A Survey to Evaluate the Current Status of Land Grant University and State Department of Agriculture Soil Fertility Recommendations and Analytical Methods 2020-2021

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Author Roles
[a]Conceptualization, [b]Visualization, [c]Data curation, [d]Formal analysis, [e]Writing-original draft, [f]Project administration

Conducted as part of the Fertilizer Recommendation Support Tool (FRST) project

The following tables correspond to the Survey Questionnaire and Survey Data Spreadsheet

INTRODUCTION

Soil fertility testing is an integral tool used in nutrient management planning, providing the information needed to determine where nutrients are required and how much to apply. Over the last several decades, a great deal of effort has been successfully invested in standardizing soil test methods in the U.S. Less progress has been made toward coordination of soil test correlation and calibration efforts and development of clear and consistent guidelines for interpreting soil test results used to make fertilizer recommendations. Research in support of soil test recommendations has been conducted mostly by land-grant universities with only limited interstate or regional coordination for interpreting and developing soil-test-based recommendations. One of the first steps in addressing the lack of regional coordination is a comprehensive assessment of knowledge and resources that exist in support of land grant university soil testing and fertility programs. The last known national survey of land-grant university soil fertility recommendations was published over 20 years ago (Voss, 1998). Since that time, new analytical methods have been adopted, recommendation frameworks have been refined, new regional partnerships have formed, and the allocation of resources has shifted.

In 2019, we began developing a survey to collect contemporary information from our land-grant university colleagues working in soil fertility. The goals of the survey were to gain a better understanding of the current status of soil testing across the U.S. to inform future collaborative efforts among states and regions, and to identify where opportunities exist to harmonize recommendation guidelines. The objectives were to collect information about state soil test recommendations, fertilization philosophy, analytical methods, and the provenance of correlation and calibration data that support soil-test-based recommendations.

METHODS

The survey was adapted from one conducted in 2018 for the Southern states for a meeting in Athens, GA (D. Osmond, personal communication, April 12, 2022), and expanded to include information relevant to other regions in the U.S. The survey was developed using Qualitrics Software (Qualtrics, Provo, UT). Input on questions and formatting were provided by soil fertility specialists across the U.S. Distribution of the survey was coordinated with regional soil test working groups and committees in February 2020. Over 60 responses from 48 states and Puerto Rico were received by the survey close in June 2020. Survey responses for each state were reviewed for consistency and correctness and organized into 17 topic-specific tables. These tables were re-distributed to survey participants for follow-up review and confirmation of provided information, totaling three years of data collection (2020-2022). Results from this survey will help guide future soil fertility work and cooperation across state lines.

REFERENCE

Voss, R. 1998. Fertility recommendations: past and present. Comm. Soil Sci. Plant Anal. 29(11-14):1429-1440. https://doi.org/10.1080/00103629809370040

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LIST OF TABLES

Table 1. Survey participant information. Responses given in 2020 and 2021 (Question 1.4)

Region[a] & state	Institution	Participant	Membership in soil testing/fertility working groups or committees[b]
NORTH CENTRAL			
Illinois	University of Illinois Urbana-Champaign	Andrew Margenot	NCERA-13
Indiana	Purdue University	Jim Camberato	NCERA-103
Iowa	Iowa State University	Antonio Mallarino	NCERA-13
Kansas	Kansas State University	Nathan Nelson	SERA-17
Michigan	Michigan State University	Kurt Steinke	NC1195, NCERA-103, Tri-State fertilizer recommendation committee, 4R N subcommittee Lake Erie Watershed
Minnesota	University of Minnesota	Fabian Fernandez	NCERA-13
		Daniel Kaiser	NCERA-13
Missouri	University of Missouri	Manjula Nathan	NCERA-13
Nebraska	University of Nebraska	Charles Wortmann	None
North Dakota	North Dakota State University	David Franzen	NCERA-13
Ohio	Ohio State University	Steve Culman	NCERA-13
South Dakota	South Dakota State University	Jason Clark	NCERA-13, NCERA-103
Wisconsin	University of Wisconsin-Madison	Carrie Laboski	NCERA-13
		Andrew Stammer	NCERA-13
NORTHEASTERN			
Connecticut	University of Connecticut	Dawn Pettinelli	NECC-1812
Delaware	University of Delaware	Amy Shober	NECC-1812, MASTPAWG
Maine	University of Maine	Bruce Hoskins	NECC-1812
Maryland	University of Maryland	Brian Kalmbach	MASTPAWG
		Emileigh Lucas	NECC-1812, MASTPAWG, SERA-17
		Gurpal Toor	NECC-1812, MASTPAWG
Massachusetts	University of Massachusetts	Tracy Allen	NECC-1812
New Hampshire	University of New Hampshire	Tom Buob	None
		Olivia Saunders	NECC-1812
New Jersey	Rutgers University	Joseph Heckman	NECC-1812, MASTPAWG
New York	Cornell University	Quirine Ketterings	NECC-1812
Pennsylvania	Penn State University	John Spargo	NECC-1812, MASTPAWG
Rhode Island	University of Rhode Island	Andy Radin	Informally with University of Connecticut and University of Massachusetts
Vermont	University of Vermont	Don Ross	NECC-1812
West Virginia	West Virginia University	Eugenia Pena-Yewtukhiw	NECC-1812, MASTPAWG, SERA-6
SOUTHERN			
Alabama	Auburn University	Gobena Huluka	SERA-6
Arkansas	University of Arkansas	Nathan Slaton	SERA-6

