PHOSPHORUS REQUIREMENTS OF GREEN ASH SEEDLINGS IN ALKALINE SOILS

M. R. Carter
Investigations Section, PFRA Tree Nursery,
Indian Head, Sask., Can.

Adequate levels of available soil phosphorus are a necessary prerequisite for successful growth of tree seedlings under nursery conditions. This is of special importance in alkaline and calcareous soils where available phosphorus for plant growth is often low.

Soil tests for plant-available phosphorus in neutral or calcareous soils usually employ alkaline extractants toy correlate plant growth with extracted phosphorus. In the prairie or Great Plains region of North America, where alkaline soils prevail, the main extractant used is sodium bicarbonate (*7*).

The objectives of this study were to evaluate the sodium bicarbonate soil test for predicting potential response of green ash (*Fraxinus pennsylvanica* Marsh. *lanceolata* (Borkh.) Sarg.) seedlings to phosphorus fertilizer, and the implications of phosphorus fertilization under row crop conditions where response to phosphorus fertilizer had been variable in the past.

Table 1.—*Chemical and physical characteristics of Oxbow loam*

Sand	Clay	EC[1]	pH	Organic matter	Soluble ions: Na	Ca	Mg	K	Cl	SO_4	HCO_3
pct.	*pct.*	*mmhos /cm*		*pct.*	*meq /l*						
46	20	0.31	7.5	3.0	0.26	2.75	1.65	0.26	0.71	0.57	3.64

[1]Electrical conductivity (EC) and soluble ions (milliequivalents per liter) were determined on saturation paste extracts.

Materials and Methods

Greenhouse experiments were run in 1979 to evaluate the phosphorus requirements of green ash seedlings. Bulk soil samples were obtained, air dried, and passed through a 2 mm sieve. The soil was a Black Chernozemic Oxbow loam (table 1), which had given low available phosphorus readings prior to sampling in the fall. After being sieved, samples of soil were sprayed with various H_3PO_4 solutions (using an atomizer) and thoroughly mixed before being potted in porcelain containers (4.5 kg soil per container) lined with a plastic bag. A total of 24 containers were used.

Seeds of green ash were planted in moist peat and transplanted at the cotyledon to one leaf stage into the containers (15 per container), which were then watered to field capacity and thereafter kept at approximately 85 percent field capacity weight. Plants were grown for 43 days in the greenhouse (16-hour day; 22-25° C). At harvest, total tops and roots for each container were measured for height and length, respectively, before drying at 65° C to obtain dry weight. Duplicate soil samples were taken from each container at two periods throughout the experiment and extracted with 0.5 M sodium bicarbonate (*7*). The soluble phosphorus in the extract was determined using the ammonium molybdate - ascorbic acid method (*3*). Phosphorus uptake was determined by dry ashing top and root samples at 450° C, extracting the ash with HCl, and using the above procedure for soluble phosphorus.

Field studies were conducted on the same Oxbow loam as that used for the greenhouse experiment. Two rates of phosphorus (50 and 70 kg/ha) applied as monocalcium phosphate (0-45-0) were broadcasted and mixed into the soil. Each treatment had four replicates of 0.5 X 2.0 m size arranged in a randomized block design; each block consisting of one row of green ash with adjacent blocks every other row. In each block the treatments were separated by a 0.5 m buffer zone. The field study area was subjected to normal interrow tillage operations and maintained weed-free.

Soil tests for available phosphorus were taken several times throughout the growing season. Plant height was measured three months after germination.

Results

In the greenhouse experiments, available phosphorus extracted by sodium bicarbonate was related with growth of green ash seedlings as indicated by dry weight and height measurements (fig. 1). Both growth and height responses leveled off as available phosphous exceeded 20 ppm. High levels of available phosphorus did not adversely affect growth. Phosphorus uptake per seedling was significantly correlated with soil available phosphorus with the linear correlation coefficient being 0.77 (P =0.01). Shoot-to-root ratios were not affected by increasing available phosphorus.

In the field studies, soil samples obtained in the fall and spring and extracted with sodium bicarbonate indicated initial low levels of available phosphorus (6 ppm). However, further soil samples obtained throughout the growing season showed an increasing level of available phosphorus in the control treatment which began to decline to initial levels in the fall (table 2). Phosphorus treatments initially increased the available phosphorus level to over 10 ppm, with further increases to 15 ppm as the growing season progressed (table 2). Growth of green ash reflected the above changes in available phosphorus, in that initial growth increases caused by the addition of phosphorus were soon negated as phosphorus levels in the control increased. At the end of the growing season no difference was measured in height between treatments (average height 13.7 cm).

