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History and Methods of the Everglades Soil Testing Laboratory[1]

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The University of Florida Everglades Soil Testing Laboratory (EvSTL) at the UF/IFAS Everglades Research and Education Center (UF/IFAS EREC) in Belle Glade analyzes 8,000 to 10,000 soil samples annually, with most of the analyses conducted for agriculture operations in the Everglades Agricultural Area (EAA). The laboratory was established to develop methods of analysis for the organic soils in the EAA and to provide growers with calibrated soil tests for crops and soils of the region. This publication is intended for growers and researchers in and adjacent to the EAA. It provides a history of the EvSTL, current analytical methods, and information about fertilizer recommendations made by the laboratory.

Early Research and EvSTL Establishment

UF/IFAS EREC in Belle Glade was established by the Florida Legislature in 1921. UF/IFAS EREC, originally called the Everglades Experiment Station, has the mission of promoting profitable and sustainable agriculture systems on the organic soils (Histosols) of the EAA. Early research at UF/IFAS EREC focused on soil fertility studies to find solutions to crop failures on the organic soils. A major breakthrough came in 1927 when Dr. Robert Allison determined that copper (Cu) must be applied for crops to perform well on these soils (Allison et al. 1927; Allison 1930). This early research also determined that there were often deficiencies of manganese (Mn), zinc (Zn), and boron (B), and that crop performance often responded to applications of phosphorus (P) and potassium (K) (Allison 1931). Research in the 1930s determined that Mn deficiency in crops on muck soils was often associated with high pH caused by muck fires and the alkaline mineral fraction that developed in topsoil after organic matter was lost through combustion. It was determined that the Mn deficiency could be corrected by applying either Mn or acid-forming elemental sulfur applications or both in combination (Allison 1933; Allison 1934).

By the mid-1930s, practical solutions had been developed for problems that had plagued early Everglades farmers. In 1938, Dr. William Forsee initiated research to develop rapid laboratory methods specifically for the muck soils of the EAA (Forsee 1945a). The UF/IFAS EREC had conducted soil pH tests on grower samples as early as 1932 (Sanchez 1990), but the project started by Forsee in 1938 was the actual beginning of the EvSTL. Thomas (1965) described the EvSTL being established during the period of 1943 to 1948 from the perspective of analyzing samples for growers and the public as an organized laboratory. During these early soil fertility investigations, EvSTL researchers recognized the value of calibrated soil tests and the importance of grower cooperation to ensure that soil test results and interpretations would be applicable to field conditions (Neller and Forsee 1939).

Soil Tests for N and P

In 1939, 0.3 N hydrochloric acid (HCl) was selected as the extractant for soil nitrate-N, P, and K determinations (Hortenstine and Forsee 1960). In this procedure, 10 mL 0.3 N HCl were added to 1 teaspoon air-dry soil followed by a 1-minute shaking interval, filtration, and analysis. Both N and P concentrations were determined by colorimetry, using diphenylamine for nitrate-N and ammonium molybdate for P. Soil test levels were correlated with yields recorded from celery and pasture fertility trials (Hortenstine and Forsee 1960). Although there were improvements in the procedure, including photoelectric instrumentation to replace visual estimation of color by 1942 (Neller and Forsee 1942), there were problems with the HCl extraction. The P soil test using HCl was not able to predict yield responses to some P amendments such as rock phosphate and "basic slags." Studies were initiated to screen alternative chemistries for P including different concentrations of HCl, sulfuric acid, and acetic acid (Forsee 1942). Soon thereafter, the HCl extraction was phased out in favor of investigating 0.5 N acetic acid for N, P, and K determinations (Neller and Forsee 1942).

Testing organic soils for N was eventually abandoned because few crops in the early studies responded to supplementary N (Sanchez 1990). High mineralization rates in the organic soils resulted in rapid changes in N concentration in the field and in soil samples so that soil test calibration for N was not possible (Sanchez 1990; Terry 1980).