Region[a] & state	Institution	Participant	Membership in soil testing/fertility working groups or committees[b]
Florida	University of Florida	Rao Mylavarapu	SERA-6
Georgia	University of Georgia	Jay Lessl	SERA-6, MASTPAWG
Kentucky	University of Kentucky	John Grove	SERA-6
Louisiana	Louisiana State University	Jim Wang	SERA-6
Mississippi	Mississippi State University	Keri Jones	None
North Carolina	North Carolina State University	Deanna Osmond	SERA-6, SERA-17
	North Carolina Department of Agriculture	David Hardy	SERA-6, MASTPAWG
Oklahoma	Oklahoma State University	Hailin Zhang	SERA-6
Puerto Rico	University of Puerto Rico	David Sotomayor	SERA-6
South Carolina	Clemson University	Shannon Alford	SERA-6, MASTPAWG
Tennessee	University of Tennessee	Robert Florence	SERA-6
Texas	Texas A&M AgriLife Extension	Tony Provin	SERA-6
Virginia	Virginia Tech University	Rory Maguire	SERA-6, MASTPAWG
WESTERN			
Alaska[c]	-	-	-
Arizona	University of Arizona	James Walworth	WERA-103
California	University of California-Davis	Daniel Geisseler	WERA-103
Colorado	Colorado State University	Jim Self	None
Hawaii	University of Hawaii	Nguyen Hue	None
Idaho	University of Idaho	Robert Mahler	None
Montana	Montana State University	Clain Jones	WERA-103
Nevada[c]	-	-	-
New Mexico	New Mexico State University	Robert Flynn	WERA-103
Oregon	Oregon State University	Amber Moore	WERA-103
Utah	Utah State University	Grant Cardon	WERA-103, SSSA-NAPT
	Brigham Young University	Bryan Hopkins	WERA-103, SSSA-NAPT
Washington	Washington State University	Joan Davenport	WERA-103
Wyoming	University of Wyoming	Jay Norton	WERA-103

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA).

[b]MASTPAWG, Mid-Atlantic Soil Testing and Plant Analysis Workshop Group; NC1195, North Central research project on enhancing nitrogen utilization in corn-based cropping systems to increase yield, improve profitability and minimize environmental impacts; NCERA-13, North Central coordinating committee on soil testing and plant analysis; NCERA-103, North Central coordinating committee on specilalized soil amendments and products, growth stimulants and soil fertility management programs; NECC-1812, Northeast Coordinating Committee on Soil Testing; SERA-6, Southern coordinating committee on methodology, interpretation, and implementation of soil, plant, byproduct, and water analyses; SERA-17, Southern organization to minimize nutrient loss from the landscape; WERA-103, Western coordinating committee on nutrient management and water quality; SSSA-NAPT, Soil Science Society of America North American Proficiency Testing Program

[c]No representatives from Alaska or Nevada were available to complete the survey.

Table 2. General information about public soil testing laboratories, sources of funding, and participation in the two primary soil fertility testing proficiency programs: North American Proficiency Testing (NAPT) and Agricultural Laboratory Proficiency (ALP). Responses given in 2020 and 2021 (Questions, 1.7-1.9, 8.31)

		Laboratory Funding Sources				
Region & state[a]	Public service laboratory name	Service fees	University budgeted funding	State appropriations	Fertilizer tonnage fees/taxes	Proficiency program participation[b]
NORTH CENTRAL						
Illinois	None	-	-	-	-	N/A
Indiana	None	-	-	-	-	N/A
Iowa	None	-	-	-	-	N/A
Kansas	Kansas State Soil Testing Lab	X	-	-	-	NAPT
Michigan	Michigan State University Soil and Plant Nutrient Laboratory	X	-	-	-	NAPT
Minnesota	University of Minnesota Soil Testing Laboratory	X	X	-	-	NAPT
Missouri	Missouri University Soil & Plant Testing Lab	X	-	-	-	NAPT
Nebraska	None	-	-	-	-	N/A
North Dakota	North Dakota State University Soil Testing Laboratory	X	X	-	-	NAPT
Ohio	None	-	-	-	-	N/A
South Dakota	None	-	-	-	-	N/A
Wisconsin	University of Wisconsin Soil and Forage Analysis Lab	X	-	-	-	NAPT
NORTHEASTERN						
Connecticut	University of Connecticut Soil Nutrient Analysis Lab	X	X	-	-	None
Delaware	University of Delaware Soil Testing Program	X	-	X	-	NAPT
Maine	Maine Soil Testing Service	X	X	-	-	NAPT
Maryland	None	-	-	-	-	N/A
Massachusetts	University of Massachusetts Soil & Plant Nutrient Testing Laboratory	X	-	-	-	NAPT, ALP
New Hampshire	None	-	-	-	-	N/A
New Jersey	Rutgers University Soil Test Laboratory	X	X	X	-	NAPT
New York	None	-	-	-	-	N/A
Pennsylvania	Agricultural Analytical Services Laboratory	X	-	-	-	NAPT, ALP
Rhode Island	None	-	-	-	-	N/A
Vermont	University of Vermont Agricultural and Environmental Testing Lab	X	-	-	-	N/A
West Virginia	West Virginia University Soil Testing Laboratory	X	X	X	-	NAPT
SOUTHERN						
Alabama	Auburn University Soil and Forage Testing lab	X	X	X	-	NAPT
Arkansas	Marianna Soil Test Laboratory	X	-	-	X	ALP

Region & state[a]	Public service laboratory name	Laboratory Funding Sources				Proficiency program participation[b]
		Service fees	University budgeted funding	State appropriations	Fertilizer tonnage fees/taxes	
Florida	University of Florida Institute of Food and Agricultural Sciences Analytical Services Laboratories	X	X	-	-	NAPT
Georgia	Agricultural & Environmental Services Laboratories	X	X	-	-	ALP
Kentucky	University of Kentucky Soil Testing Laboratory	X	-	-	X	NAPT
Louisiana	Soil Testing and Plant Analysis Lab	X	-	-	-	ALP
Mississippi	Mississippi State University Soil Testing Laboratory	X	X	-	-	None
North Carolina	Soil Testing Lab, Agronomic Division – North Carolina Department of Agriculture and Consumer Services	X	-	X	X	NAPT, ALP
Oklahoma	Soil, Water and Forage Analytical Laboratory	X	-	-	-	ALP
Puerto Rico	None	-	-	-	-	N/A
South Carolina	Clemson University Agricultural Service Laboratory	X	-	-	X	ALP
Tennessee	Soil, Plant & Pest Center	X	X	-	-	NAPT
Texas	Texas A&M AgriLife Extension Soil, Water and Forage Testing Laboratory	X	-	-	-	NAPT
Virginia	Virginia Tech Soil Testing Lab	X	X	-	-	NAPT
WESTERN						
Arizona	None	-	-	-	-	N/A
California	None	-	-	-	-	N/A
Colorado	Soil, Water and Plant Testing Laboratory	X	X	-	-	NAPT
Hawaii	Agricultural Diagnostic and service center	X	X	X	-	Unknown
Idaho	University of Idaho Analytical Services Laboratory	X	X	-	-	NAPT
Montana	None	-	-	-	-	N/A
New Mexico	None	-	-	-	-	N/A
Oregon	None	-	-	-	-	N/A
Utah	Utah State Analytical Laboratory	X	X	-	-	NAPT
Washington	None	-	-	-	-	N/A
Wyoming	None	-	-	-	-	N/A

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.