Table 2.—*Change in level of soil available phosphorus in the field over one season (1979)*

	Soil-available phosphorus		
Date of sampling	Control	50 kgP/ha	75 kgP/ha
		Ppm	
May 16	6	—	—
June 12	7	10	12
July 16	15	13	13
August 7	13	14	15
August 24	12	14	14
September 24	9	14	15
October 29	8	9	12

Discussion

The results indicate that green ash has similar phosphorus requirements as do many agronomic crops, in that growth response to available phosphorus levels off between 15-20 ppm, while uptake of phosphorus is highly correlated to soil-available phosphorus.

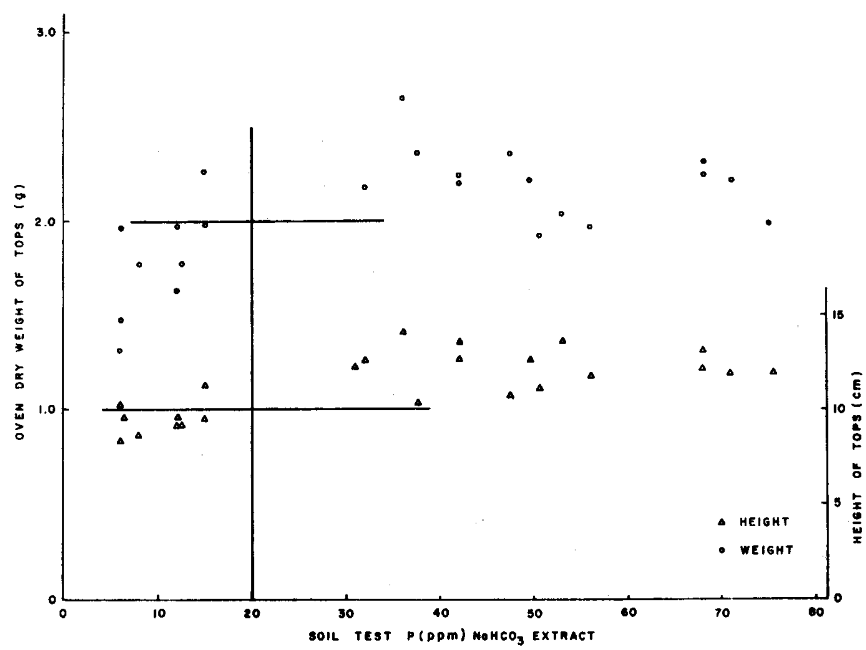

Figure 1.—*Relationship between weight and height of green ash and extractable phosphorus.*

One factor that is the cause for varied response to added fertilizer phosphorus is the release of soil organic phosphorus. Prairie soils usually contain adequate amounts of organic phosphorus that may be readily mineralized, releasing phosphorus available for plant use (*5*). In this study, increases in mineralization or breakdown of organic phosphorus would explain the increase in levels of inorganic available phosphorus over the growing season. Significant increases in available phosphorus did not occur in the greenhouse experiment; however, this was probably due to the short time period involved. In the field, interrow tillage would tend to increase the rate of phosphorus mineralization. Furthermore, freeze and thaw conditions in the spring would also release organic phosphorus available for mineralization over the growing season (*8*). Other studies have indicated the need to determine total phosphorus (inorganic and organic) in the sodium bicarbonate extract to improve the relationship between available phosphorus and growth or phosphorus uptake (*1*).

Similar greenhouse experiments (*2*) conducted for 1-year-old green ash in their second year of growth did not show any growth response to applied phosphorus even when soil levels of available phosphorus were low (6 ppm). The relationship between soil-available phosphorus and phosphorus uptake by second year growth of green ash was also nonsignificant, the linear correlation coefficient being 0.48. Evidently, the ability of trees to utilize to some extent previously assimilated phosphorus could negate any relationship between soil-available phosphorus and growth. Another consideration is natural root -infection with mycorrhizae, which does not usually become well developed until the end of the first (*6*) or second (*4*) growing season and may allow adequate phosphorus uptake even if low levels of available phosphorus prevail.

Conclusions

First year growth of green ash seedlings was increased as soil-available inorganic phosphorus extracted with sodium bicarbonate increased to 15 to 20 ppm.

Under conditions of adequate organic matter, moisture, and interrow cultivation, initial low levels of available phosphorus in the fall or spring may increase over the growing season and satisfy growth requirements. Therefore, soil samples obtained in the fall or spring and tested for available phosphorus may not reflect available phosphorus available for seedling growth during the growing season.

Second year growth or phosphorus uptake by green ash seedlings did now show any relation to levels of soil available phosphorus.

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