During the early 1940s, Forsee pursued studies that focused on three extractants for P, including carbonic acid, 0.5 N acetic acid, and distilled water. Based on the assessment of the correlation between soil test P levels and celery tissue P concentrations, acetic acid extractions were found to be unreliable, particularly across soils of varying pH. Conclusions favored the use of either carbonic acid or water because resulting soil test P values correlated best with P uptake during celery growth (Forsee 1945b). Ultimately, the water-extractable P test was adopted because extractions with water rather than with carbonic acid were cheaper to conduct (Forsee and Erwin 1947). In theory, water extraction provides a good estimate of quickly solubilized soil P, which suggests that water-extractable P is appropriate for assessing P requirements for short-season vegetable crops.

In more recent years, there has been interest in evaluating alternative soil extraction procedures. Sanchez and Burdine (1987) stressed the need to investigate new extractants that were less sensitive to soil pH and P-buffering capacities while providing improved estimates for soil iron (Fe), aluminum (Al), and Ca-P fractions that might relate to plant uptake of P over the longer term. Using lettuce as a test crop, Sanchez and Hanlon (1990) evaluated six extractants for soil P but determined that none produced improved correlations relative to the water extraction. The Mehlich 1 extractant did not perform well on EAA organic soils with a wide pH range. This is important because soil pH in EAA soils has generally increased in recent years due to the incorporation of calcium carbonate into the topsoil from underlying limestone as soils have become shallower with soil subsidence (Bhadha et al. 2020). Sanchez and Hanlon (1990) determined that the Mehlich 3 (Mehlich 1984) extractant showed promise and recommended additional research for all crops produced on Florida organic soils. Mehlich 3 has the advantage of being a "universal" extractant that can be used to determine available soil P, K, Ca, Mg, and several micronutrients, with an extraction chemistry that works well across a wider soil pH range than water or Mehlich 1. Water-extractable P (Table 1) continues to be used by the EvSTL to produce P fertilizer recommendations for vegetable crops grown on organic soils (Hochmuth et al. 2018; Hochmuth et al. 2023).

Korndorfer et al. (1995) investigated several extractants for sugarcane, including Mehlich 1, 0.5 N acetic acid (using a different soil/extractant ratio than used for K), and water. Korndorfer et al. recommended continued investigations with the acetic acid extractant. For a few years, it was used by the EvSTL as an additional P extraction for sugarcane on organic soils in addition to the official water extraction. However, McCray et al. (2021) determined that there were some inconsistencies with using acetic acid for P extraction on these soils, and that Mehlich 3-extractable P (Table 1) related better to sugarcane yield than soil P extracted with water or acetic acid. Based on that research, UF/IFAS P fertilizer recommendations for sugarcane on organic soils were revised in 2012 to the current calibration based on the Mehlich 3 extraction (McCray et al. 2021). Further research with sugarcane on mineral soils adjacent to the EAA led to revised P fertilizer recommendations for these soils using Mehlich 3 in 2022 (McCray 2022a).

Soil Tests for Other Nutrients and pH

Forsee's early work with the HCl extraction determined that a new method of K extraction was needed that was more reproducible, particularly at low concentrations (Forsee 1942). A new extraction was developed using 0.5 N acetic acid (originally 1 teaspoon soil combined with 10 mL 0.5 N acetic acid with a 2-minute shaking prior to filtration and analysis) (Forsee 1942). This procedure was later modified for extraction of K, calcium (Ca), magnesium (Mg), and sodium (Na) (Thomas 1965) to be almost identical to the procedure used today (Table 1). Much research has been conducted to develop K fertilizer recommendations for vegetables on organic soils (Hochmuth et al. 2018; Hochmuth et al. 2023) and sugarcane on organic and mineral soils (McCray 2022b; McCray 2022c) using the acetic acid method. Extractable Na has not been determined or reported in recent years because high rainfall in south Florida generally prevents high levels of Na from accumulating in the soil and being a problem for plant growth. However, analysis of Na could be included if requested.