[b]N/A, not applicable (no public service laboratory)

Table 3. Sources of support and funding for correlation and calibration research in each state. Estimates are provided by faculty (research or extension) full time equivalents (FTE) currently involved in and/or responsible for soil test correlation and calibration research and updating or validating soil test recommendations. Funding from fertilizer fees and taxes specifically allocated to support soil testing, soil fertility and nutrient management research and/or extension efforts, and estimated funds ($ USD) available on an annual basis. Responses given in 2020 and 2021 (Questions 1.10-1.14)

		Crops for which FTEs are responsible for soil test calibration research or recommendations						Allocated funds		Approximate funding available, USD per annum		
Region & state[a]	Total FTE faculty	Field crops[b]	Vegetable	Forage & pasture[c]	Tree fruit	Small fruit	Turf[d]	Research	Extension	Research	Extension	Combined
NORTH CENTRAL												
Illinois	0.1	X	-	-	-	-	-	Yes	Yes	-	-	$1,000,000
Indiana	2.0	X	-	-	-	-	-	No	No	-	-	-
Iowa	2.0	X	-	X	-	-	-	No	No	-	-	-
Kansas	0.5-1.0[e]	X	-	-	-	-	-	Yes	Yes	-	-	$90,000
Michigan	1.0	X	X	-	-	-	X	No	No	-	-	-
Minnesota	1.5	X	X	X	-	-	-	No	No	-	-	$1,100,000
Missouri	2.0	X	-	X	-	-	-	No	No	-	-	-
Nebraska	3.0	X	-	-	-	-	-	No	No	-	-	-
North Dakota	1.0	X	X	X	-	-	-	No	No	-	-	-
Ohio	1.0	X	X	X	-	-	-	No	No	-	-	-
South Dakota	1.0	X	-	-	-	-	-	Yes	Yes	-	-	$800,000
Wisconsin	1.5	X	-	X	-	-	-	Yes	Yes	$210,000	$130,000	$340,000
NORTHEASTERN												
Connecticut	0.1	X	-	-	X	X	X	No	No	-	-	-
Delaware	0.3	X	X	X	X	X	X	No	No	-	-	-
Maine	0.5	X	X	-	-	-	-	No	No	-	-	-
Maryland	0.4	X	X	X	X	X	-	No	No	-	-	-
Massachusetts	Unknown	-	-	-	-	-	-	-	-	-	-	-
New Hampshire	0.0	-	-	-	-	-	-	Yes	No	-	-	-
New Jersey	-	X	X	X	X	X	X	No	No	-	-	-
New York	4.0	X	X	X	X	X	X	No	No	-	-	-
Pennsylvania	0.3	X	X	-	-	-	X	No	No	-	-	-
Rhode Island	0.0	-	-	-	-	-	-	No	No	-	-	-
Vermont	0.1	X	X	X	-	-	X	No	No	-	-	-
West Virginia	1.5	X	X	X	-	-	-	No	No	-	-	-
SOUTHERN												
Alabama	0.2	X	X	X	X	X	X	No	No	-	-	-

		Crops for which FTEs are responsible for soil test calibration research or recommendations						Allocated funds		Approximate funding available, USD per annum		
Region & state[a]	Total FTE faculty	Field crops[b]	Vegetable	Forage & pasture[c]	Tree fruit	Small fruit	Turf[d]	Research	Extension	Research	Extension	Combined
Arkansas	4.0	X	-	X	-	-	-	Yes	No	$300,000	-	$1,800,000
Florida	4.0	X	X	X	-	-	X	Yes	Yes	-	-	Other[f]
Georgia	1.0	X	-	-	-	-	-	No	No	-	-	-
Kentucky	1.0	X	-	-	-	-	-	No	No	$0	$0	$0
Louisiana	1.0	X	-	-	-	-	-	No	No	-	-	-
Mississippi	0.5	X	-	-	-	-	-	No	No	-	-	-
North Carolina	0.5	X	X	X	-	-	X	No	No	-	-	-
Oklahoma	2.0	X	-	X	-	-	-	Yes	Yes	$250,000	$0	$250,000
Puerto Rico	0.5	-	X	X	X	-	-	No	No	-	-	$10,000
South Carolina	1.0	-	-	-	-	-	-	Yes	No	$50,000	-	$50,000
Tennessee	1.0	X	-	-	-	-	-	No	No	-	-	-
Texas	3.0	X	-	X	-	-	-	No	No	-	-	-
Virginia	0.6	X	X	X	-	-	X	No	No	-	-	-
WESTERN												
Arizona	1.5	X	X	X	X	-	-	No	No	-	-	-
California	Close to 0.0	-	-	-	-	-	-	Yes	Yes	-	-	Unknown
Colorado	0.0	X	-	X	-	-	-	No	-	-	-	-
Hawaii	4.0	X	X	-	X	X	X	No	Yes	-	$100,000	$100,000
Idaho	1.0	X	X	X	-	-	-	Yes	Yes	-	-	$75,000
Montana	0.02	X	-	X	-	-	-	Yes	Yes	$400,000	$150,000	$550,000
New Mexico	1.5	X	X	X	X	X	X	No	No	-	-	-
Oregon	2.0	X	X	X	-	-	X	Yes	No	$50,000	-	$50,000
Utah	3.0	X	X	X	X	X	X	Yes	No	-	-	$50,000
Washington	0.5	X	X	-	X	X	-	No	No	-	-	-
Wyoming	1.0	X	-	X	-	X	-	No	No	-	-	-

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.

