlings approached in size and color those which had been given both N and P and their roots contained nodules about an inch in diameter, and several smaller ones of assorted sizes. The smallest plants were chlorotic in a fashion typical of nitrogen deficiency in many plants with the leaves yellow-green. The roots had several minute nodules but no large ones. The seedlings intermediate in size had nodules about a half inch in diameter and foliage of a pale-green coloration.

In Table 3 are given the average dry weights of roots per plant and the distribution of root nodules according to treatment and size class. The appearance of roots bearing nodules is shown in the photograph. Of special interest is the large nodule joining

the roots of the two plants. Through careful slicing of this nodule it became apparent that it grew on one plant but enveloped the root of the other. The dry weights showed that plants supplied with N+P had the largest root system and no nodule formation. Of the plants supplied with only P, the ones with the best nodule development produced the most root weight.

On wildland soils low in nitrogen it would be well to manage for those species which increase fertility. It appears that western mountain mahogany is capable of improving the nitrogen status of low fertility soils.

Table 3. Root dry weights of seedlings and size of nodules.

Treatment	Average number of nodules per plant			Average root weight per plant (Grams)
	small	medium	large	
N+P	none	none	none	9.7
P	5	0	0	0.9
P	4	2	0	1.8
P	3	2	3	6.4