A substantial amount of research has been done since the 1970s demonstrating the response of sugarcane and rice to silicon (Si) amendments when soluble soil Si is low. In more recent years, calcium silicate recommendations for sugarcane have been developed for organic and mineral soils using the acetic acid soil test (McCray et al. 2022; McCray 2022d).

In the 1990s, Dr. George Snyder investigated the problem of seedling chlorosis in rice and developed a soil test for Fe availability using concentrated hydrochloric acid (Table 1). This work led to Snyder's recommendation that for rice grown on organic soils in the EAA, Fe should be applied when the soil test Fe index < 3.5 (Snyder and Elliott 1994).

Soil pH is determined in the EvSTL using a 1:2 soil/water volumetric ratio (Table 1). In recent years, soil pH values have increased in EAA organic soils. This is a result of influences of the underlying calcium carbonate bedrock as soil profile depths decline with subsidence (Bhadha et al. 2020). Soil pH values provide important information to growers for nutrient management decisions. Recommendations were revised for elemental sulfur application (a pH reduction strategy) on organic and mineral soils based on soil pH in 2018 (McCray 2022e) and 2022 (McCray and Rice 2023), respectively.

Collecting and Submitting Soil Samples

Soil testing is a 3-step process that includes (1) collecting and submitting the soil sample, (2) preparing the sample, and extracting and measuring nutrient concentrations, and (3) making research-based fertilizer recommendations for specific crops. All steps in this process are critical to reach a cost-effective and environmentally sound fertilizer recommendation. To start the process, it is very important to collect a soil sample that is representative of the field or sample area. Generally, for row crops in south Florida, it is preferable to collect soil samples in disked fields prior to planting the crop. Sampling depth can vary, but it is generally based on the rooting depth of the crop. Crop history should be considered when collecting samples so that soil cores from areas with different fertilization histories are not mixed together in the same composite sample. A composite soil sample should contain 20–25 cores and should not be from an area larger than 40 acres. For precision agriculture samples, smaller areas may be included, with fewer cores per sample. Soil cores should not be taken within 100 ft of marl roads or 30 ft of field ditches due to possible inclusion of high pH materials from roads and ditch cleaning operations. Each composite sample should be mixed well, placed in a clean plastic or paper bag, and labeled properly with legible sample identification. Submission forms for the EvSTL are included in this publication and are also available at the laboratory. Completed forms should provide contact information, the crop being grown, and the requested package of soil analyses.

Laboratory Soil Prep and Volumetric Analysis

When a soil sample is brought to the EvSTL for analysis, it is placed into an aluminum pan and air-dried in a forced-air drying room at temperatures between 90°F and 100°F (32°C–38°C. The air-dried sample is sieved through a 2 mm screen prior to analysis. Volumetric soil analysis has been done throughout the history of the EvSTL, and as explained by Ray (1958), measuring by volume rather than weighing not only increased the speed of the procedure, but was also considered appropriate for EAA organic soils that naturally underwent bulk density changes over time. Also, with varying organic matter content in these soils, disturbed soil density values can vary from 0.6 g/cm^3 to 1.0 g/cm^3 (Andreis and McCray 1998), so volumetric measurements are considered more consistent across varying soil densities. As part of quality control in the laboratory, standard soil samples and duplicate soil samples are run with each batch of samples. Consistency of analysis of standards and duplicates has provided confidence in the consistency of the volumetric measurement of samples.

For calculations of soil index units that are reported in lb/acre, a calculation of volume of 6 inches deep in an acre is used to convert extracted soil values. However, it is important to understand that regardless of the units (lb/acre, g/m^3, mg/kg, etc.), soil test values are index values that only have meaning in relation to a specific soil test calibration developed from field research trials that evaluated variable nutrient inputs in relation with crop yield response. A soil test index value in a soil test report indicates the probability of crop yield response to application of a given nutrient; if available, a recommendation for rate of nutrient application is included in the report.