[b]Field crops include small grains, cotton, corn, etc.

[c]Forage crops include alfalfa, pasture, hay, etc.

[d]Turf includes lawn and recreational/sports turf.

[e]Kansas: Many faculty are involved in the process, but only a small part of their time is dedicated to fertilizer recommendations. As many as 10 faculty are involved in the recommendations; however, there may only be 0.5 to 1 FTE of time devoted to the calibration, correlation, and true validation of soil test recommendations

[f]Florida: Combined Funding from Florida Department of Agriculture with no fixed amount.

Table 4. Soil test P recommendations. Survey responses for each state and crop indicating the year soil-test P (STP) recommendations (recs) were established and revised or validated, as well as critical soil test P concentrations or ranges and minimum soil test P values above which no fertilizer is recommended. The critical soil test P concentration range includes the soil test P concentration point of no expected yield benefit from fertilization. Crops within the same shaded sections have the same responses. Responses given in 2020 and 2021 (Question 2.2)

Region & state[a]	Crop[b]	Year current STP field correlation established/ validated	Year existing P recs. last revised/ validated	STP method[c]	Critical STP (mg kg^{-1})	Minimum STP where no fertilizer is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine P recommendations[d]
NORTH CENTRAL							
Illinois	All crops	Unknown	Unknown	Bray-1	20-25	40	
Indiana	Corn Soybean	1970-1979	Unknown	Bray-1	15-30	40	
	Winter wheat Alfalfa	Unknown	Unknown	Bray-1	25-40	50	
Iowa	All crops	-	-	Bray-1, Olsen, Mehlich-3_{col}, Mehlich-3			Yield/removal used only for Optimum class (Maintenance), not for Very Low and Low classes
	Corn Soybean	2019	2013	Bray-1 Olsen Mehlich-3_{col} Mehlich-3	16-20 10-13 16-20 26-35	21 14 21 36	
	Oats Corn silage Warm-season tall grasses Pastures	-	2013	Bray-1 Olsen Mehlich-3_{col} Mehlich-3	16-20 10-13 16-20 26-35	21 14 21 36	
	Cool-season grass	-	-	Bray-1 Olsen Mehlich-3_{col} Mehlich-3	16-20 10-13 16-20 26-35	21 14 21 36	
	Winter wheat	-	2013	-	-	-	
	Spring wheat	-	2013	Bray-1 Olsen Mehlich-3_{col} Mehlich-3	21-25 14-16 21-25 31-40	26 17 26 41	

Region & state[a]	Crop[b]	Year current STP field correlation established/ validated	Year existing P recs. last revised/ validated	STP method[c]	Critical STP (mg kg^{-1})	Minimum STP where no fertilizer is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine P recommendations[d]
	Alfalfa	2012	2013	Bray-1 Olsen Mehlich-3_{col} Mehlich-3	-	26 17 26 41	
	Bluegrass pastures	-	2013	Bray-1 Olsen Mehlich-3_{col} Mehlich-3	9-15 6-9 9-15 16-25	16 7 16 26	Yield/removal not used
Kansas	All crops	2002	2002	Mehlich-3	20	100	Minimum soil test where no starter is recommended is not well documented. Recommendation equations use Bray 1 soil test values, but the lab substitutes Mehlich-3 for Bray 1
Michigan	All crops	1995	-	Bray-1, Olsen	-	-	In the process of updating many of these
	Corn Soybean	-	2020	-	15	40	
	Winter wheat	-	2020	-	25	50	
	Sugar Beets	-	2019	-	25	50	
	Dry edible beans	-	2019	-	15	50	
	Potato	-	2020	-	75	200	
Minnesota	All crops	-	-	Bray-1, Olsen	-	20,15	Yield goal is used for P recommendations
	Corn	2018	2018	Bray-1	-	21	Suggested P_2O_5 = [0.7 – 0.035 (Bray P in ppm)] (expected yield)
	Soybean	2018	2018	Bray-1	-	11	Suggested P_2O_5 = [1.752 – 0.0836 (Bray P in ppm)] (expected yield)
Missouri	All crops	1960-1969	2009	Bray-1	-	-	
	Corn Soybean	-	-	-	22.5	35	
	Winter wheat Spring wheat Cotton Grain sorghum	-	-	-	22.5	-	

Region & state[a]	Crop[b]	Year current STP field correlation established/ validated	Year existing P recs. last revised/ validated	STP method[c]	Critical STP (mg kg^{-1})	Minimum STP where no fertilizer is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine P recommendations[d]
	Barley Sunflower Dry edible beans Peanuts Sugar beets Oats Potato Alfalfa						
	Cool-season grass Bermudagrass Pastures	-	-	-	20	-	
	Lespedeza hay Lespedeza pasture Warm-season grass hay/pasture	-	-	-	15	-	
	Rice	-	2014		15		
Nebraska	All crops	Unknown	Unknown	Bray-1			
	Corn	-	2017	-	15-20	15	Critical soil test value varies with previous crop and harvest P removal.
	Soybean	-	2015	-	12	12	
	Winter wheat	1994	2017	-	35	35	
	Spring wheat Barley Sunflower Proso millet Oats Potato Alfalfa	-	-	-	25	25	

Region & state[a]	Crop[b]	Year current STP field correlation established/ validated	Year existing P recs. last revised/ validated	STP method[c]	Critical STP (mg kg^{-1})	Minimum STP where no fertilizer is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine P recommendations[d]
	Cool-season grass Pastures						
	Popcorn Grain sorghum	-	-		15	15	
	Dry edible beans	-	-		14	14	
	Sugar beets	-	-		18	18	
North Dakota	All crops	-	2018	Olsen	-	-	
	Corn	2014	-	-	15	25	Recommendations vary east and west of Missouri River
	Soybean	2018	-	-	7	8	
	Winter wheat	1991	-	-	15	See comment	Starter P always recommended regardless of P test
	Spring wheat	1999	-	-	15	See comment	Starter P always recommended regardless of P test
	Barley	2014	-	-	15	16	Ongoing research for 2-row barley
	Sunflower	2016	-	-	Not defined	Not defined	No response to P in ND
	Canola	2011	-	-	15	16	Starter P strongly recommended for values less than critical
	Dry edible beans	2018	-	-	15	16	
	Sugar beets	2009	-	-	15	16	
	Oats	1991	-	-	15	16	Starter P highly recommended
	Potato	2015	-	-	42	See comment	Starter P always recommended regardless of soil test P, rate varies with variety
	Alfalfa	Unknown	-	-	15	See comment	Some P is recommended at establishment regardless of soil test P (40 lbs P_2O_5 ac^{-1})
	Pastures	1991	-	-	-	-	No P is recommended. No response seen with P addition.
	Chickpea	1997	-	-	15	16	
	Field pea	1999	-	-	15	16	

