Lime Requirement for New Jersey Blueberry-producing Soils

J.R. Heckman,¹ G.C. Pavlis,²
and W.L. Anastasia³

ADDITIONAL INDEX WORDS. soil pH, soil acidity, limestone, lime incubation, liming value determination, lime recommendation, *Vaccinium corymbosum*

Summary. In New Jersey, the major soil series (Sassafras, Pocomoke, Berryland, Atsion, and Downer) used for blueberry (*Vaccinium corymbosum* L.) production often have soil pH levels much lower than the soil pH range of 4.0 to 5.2 that is considered satisfactory for blueberry. The lime requirements for these soils to achieve a target soil pH of 4.8 has not been established. Soils with current soil pH levels in the range of 3.3 to 3.9 were collected from eight New Jersey sites used for blueberry production. The soils were treated with various application rates of calcium carbonate (CaCO_3) and incubated in a greenhouse to estimate the lime requirement of each soil. After 70 days of incubation with CaCO_3 , results show that a general lime recommendation of 100 lb of calcium carbonate equivalent (CCE)/acre ($112 \text{ kg} \cdot \text{ha}^{-1}$) for each one tenth of a soil pH unit increase desired would elevate pH of each of the soils to within a range (pH 4.3 to 5.0) that brackets the target pH of 4.8 without causing serious risk of overliming.

Blueberries (*Vaccinium corymbosum*) grow best in acid soils within a relatively narrow soil pH range. A soil pH range of 4.0 to 5.2 is generally satisfactory for blueberry (Austin et al., 1986; Austin and Bondari, 1992; Cummings et al., 1981; Harmer, 1944). Extremely low soil pH values (<4.0) are detrimental to plant growth (Spiers, 1984). A recent

review (Gough, 1996) of blueberry culture suggests that 4.8 is the optimum pH.

In New Jersey, the soil series most often used for blueberry production are Sassafras, Pocomoke, Berryland, Atsion, and Downer (Table 1). The soil survey of Atlantic County, N.J. (Johnson, 1978), describes the reaction of the Sassafras series as medium acid (pH 5.6 to 6.0), the Downer series as very strongly acid (pH 4.5 to 5.0) and the Pocomoke, Berryland, and Atsion series as extremely acid (pH below 4.5). After many years of cropping these soils to blueberry, receiving annual applications of about 60 lb/acre of nitrogen (N) ($67.2 \text{ kg} \cdot \text{ha}^{-1}$) as ammonium-N (Eck, 1988), these soils may become increasingly acidic. The lime requirements of these soils to achieve a target soil pH of 4.8 has not been established. Traditionally, most lime recommendation databases were developed to achieve target pH levels ranging from 6.0 to 7.0 (McLean, 1982). Rough estimates of soil lime requirements for blueberry are unacceptable because the consequences of excessive lime application may lead to a deficiency of iron and other micronutrients (Haynes and Swift, 1985). Raising the soil pH too high can also promote conversion of ammonium nitrogen to nitrate, a form of nitrogen less available to blueberry (Townsend, 1970). The objectives of this study were to survey commercial blueberry fields for soil pH and to develop a database using the lime incubation method to determine lime requirements for important New Jersey soils used for blueberry culture.

Materials and methods

Soil test reports from samples submitted during 2000 for 104 commercial blueberry field sites in Atlantic and Burlington Counties, N.J., were obtained from records at the Rutgers Soils Laboratory. From these reports, soil pH data were examined by frequency distribution (Fig. 1).

Acid soils with pH values less than 4.0 were collected from the surface 6 inches (15 cm) of eight commercial blueberry farms in Atlantic County, N.J. The taxonomy, pH, and organic matter content of each soil are shown in Table 1. Particle-size analysis was determined by the hydrometer method (Gee and Bauder, 1986). Soil organic matter concentration was determined

by the modified Walkley-Black method (Walkley and Black, 1934).

Lime requirement was determined by incubation (Offiah and Fanning, 1994) using powdered CaCO_3 (Fisher Analyzed Reagent), which had a CCE of 99.2%. Various rates (Fig. 1) of CaCO_3 [in increments equivalent to 50, 100, or 200 lb/acre (56, 112, or 224 $\text{kg} \cdot \text{ha}^{-1}$) assuming that the surface 6 inches of an acre of soil weighs 2×10^6 lb (15 cm of a hectare of soil weighs 2.24×10^6 kg)] were added to 7.1 oz (200 g) of air-dried soil held in styrofoam cups. Amended soil samples were mixed thoroughly with a spatula and placed in a greenhouse on a bench. The soils were incubated for 70 d with alternating wet and dry cycles. Greenhouse temperatures ranged from 21 to 30 °C (70 to 86 °F). At the conclusion of the incubation period, the soils were air-dried and homogenized with a spatula. Soil pH values were determined with a pH meter using 1 soil : 1 water volume ratio. The pH values were correlated to additions of CaCO_3 to determine lime requirement for each soil separately (Fig. 2) and group of eight soils collectively.