EvSTL Fertilizer Recommendations

A soil test calibrated for the grower's specific crop and soil type is an essential tool for quantifying the nutrient inputs required for optimal crop production. As previously discussed, the methods used in the EvSTL were developed specifically for the crops and soils in and adjacent to the EAA. While the EvSTL was originally established for analysis of organic soils in the EAA, in recent years there has been an increased analysis of mineral soils, particularly for sugarcane nutrient recommendations for areas in and adjacent to the EAA. Sugarcane acreage on mineral soils in Florida has increased to almost 30%, with 70% being on organic soils (VanWeelden et al. 2022). Similarly, as of this writing, about 70% of soil samples submitted to the EvSTL are muck soils (>20% organic matter), and about 30% are sands or transitional soils (sandy mucks or mucky sands).

Field research has produced nutrient response curves and soil test calibrations based on multiple crop years and multiple locations of fertilizer and amendment trials. On-farm research trials have been emphasized to accurately capture grower production systems. Nutrient recommendations are based on the concept of providing the nutrients required to produce the current year's crop. Exceptions to that would include micronutrients and amendments (such as calcium silicate or elemental S) that may be applied before planting sugarcane to supply nutrients throughout a multi-year crop cycle. Fertilizer recommendations will need to be updated as farming conditions change and/or when additional research findings warrant updates. Fertilizer recommendations including P and K recommendations and specific notes about macro- and micronutrient applications for vegetables and selected other crops grown on organic soils are included in Tables 2–6. More information about vegetable fertilizer recommendations for organic soils is available at https://ask.ifas.ufl.edu/publication/WQ114 (Hochmuth et al. 2023) and https://ask.ifas.ufl.edu/publication/CV008 (Hochmuth et al. 2018). A comprehensive guide for sugarcane fertilization on organic and mineral soils is available at https://ask.ifas.ufl.edu/publication/SC028 (McCray and Rice 2023).

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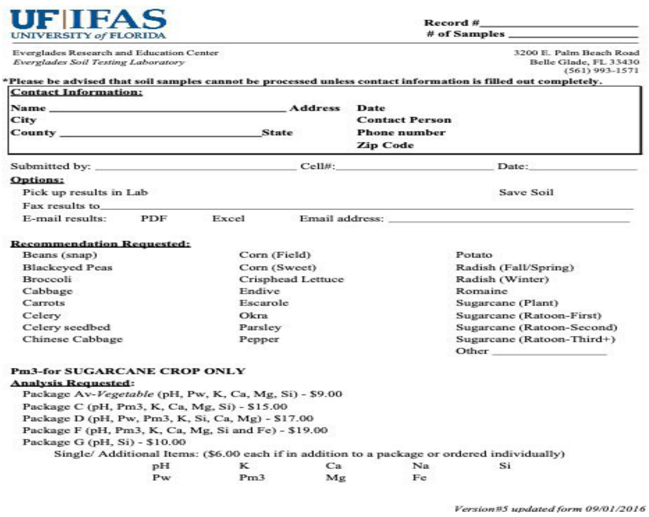
UF|IFAS
UNIVERSITY of FLORIDA

Record #________
\# of Samples ________

Everglades Research and Education Center
Everglades Soil Testing Laboratory

3200 E. Palm Beach Road
Belle Glade, FL 33430
(561) 993-1571

*Please be advised that soil samples cannot be processed unless contact information is filled out completely.

Contact Information:
Name ________ Address Date
City Contact Person
County ________ State Phone number
Zip Code

Submitted by: ________ Cell#: ________ Date: ________

Options:
Pick up results in Lab Save Soil
Fax results to ________
E-mail results: PDF Excel Email address: ________

Recommendation Requested:

Beans (snap)	Corn (Field)	Potato
Blackeyed Peas	Corn (Sweet)	Radish (Fall/Spring)
Broccoli	Crisphead Lettuce	Radish (Winter)
Cabbage	Endive	Romaine
Carrots	Escarole	Sugarcane (Plant)
Celery	Okra	Sugarcane (Ratoon-First)
Celery seedbed	Parsley	Sugarcane (Ratoon-Second)
Chinese Cabbage	Pepper	Sugarcane (Ratoon-Third+)
		Other ________