Region & state[a]	Crop[b]	Year current STP field correlation established/ validated	Year existing P recs. last revised/ validated	STP method[c]	Critical STP (mg kg^{-1})	Minimum STP where no fertilizer is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine P recommendations[d]
	Lentil	1995	-	-	15	16	
Ohio	Corn Soybean	1994	2019	Mehlich-3	20	40	
	Winter wheat Alfalfa	1994	2019	Mehlich-3	30	50	
	Cool-season grass	1994	-	-	-	-	
South Dakota	All crops	Unknown	Unknown	Olsen, Bray-1	16, 21	16, 21	
	Soybean	2014	-	-	-	-	
Wisconsin	All crops	-	2012	Bray-1			
	Alfalfa	1962	-	-	18-25 26-37	36 55	Medium-/fine-textured soils Sand/loamy sand and histosols
	Beans Fruit Peas Sweet corn	1966	-	-	18-25 26-37	36 55	Medium-/fine-textured soils Sand/loamy sand and histosols
	Corn grain Oats Small grains (excluding wheat) Grass, pasture,hay	1962	-	-	16-20 23-32	31 42	Medium-/fine-textured soils Sand/loamy sand and histosols
	Corn silage	1962	-	-	18-25 26-37	36 55	Medium-/fine-textured soils Sand/loamy sand and histosols
	Potato	1966	-	-	161-200 61-90	201 120	Medium-/fine-textured soils Sand/loamy sand and histosols
	Soybean	1966	-	-	16-20 23-32	31 42	Medium-/fine-textured soils Sand/loamy sand and histosols
	Tomato Pepper Brassica Leafy greens Vine	1966	-	-	31-45 36-50	76 80	Medium-/fine-textured soils Sand/loamy sand and histosols

Region & state[a]	Crop[b]	Year current STP field correlation established/ validated	Year existing P recs. last revised/ validated	STP method[c]	Critical STP (mg kg^{-1})	Minimum STP where no fertilizer is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine P recommendations[d]
	Truck crops						
	Wheat	1966	-	-	18-25 26-37	36 55	Medium-/fine-textured soils Sand/loamy sand and histosols
NORTHEASTERN							
Connecticut	All crops	2015	1950-1959	Mod. Morgan	7	10	Extractable aluminum used to adjust P fertilizer recommendation
	Corn Cool-season grass	-	2015	Mod. Morgan	20	10	
Delaware	All crops	Unknown	-	Mehlich-3	51-100	-	-
	Corn Soybean Winter wheat Grain sorghum Barley Oats	-	2018	-	-	101	No recommendation above 100 ppm, but for higher yields crop removal rates are recommended for most crops
	Sunflower	-	2018	-	-	80	-
	Potato	-	2019	-	-	101	-
	Alfalfa Bermudagrass	-	2019	-	-	70	-
	Cool-season grass	-	2019	-	-	90	-
	Pastures	-	2019		-	70	Several species-specific recommendations available, but most list 70 ppm Mehlich-3 as the highest soil test P with a recommendation
Maine	All crops	1970-1979	1970-1979	Mod. Morgan	5-10	20	Adapted from old Cornell guidelines
	Potato	1994	2004	Mod. Morgan	15	25	Currently under recalibration
Maryland	All crops	1970-1979	1970-1979	Mehlich-1	45	45	Use an index value (FIV), currently a conversion is done from multiple laboratory chemistries to the FIV scale
Massachusetts	-	-	-	-	-	-	

Region & state[a]	Crop[b]	Year current STP field correlation established/ validated	Year existing P recs. last revised/ validated	STP method[c]	Critical STP (mg kg^{-1})	Minimum STP where no fertilizer is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine P recommendations[d]
New Hampshire	All crops	Unknown	2005	Mehlich-3	30-50	75	Varies by crop and expected yield
New Jersey	All crops	1998	1998	Mehlich-3	36	69	
New York	All crops	Unknown	Unknown	Morgan	5-10	20	Critical values can vary by crop but not adjusted for expected yield
	Corn	Unknown	2001-2003	Morgan	5-10	20	Large statewide evaluations study confirmed originally designed P recommendation system for corn
Pennsylvania	Corn	1993	2013	Mehlich-3	30	50	Adjusted for expected yield
Rhode Island	-	-	-	-	-	-	
Vermont	All crops	Unknown	2016	Mod. Morgan	4-7	7.1	Validation of field response has been done erratically over the years as an add-on to other field research. No data appear to have survived. Extractable aluminum used to adjust P fertilizer recommendation
West Virginia	All crops	Unknown	2018	Mehlich-3	-	30	Recommendations were revised, not calibrated.
SOUTHERN							
Alabama	All crops	-	-	Mehlich-1	25-33; 15-20-40	25;15	Have two levels of crops and four soil classes. These values are for soil classes 1, 2, and 3.
	Corn Soybean Cotton	2018	2018	-	-	-	
	Winter wheat Spring wheat Grain Sorghum Barley Sunflower Canola Dry edible beans	Unknown	-	-	-	-	