Results and discussion

The frequency distribution of soil pH data (Fig. 1) shows that 35% of the blueberry field soil samples had initial pH levels less than 4.0, and 81% have pH levels lower than the target pH of 4.8. Clearly, there are many blueberry production sites that need to be limed.

The soils from the eight blueberry fields used in the lime incubation study had a soil pH range of 3.3 to 3.9 and mean of 3.7 (Table 1). They are representative of soils that have become excessively acidic and need lime amendment to raise soil pH to the level of 4.8 considered optimum for blueberry. The soils also have a wide range of soil organic matter contents (Table 1). Particle-size analysis revealed that this group of soils was very uniform in texture. Except for the Sassafras soil, which had 2.6% clay, the soils all had less than 0.05% clay. Sand contents ranged from 98% to 85% with a mean sand content of 93%.

The lime incubation relationships presented in Fig. 2 show how soil pH increases with lime application rate. In the range of interest for blueberry production, the relationships are effectively linear. Calculations of the amount of lime required to raise pH of each individual soil by one tenth of a unit within

¹Extension specialist in soil fertility, Plant Science Dept., Rutgers Univ., 59 Dudley Road, New Brunswick, NJ 08901-8520.

²County agricultural agent, Atlantic County Cooperative Extension, 6260 Old Harding Highway, Mays Landing, NJ 08330-1533.

³Graduate student, P.O. Box 332, Bradley Beach, NJ 07720.

Table 1. Soil type, pH, organic matter content, and calcium carbonate equivalent (CCE) requirement to raise soil pH by 0.1 when initial soil pH is below 4.0.

Site	Taxonomy of the soil series	pH	Organic matter (%)	CCE ^{z,y} (lb/acre) to raise soil pH by 0.1
1	Sassafras: Typic Hapludult; fine-loamy, siliceous, mesic	3.6	1.0	143
2	Pocomoke: Typic Umbraquult; coarse-loamy, siliceous, thermic	3.9	3.7	143
3	Berryland: Typic Haplaquod; sandy, siliceous, mesic	3.9	3.6	250
4	Berryland: Typic Haplaquod; sandy, siliceous, mesic	3.4	3.9	167
5	Atsion: Aeric Hapludult; sandy, siliceous, mesic	3.3	4.5	143
6	Atsion: Aeric Hapludult; sandy, siliceous, mesic	3.5	4.5	143
7	Downer: Typic Hapludult; coarse-loamy, siliceous, mesic	3.8	2.0	125
8	Downer: Typic Hapludult; coarse-loamy, siliceous, mesic	3.9	0.5	111

^zCCE requirements were estimated for each soil based on the equations shown in Fig. 2.

^y(1 lb/acre = 1.12 kg·ha⁻¹).

the range of interest for blueberry production show the amounts of lime required for the eight soil ranged from 111 to 250 lb/acre CCE (124 to 280 kg·ha⁻¹) and had a mean of 153 lb/acre (171 kg·ha⁻¹) (Table 1).

When the general relationship of soil pH increase with the lime application rate (in lb/acre where 1 lb/acre = 1.12 kg·ha⁻¹) was examined for the eight soils collectively, the following equation provided the best fit: $y = -0.0000001x^2 + 0.0011x + 3.70$ with an r value of 0.76. Using this equation, the calculated amount of lime amendment suggests that the general lime recommendation for New Jersey blueberry soils is

approximately 100 lb/acre CCE for each one tenth of a soil pH unit increase desired.

We examined the consequences of applying this general recommendation of 100 lb/acre CCE per one-tenth unit increase to raise the pH of each of the individual soils to 4.8. On average for eight soils, applying this recommendation would result in a soil pH of 4.7, slightly below the target of 4.8. In the worst case scenario (Downer loamy sand—site 8), following the general lime requirement recommendation would result in a soil pH of 5.0. In the case of the Berryland sand—site 4, the general lime requirement rec-

ommendation would have resulted in a soil pH of 4.3. Because a soil pH range of 4.0 to 5.2 is generally satisfactory for blueberry, we conclude from the results of this study that a general lime recommendation of 100/acre CCE for each one tenth of pH unit increase desired will place these in a soil pH range that is satisfactory for blueberry production. Alternatively, when the soil series is known, the lime requirement values given in Table 1 may be used. The above lime requirement recommendation may not, however, apply to soils with a significantly different soil texture or organic matter content than the soils examined here.