Pm3-for SUGARCANE CROP ONLY
Analysis Requested:
Package Av-*Vegetable* (pH, Pw, K, Ca, Mg, Si) - $9.00
Package C (pH, Pm3, K, Ca, Mg, Si) - $15.00
Package D (pH, Pw, Pm3, K, Si, Ca, Mg) - $17.00
Package F (pH, Pm3, K, Ca, Mg, Si and Fe) - $19.00
Package G (pH, Si) - $10.00
Single/ Additional Items: ($6.00 each if in addition to a package or ordered individually)

pH	K	Ca	Na	Si
Pw	Pm3	Mg	Fe	

Version#5 updated form 09/01/2016

Figure 1.
Credit: UF/IFAS

Table 1. Basic information on methods used in the Everglades Soil Testing Laboratory.[a]

Extracting Solution	Soil/Extractant Ratio	Nutrient/Measurement	Contact/Shaking Time	Method/Instrument
DI water	4 cm^3/50 mL	P	Overnight/50 min shake/filter	Colorimetric/ probe colorimeter
Mehlich 3	2.5 cm^3/25 mL	P	5 min shake/ filter	Colorimetric/ discrete analyzer
0.5 N Acetic acid	10 cm^3/25 mL	K, Ca, Mg, Si	Overnight/50 min shake/ filter	Optical emission/ ICP
Concentrated HCl	4 cm^3/10 mL	Fe	30 min/add 40 mL water/mix/ filter and dilute	Optical emission/ ICP
DI water	15 cm^3/30 mL	pH	Stir 10 min/ stand 1 hr/ stir and measure	pH meter

[a] While historical research has shown that inputs of various micronutrients (B, Cu, Mn, Zn) will promote improved crop performance, these micronutrients have not been calibrated with a soil test.

Table 2. Phosphorus fertilizer recommendations for vegetables and other selected crops on organic soils for water-extractable P soil index values 0–15.

Vegetable Crop	Water-Extractable Soil P Index (lb P/acre)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Recommended lb P_2O_5/acre															
Blackeyed peas	80	80	80	80	60	40	20	0	0	0	0	0	0	0	0	0
Broccoli	140	140	140	140	120	100	80	60	40	20	0	0	0	0	0	0
Cabbage	140	140	140	140	120	100	80	60	40	20	0	0	0	0	0	0
Carrots	260	260	260	260	240	220	200	180	160	140	120	100	80	60	40	20
Celery	260	260	260	260	240	220	200	180	160	140	120	100	80	60	40	20
Celery seedbed	220	220	220	220	200	180	160	140	120	100	80	60	40	20	0	0
Chinese cabbage	340	340	340	340	320	300	280	260	240	220	200	180	160	140	120	100
Field corn	240	240	240	240	220	200	180	160	140	120	100	80	60	40	20	0
Sweet corn	160	160	160	160	147	133	120	107	93	80	67	53	40	27	13	0
Crisphead lettuce	200	200	200	200	192	183	175	167	158	150	142	133	125	117	108	100
Endive	200	200	200	200	192	183	175	167	158	150	142	133	125	117	108	100
Escarole	200	200	200	200	192	183	175	167	158	150	142	133	125	117	108	100

Vegetable Crop	Water-Extractable Soil P Index (lb P/acre)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Recommended lb P_2O_5/acre															
Okra	240	240	240	240	220	200	180	160	140	120	100	80	60	40	20	0
Parsley	340	340	340	340	320	300	280	260	240	220	200	180	160	140	120	100
Pepper	180	180	180	180	160	140	120	100	80	60	40	20	0	0	0	0
Potatoes	220	220	220	220	200	180	160	140	120	100	80	60	40	20	0	0
Radish	100	100	100	100	80	60	40	20	0	0	0	0	0	0	0	0
Romaine	200	200	200	200	192	183	175	167	158	150	142	133	125	117	108	100
Snap beans	100	100	100	100	80	60	40	20	0	0	0	0	0	0	0	0
Sorghum (grain)	140	140	140	140	120	100	80	60	40	20	0	0	0	0	0	0

Table 3. Phosphorus fertilizer recommendations for vegetables and other selected crops on organic soils for water-extractable P soil index values 16–27.