Region & state[a]	Crop[b]	Year current STP field correlation established/ validated	Year existing P recs. last revised/ validated	STP method[c]	Critical STP (mg kg^{-1})	Minimum STP where no fertilizer is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine P recommendations[d]
	Peanuts	-	-	-	10-12; 6-7	10; 6	
Arkansas	All crops	-	-	Mehlich-3	-	-	
	Corn Winter wheat Cotton Grain sorghum Oats Pastures	2005	2005	-	26-35	36	
	Soybean	2015	2015	-	17-25	26	
	Rice	2015	2015	-	17-25	26	Recommendations differ above and below soil pHw 6.5. Less P is recommended when pH is greater than 6.5.
	Alfalfa Cool season grass Bermudagrass	2005	2005	-	26-35	51	
Florida	All crops	2016	2016	Mehlich-3	26-45	45	
Georgia	All crops	1960-1969	Unknown	Mehlich-1	-	-	
	Corn	-	-	-	30-50	50	For early planted corn, 30-60 lbs P_2O_5 ac^{-1} is recommended
	Grain sorghum Sunflower Dry edible beans Bermudagrass Alfalfa	-	-	-	30-50	50	
	Pastures	-	-	-	30-50	50	Bermuda pasture
	Canola	Unknown	-	-	30-50	50	
	Sugar beets	-	-	-	30-50	67	
	Potato	-	-	-	30-50	71.5	
	Soybean Winter wheat	-	-	-	15-30	36	

Region & state[a]	Crop[b]	Year current STP field correlation established/ validated	Year existing P recs. last revised/ validated	STP method[c]	Critical STP (mg kg^{-1})	Minimum STP where no fertilizer is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine P recommendations[d]
	Spring wheat	-	-	-	15-30	35	
	Cotton	-	-	-	15-30	36.5	
	Rice	Unknown	-	-	15-30	35.5	
	Barley Oats Cool-season grass	-	-	-	15-30	35.5	
	Peanuts	-	1993	-	8-15	20	
Kentucky	All crops	Unknown	1998/1999	Mehlich-3	-	-	
	Corn Soybean Winter wheat Grain sorghum Barley Oats Alfalfa Cool-season grass Bermudagrass Pastures Corn silage	-	1999	-	-	30	
	Canola	-	1998	-	-	30	
	Burley tobacco Dark tobacco	-	1999	-	-	40	
Louisiana	All crops	2014	-	Mehlich-3	20-35	35	Recommendations for all crops were reviewed in 2015
Mississippi	All crops	Unknown	Unknown	Lancaster	-	37	
North Carolina	All crops	1981	-	Mehlich-3	-	-	
	Corn	-	1997	-	17-34	84	Critical level based on published data
	Soybean	-	1993	-	23-41	84	Crtitical level based on published data
	Winter wheat	-	1993	-	20-40	84	Crtitical level based on published data
	Cotton	-	1999, 2002	-	13-42	84	Crtitical level based on publish data, upper end general crtitical level for crops

Region & state[a]	Crop[b]	Year current STP field correlation established/ validated	Year existing P recs. last revised/ validated	STP method[c]	Critical STP (mg kg^{-1})	Minimum STP where no fertilizer is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine P recommendations[d]
	Grain sorghum Oats Sunflower Canola Cool-season grass Bermudagrass	-	-	-	30	84	Crtitical level based on general knowledge of research and lab history
	Barley	-	-	-	30	-	Critical level based on general knowledge of research and lab history
	Peanuts	-	1995	-	17-24	60	Critical level based on published data
	Potato	-	-	-	-	192	
	Alfalfa	-	-	-	30	96	Critical level based on research and lab history
Oklahoma	All crops	1980-1989	1980-1989	Mehlich-3	40	40	Several long-term N, P, K plots are in place for validation
Puerto Rico	All crops	-	-	Bray-1 Olsen	22 16	-	Critical level based on literature review of published and unpublished data
South Carolina	All crops	Unknown	2007	Mehlich-1	-	-	
	Corn	-	-	-	30.5-40	40.5	For 150 bu ac^{-1}
	Soybean	-	-	-	30.5-40	40.5	For 160 bu ac^{-1}
	Spring wheat Grain sorghum Rice Sunflower Canola Sugar beets Oats Alfalfa Cool-season grass Bermudagrass Pastures	-	-	-	30.5-40	40.5	
	Potato	-	-	-	40.5-60	60	

Region & state[a]	Crop[b]	Year current STP field correlation established/ validated	Year existing P recs. last revised/ validated	STP method[c]	Critical STP (mg kg^{-1})	Minimum STP where no fertilizer is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine P recommendations[d]
	Cotton	-	-	-	15.5-30	30.5	Dryland cotton-specific
	Peanuts	-	-	-	5.5-9.5	10	
Tennessee	All crops	-	-	Mehlich-1	30	30	
Texas	All crops	Unknown	2003	Mehlich-3	50	50	
	Corn	2004	-	-	-	-	
	Cotton	2011	-	-	-	-	
	Grain sorghum	2005	-	-	-	-	
	Bermudagrass Pasture	2010	-	-	-	-	
	Rice	-	-	-	30	50	
Virginia	All crops	Unknown	Unknown	Mehlich-1	6	55	
WESTERN							
Arizona	-	-	-	-	-	-	
California	All crops	Unknown	1960-1969	Olsen	-	-	
	Corn Winter wheat	-	-	-	6-12	-	
	Cotton	1940-1949	Unknown	-	5-8	-	
	Barley	-	-	-	6-15	-	
	Potato	-	-	-	12-25	-	
Colorado	All crops	1995	-	Olsen	-	-	
	Corn	-	2013	-	7-14	11	
	Winter wheat	-	2013	-	7-14	22	
	Sunflower	-	1995	-	7-14	14	
	Dry edible beans	-	2008	-	7-14	14	
	Sugar beets	-	2014	-	8-14	22	
	Potato	-	2018	-	15-22	22	
	Alfalfa	1998	2012	-	-	-	
	Cool-season grass	-	2010	-	7-14	22	
	Millet	-	2013	-	9-12	12	
Hawaii	Corn	1950-1959	1999	Truog	25-50	50	In process of changing to Mehlich 3 or Olsen