Fig. 1. Frequency distribution of soil pH values from 104 commercial blueberry soil samples collected during 2000.

Fig. 2. Soil pH as affected by application rate of calcium carbonate (CaCO_3) to blueberry-producing soils from eight different New Jersey sites (1 lb/acre = 1.12 kg-ha⁻¹).

Literature cited

- Austin, M.E. and K. Bondari. 1992. Soil pH effects on yield and fruit size of two rabbiteye blueberry cultivars. *J. Hort. Sci.* 67:779-786.
- Austin, M.E., T.P. Gaines, and R.E. Moss. 1986. Influence of soil pH on soil nutrients, leaf elements, and yield of young rabbiteye blueberries. *HortScience* 21:443-445.
- Cummings, G.A., C.M. Mainland, and J.P. Lilly. 1981. Influence of soil pH, sulfur, and sawdust on rabbiteye blueberry survival, growth, and yield. *J. Amer. Soc. Hort. Sci.* 106:783-785.
- Eck, P. 1988. *Blueberry science*. Rutgers Univ. Press, New Brunswick, N.J.
- Gee, G.W. and J.W. Bauder. 1986. Particle size analysis, p. 383-441. In: A. Klute (ed.). *Methods of soil analysis*. Part 1. 2nd ed. ASA and SSSA, Madison, Wis., Agron. Monogr. 9.
- Gough, R.E. 1996. Blueberries—North and south. *J. Small Fruit Viticult.* 4:71-106.
- Harmer, P.M. 1944. The effect of varying the reaction of organic soil on the growth and production of domesticated blueberry. *Proc. Soil Sci. Amer.* 9:133-141.

Haynes, R.J. and R.S. Swift. 1985. Effects of liming on the chemical extractability of Fe, Mn, Zn, and Cu and their uptake by highbush blueberry plants. *Plant Soil* 84:201-212.

Johnson, J.H. 1978. Soil survey of Atlantic County, New Jersey. USDA Soil Conservation Serv., Wash., D.C.

McLean, E.O. 1982. Soil pH and lime requirement, p. 199-224. In: A.L. Page (ed.). *Methods of soil analysis*. part 2. 2nd ed. ASA and SSA, Madison, Wis., Agron. Monogr. 9.

Offiah, O. and D.S. Fanning. 1994. Liming value determination of a calcareous, gypsiferous waste for acid sulfate soil. *J. Environ. Qual.* 23:331-337.

Spiers, J.M. 1984. Influence of lime and sulfur soil additions on growth, yield, and leaf nutrient content of rabbiteye blueberry. *J. Amer. Soc. Hort. Sci.* 109:599-562.

Townsend, L.R. 1970. Effect of form of N and pH on nitrate reductase activity in low bush blueberry leaves and roots. *Can. J. Plant Sci.* 50:603-605.

Walkley, A. and I.A. Black. 1934. An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.* 37:29-37.

Effects of a Microbial Inoculant on Plant Growth and Rhizosphere Bacterial Populations of Container-grown Plants

Monica L. Elliott and
Timothy K. Broschat

ADDITIONAL INDEX WORDS.

Spathiphyllum, *Hibiscus rosa-sinensis*, *Dyopsis lutescens*, areca palm, fluorescent pseudomonads, actinomycetes, heat-tolerant bacteria

SUMMARY. A commercially available microbial inoculant (Plant Growth Activator Plus) that contains 50 microorganisms, primarily bacteria, was evaluated in a soilless container substrate to determine its effects on root bacterial populations and growth response of container-grown plants at three fertilizer rates. The tropical ornamental plants included hibiscus (*Hibiscus rosa-sinensis* 'Double Red'), spathiphyllum (*Spathiphyllum* 'Green Velvet') and areca palm (*Dyopsis lutescens*). The bacterial groups enumerated were fluorescent pseudomonads, actinomycetes, heat-tolerant bacteria, and total aerobic bacteria. Analysis of the inoculant before its use determined that fluorescent pseudomonads claimed to be in the inoculant were not viable. The plant variables measured were plant color rating, shoot dry weight and root dry weight. Only hibiscus shoot dry weight and color rating increased in response to the addition of the inoculant to the substrate. Hibiscus roots also had a significant increase in the populations of fluores-

University of Florida, Ft. Lauderdale Research and Education Center, 3205 College Avenue, Ft. Lauderdale, FL 33314.

This research was supported by the Florida Agricultural Experiment Station, and approved for publication as journal series R-08513. The authors wish to thank Susan Thor, Elizabeth Des Jardin, and Lucy Fisher for their assistance in this project.