Vegetable Crop	Water-Extractable Soil P Index (lb P/acre)											
	16	17	18	19	20	21	22	23	24	25	26	27+
	Recommended lb P_2O_5/acre											
Blackeyed peas	0	0	0	0	0	0	0	0	0	0	0	0
Broccoli	0	0	0	0	0	0	0	0	0	0	0	0
Cabbage	0	0	0	0	0	0	0	0	0	0	0	0
Carrots	0	0	0	0	0	0	0	0	0	0	0	0
Celery	0	0	0	0	0	0	0	0	0	0	0	0
Celery seedbed	0	0	0	0	0	0	0	0	0	0	0	0
Chinese cabbage	80	60	40	20	0	0	0	0	0	0	0	0
Field corn	0	0	0	0	0	0	0	0	0	0	0	0
Sweet corn	0	0	0	0	0	0	0	0	0	0	0	0
Crisphead lettuce	92	83	75	67	58	50	42	33	25	17	8	0
Endive	92	83	75	67	58	50	42	33	25	17	8	0
Escarole	92	83	75	67	58	50	42	33	25	17	8	0
Okra	0	0	0	0	0	0	0	0	0	0	0	0
Parsley	80	60	40	20	0	0	0	0	0	0	0	0
Pepper	0	0	0	0	0	0	0	0	0	0	0	0
Potatoes	0	0	0	0	0	0	0	0	0	0	0	0
Radish	0	0	0	0	0	0	0	0	0	0	0	0
Romaine	92	83	75	67	58	50	42	33	25	17	8	0
Snap beans	0	0	0	0	0	0	0	0	0	0	0	0

Vegetable Crop	Water-Extractable Soil P Index (lb P/acre)											
	16	17	18	19	20	21	22	23	24	25	26	27+
	Recommended lb P_2O_5/acre											
Sorghum (grain)	0	0	0	0	0	0	0	0	0	0	0	0

Table 4. Potassium fertilizer recommendations for vegetables and other selected crops on organic soils for acetic acid-extractable K soil index values 20–130.

Vegetable Crop	Acetic Acid-Extractable Soil K Index (lb K/acre)											
	20	30	40	50	60	70	80	90	100	110	120	130
	Recommended lb K2O/acre											
Blackeyed peas	200	200	200	200	180	160	140	120	100	80	60	40
Broccoli	200	200	200	200	180	160	140	120	100	80	60	40
Cabbage	200	200	200	200	180	160	140	120	100	80	60	40
Carrots	200	200	200	200	180	160	140	120	100	80	60	40
Celery	300	300	300	300	280	260	240	220	200	180	160	140
Celery seedbed	300	300	300	300	280	260	240	220	200	180	160	140
Chinese cabbage	200	200	200	200	180	160	140	120	100	80	60	40
Field corn	300	300	300	300	280	260	240	220	200	180	160	140
Sweet corn	120	120	120	120	100	80	60	40	20	0	0	0
Crisphead lettuce	200	200	200	200	180	160	140	120	100	80	70	60
Endive	200	200	200	200	180	160	140	120	100	80	70	60
Escarole	200	200	200	200	180	160	140	120	100	80	70	60
Okra	200	200	200	200	180	160	140	120	100	80	60	40
Parsley	400	400	400	400	380	360	340	320	300	280	260	240
Pepper	200	200	200	200	180	160	140	120	100	80	60	40
Potatoes	250	250	250	250	230	210	190	170	150	130	110	90
Radish	100	100	100	100	80	60	40	20	0	0	0	0
Romaine	200	200	200	200	180	160	140	120	100	80	70	60
Snap beans	100	100	100	100	80	60	40	20	0	0	0	0
Sorghum (grain)	200	200	200	200	180	160	140	120	100	80	60	40

Table 5. Potassium fertilizer recommendations for vegetables and other selected crops on organic soils for acetic acid-extractable K soil index values 140–250.