Region & state[a]	Crop[b]	Year current STP field correlation established/ validated	Year existing P recs. last revised/ validated	STP method[c]	Critical STP (mg kg^{-1})	Minimum STP where no fertilizer is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine P recommendations[d]
Idaho	All crops	2009	2009	-	-	-	
	Corn	-	-	Olsen	20	25	
	Winter wheat Spring wheat Barley Canola Alfalfa Pastures	-	-	Morgan	4	4	Morgan for northern Idaho. In southern Idaho, Olsen is used.
	Dry edible beans Sugar beets Potato	-	-	Olsen	20	20	
Montana	All crops	2002	Unknown	Olsen	16	24	
	Winter wheat	-	-	-	24	-	
New Mexico	All crops	1997	1997	Olsen	25-30	31	Soil texture guides recommendations
Oregon	Corn	-	2009	Olsen	15	15	For Bray-1 P, threshold listed at 24 ppm (Ref. PNW 615).
	Winter wheat Spring wheat	-	2009	Olsen	20	20	East of Cascades soft white wheat, winter and spring (Ref. 9015E).
	Canola	-	2006	Olsen	15	15	Specific to Eastern Oregon (Ref. EM 8943E)
	Sugar beets	-	-	-	-	-	Idaho recommendations are used
	Potato	-	-	-	-	-	Washington State University recommendations are used
	Alfalfa	1998	2008	Olsen	20	20	For Eastern Oregon, Eastern Washington, and Idaho. Morgan's threshold also listed, 6 ppm (Ref. PNW0611).
	Pastures Cool-season grass	-	2018	Bray-1	30	30	Specific to Western Oregon and Western Washington (Ref. EM 9224).
	Soft white winter wheat,	1970-1979	2010	Bray-1	30	30	For Western Oregon (Ref. EM 8963)

Region & state[a]	Crop[b]	Year current STP field correlation established/ validated	Year existing P recs. last revised/ validated	STP method[c]	Critical STP (mg kg^{-1})	Minimum STP where no fertilizer is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine P recommendations[d]
	winter & spring						
	Perennial & annual grass seed	-	2013	Bray-1	25	25	For Western Oregon (Ref. EM 9099, EM 8854, EM 9086, and 20112014)
Utah	All crops	1970-1979	-	Olsen	-	-	
	Corn	-	2011	-	15	-	
	Winter wheat Spring wheat Oats Alfalfa Cool-season grass Lawn & sport turf	-	-	-	15	-	
	Barley Pastures Alfalfa	-	-	-	12	-	Dryland
	Potato	-	-	-	30	-	
	Tree fruit	-	-	-	10	-	
Washington	-	-	-	-	-	-	
Wyoming	All crops	1995	1995	Olsen	-	-	Different recommendations for coarse, medium, and fine textured soils. Those for medium textured soils are provided.
	Corn	-	-	-	15-22	23	Yield goal = 150 bu ac^{-1} or 30 tons ac^{-1} for silage; 06 lbs. P_2O_5 bu^{-1} or 3 lbs bu^{-1} for silage
	Sunflower	-	-	-	15-22	23	Yield goal = 30 cwt ac^{-1}; 2 lbs P_2O_5 cwt^{-1}
	Potato	-	-	-	15-22	23	Yield goal = 350 cwt; 0.2l bs P_2O_5 cwt^{-1}
	Alfalfa	-	-	-	15-22	23	Yield goal = 6 tons ac^{-1}; 15 lbs P_2O_5 ton^{-1}

Region & state[a]	Crop[b]	Year current STP field correlation established/ validated	Year existing P recs. last revised/ validated	STP method[c]	Critical STP (mg kg^{-1})	Minimum STP where no fertilizer is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine P recommendations[d]
	Safflower (dryland)	-	-	-	15-22	23	Yield goal = 14 cwt ac^{-1}; 2 lbs P_2O_5 cwt^{-1}
	Winter wheat Spring wheat	-	-	-	7-14	15	Yield goal = 90 bu ac^{-1}; 1.0 lbs bu^{-1}
	Barley	-	-	-	7-14	15	Yield goal = 100 bu ac^{-1}; 0.7 lbs P_2O_5 bu^{-1}
	Dry edible beans	-	-	-	7-14	15	Yield goal = 30 cwt ac^{-1}; 1.75 lbs P_2O_5 cwt^{-1}
	Oats	-	-	-	7-14	15	Yield goal = 135 bu ac^{-1}; 0.5 lbs P_2O_5 bu^{-1}
	Millet (dryland)	-	-	-	7-14	15	Yield goal = 35 bu ac^{-1}; 0.6 lbs P_2O_5 bu^{-1}
	Cool-season grass	-	-	-	7-14	16	Yield goal = 6 tons ac^{-1}; 15 lbs P_2O_5 ton^{-1}
	Sugar beets	-	-	-	22	22	Yield goal = 30 tons ac^{-1}; 3 lbs P_2O_5 ton^{-1}
	Fruits, ornamentals, trees, veggies						

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.
[b]Information in "All crops" rows apply to all crops (listed or otherwise) unless over-riding crop-specific information is supplied in a separate row within the same state
[c]Mehlich-3_{col}: Mehlich-3 colorimetric; all other Mehlich-3 are ICP; Mod. Morgan, Modified Morgan.
[d]Yield/removal: the total amount of plant nutrient removed from the field in the harvested portion of the crop. Yield goal: pre-planting metric used to make the best growing and economic decisions throughout the growing season for a desired crop yield. See Table 18 for SI unit conversions.

Table 5. Soil test K recommendations. Survey responses for each state and crop indicating the year a soil-test K (STK) recommendation was established and revised or validated, as well as the critical soil test K concentration or range and the minimum soil test value above which no fertilizer is recommended. The critical soil test K concentration range includes the soil test K concentration point of no expected yield benefit from fertilization. Responses given in 2020 and 2021 (Question 3.2)