Vegetable Crop	Acetic Acid-Extractable Soil K Index (lb K/acre)											
	140	150	160	170	180	190	200	210	220	230	240	250
	Recommended lb K_2O/acre											
Blackeyed peas	20	0	0	0	0	0	0	0	0	0	0	0
Broccoli	20	0	0	0	0	0	0	0	0	0	0	0
Cabbage	20	0	0	0	0	0	0	0	0	0	0	0
Carrots	20	0	0	0	0	0	0	0	0	0	0	0
Celery	120	100	80	60	40	20	0	0	0	0	0	0
Celery seedbed	120	100	80	60	40	20	0	0	0	0	0	0
Chinese cabbage	20	0	0	0	0	0	0	0	0	0	0	0
Field corn	120	100	80	60	40	20	0	0	0	0	0	0
Sweet corn	0	0	0	0	0	0	0	0	0	0	0	0
Crisphead lettuce	50	33	17	0	0	0	0	0	0	0	0	0
Endive	50	33	17	0	0	0	0	0	0	0	0	0
Escarole	50	33	17	0	0	0	0	0	0	0	0	0
Okra	20	0	0	0	0	0	0	0	0	0	0	0
Parsley	220	200	180	160	140	120	100	80	60	40	20	0
Pepper	20	0	0	0	0	0	0	0	0	0	0	0
Potatoes	70	50	30	10	0	0	0	0	0	0	0	0
Radish	0	0	0	0	0	0	0	0	0	0	0	0
Romaine	50	33	17	0	0	0	0	0	0	0	0	0
Snap beans	0	0	0	0	0	0	0	0	0	0	0	0
Sorghum (grain)	20	0	0	0	0	0	0	0	0	0	0	0

Table 6. Detailed notes for nutrient applications with specific crops on organic soils.

Nutrient	Crops	Note
Phosphorus	Crisphead lettuce Romaine Endive Escarole Sweet corn	The P fertilizer recommendations are based on banded applications. The P fertilizer should be banded in a 2- to 3-inch-wide band in the bed, roughly 2 to 3 inches below the row.
Phosphorus	All other vegetable crops	The P fertilizer recommendations for all remaining vegetable crops are based on broadcast applications. The recommended amount for radish is suitable for 1 to 3 crops grown in succession.
Potassium	All vegetable crops	The K fertilizer recommendations are based on broadcast applications.

Nutrient	Crops	Note
Nitrogen	Celery	Harvested before December 1: Apply 2 splits of 40 lb N/acre (at 1 and 2 months after transplanting). Harvested between December 1 and March 31: Apply 2 splits of 60 lb N/acre. Harvested after April 1: Apply 2 splits of 30 lb N/acre.
Nitrogen	Crisphead lettuce Romaine Endive Escarole	Harvested between December 15 and March 15: Apply up to 60 lb N/acre.
Nitrogen	Sweet corn	Top-dress 40 lb N/acre before tassel appears in the whorl.
Nitrogen	All other vegetable crops	No specific N recommendations are available.
Manganese	All vegetable crops	When soil pH is less than 5.7: Apply no Mn. When soil pH is equal to or greater than 5.7: Apply 8 lb Mn/acre.
Zinc	All vegetable crops	Apply 8 lb Zn/acre.
Boron	Sweet corn Radish	Apply 1.0 lb B/acre.
Boron	Blackeyed peas Okra Parsley Potatoes	Apply 1.2 lb B/acre.
Boron	Crisphead lettuce Endive Escarole Romaine	Apply 1.5 lb B/acre.
Boron	Broccoli Cabbage Carrots Chinese cabbage	Apply 1.8 lb B/acre.
Boron	Celery	Apply 2.5 lb B/acre.

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