Region & state[a]	Crop[b]	Year current STK field correlation established /validated	Year existing K recs. last revised/ validated	STK method[c]	Critical STK (mg kg^{-1})	Minimum STK where no fertilizer K is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine K recommendations[d]
NORTH CENTRAL							
Illinois	All crops	Unknown	Unknown	NH_4OAc, Mehlich-3	260-300	360-400	
Indiana	Corn Soybean	1980-1989	2011	NH_4OAc	100-130	150	Critical level and recommendations vary by CEC. Values are for CEC of 10 meq 100 g^{-1}.
	Alfalfa	1980-1989	2011	NH_4OAc	100	150	Critical level and recommendations vary by CEC. Values are for CEC of 10 meq 100 g^{-1}.
Iowa	All Crops	-	2013	NH_4OAc, Mehlich-3	-	-	Yield/removal used only for Optimum class (maintenance), not for Very Low and Low classes. Same method used for NH_4OAc and Mehlich-3, but different for dry and moist samples.
	Corn Soybean	2019	-	-	Dry: 161-200 Moist: 86-120	Dry: 201 Moist:121	Different recommendations based on whether soil was measured dried (Dry) or field-moist (Moist). Optimum class, removal-based recommendation only.
	Spring wheat Oats Alfalfa Pastures Corn silage Warm-season tall grasses	-	-	-	Dry: 161-200 Moist: 86-120	Dry: 201 Moist: 121	Different recommendations based on whether soil was measured dried (Dry) or field-moist (Moist). Optimum class, removal-based recommendation only.
	Bluegrass pastures	-	-	-	Dry: 121-160	Dry: 161 Moist: 86	Different recommendations based on whether soil was measured dried (Dry) or field-moist (Moist). Yield/removal not used.

Region & state[a]	Crop[b]	Year current STK field correlation established /validated	Year existing K recs. last revised/ validated	STK method[c]	Critical STK (mg kg^{-1})	Minimum STK where no fertilizer K is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine K recommendations[d]
Kansas	All crops	2003	2003	NH_4OAc	130	160	
Michigan	All crops	1995	-	NH_4OAc	-	-	In the process of revising
	Corn Soybean Winter wheat	-	2020	-	100-130	130 or 170	130 for CEC <5 cmol kg^{-1}; 170 for CEC >5 cmol kg^{-1}
	Dry edible beans	-	1995	-	100-130	130 or 170	130 for CEC <5 cmol kg^{-1}; 170 for CEC >5 cmol kg^{-1}
	Sugar beets	-	1998	-	100-130	130 or 170	130 for CEC <5 cmol kg^{-1}; 170 for CEC >5 cmol kg^{-1}
	Potato	-	1998	-	-	-	In the process of revising
Minnesota	Corn	2018	2018	NH_4OAc	-	200	Suggested K_2O = [1.12 – 0.0056 (soil test K ppm)] (expected yield)
	Soybean	2018	2018	NH_4OAc	-	200	Suggested K_2O = [2.0 – 0.0088 (soil test K ppm)] (expected yield)
Missouri	All crops	Unknown	-	NH_4OAc	-	-	
	Corn	-	-	-	(220 + 5*CEC)/2	-	
Nebraska	Corn	Unknown	2010	NH_4OAc	125	125	
	Winter wheat	Unknown	1995	NH_4OAc	-	-	K application not recommended
	Sugar beets	2018	Unknown	NH_4OAc	125	125	
	Soybean Spring wheat Grain sorghum Barley Dry edible beans Oats Potato Alfalfa Cool-season grass Pasture Popcorn	Unknown	Unknown	NH_4OAc	125	125	

Region & state[a]	Crop[b]	Year current STK field correlation established /validated	Year existing K recs. last revised/ validated	STK method[c]	Critical STK (mg kg^{-1})	Minimum STK where no fertilizer K is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine K recommendations[d]
	Proso millet						
	Sunflower	-	-	-	121	121	
North Dakota	All crops	2019	2019	NH_4OAc	-	-	Varies with soil type and crop. Rates are based on soil test and % of clay below or above 3.5 smectite:illite ratio
	Corn Soybean	-	-	-	-	150 200	Below 3.5 smectite:illite ratio Above 3.5 smectite:illite ratio
	Winter wheat Spring wheat	-	-	-	-	100 150	Below 3.5 smectite:illite ratio Above 3.5 smectite:illite ratio
	Barley Sunflower	-	-	-	150	151	
	Canola	-	-	-	160	161	
	Dry edible beans	-	-	-	80	81	
	Sugar beets	-	-	-	120 150	121 151	Below 3.5 smectite:illite ratio Above 3.5 smectite:illite ratio
	Oats	-	-	-	100 150	101 151	Below 3.5 smectite:illite ratio Above 3.5 smectite:illite ratio
	Potato	-	-	-	200	-	K recommended at all soil test K values
	Alfalfa	-	-	-	150 200	-	Below 3.5 smectite:illite ratio Above 3.5 smectite:illite ratio K recommended at all soil test K values
	Chickpea Field pea Lentil	-	-	-	100	101	
Ohio	Corn Soybean Winter wheat Alfalfa	1995	2020	Mehlich-3	100 120	130 170	CEC < 5 cmol kg^{-1} CEC > 5 cmol kg^{-1}
South Dakota	All crops	Unknown	Unknown	NH_4OAc	160	160	
Wisconsin	Alfalfa Corn silage	1962	2012	Bray-1	111-140 81-120	241 201	Medium-/fine-textured soils Sand/loamy sand and histosols

Region & state[a]	Crop[b]	Year current STK field correlation established /validated	Year existing K recs. last revised/ validated	STK method[c]	Critical STK (mg kg^{-1})	Minimum STK where no fertilizer K is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine K recommendations[d]
	Beans Fruit Peas Sweet corn Wheat	1966	2012	Bray-1	111-140 81-120	241 201	Medium-/fine-textured soils Sand/loamy sand and histosols
	Corn grain Oats Small grains (excluding wheat) Grass, pasture, hay	1962	2012	Bray-1	101-130 66-90	191 131	Medium-/fine-textured soils Sand/loamy sand and histosols
	Potato	1966	2012	Bray-1	121-170 101-130	221 191	Medium-/fine-textured soils Sand/loamy sand and histosols
	Soybean	1966	2012	Bray-1	101-130 66-90	191 131	Medium-/fine-textured soils Sand/loamy sand and histosols
	Tomato Pepper Brassica Leafy greens Vine Truck crops	1966	2012	Bray-1	141-200 101-150	241 181	Medium-/fine-textured soils Sand/loamy sand and histosols
NORTHEASTERN							
Connecticut	All crops	2016	1960-1969	Mod. Morgan	125	250	
Delaware	Corn Soybean Winter wheat Grain sorghum Barley Oats	Unknown	2019	Mehlich-3	91-182	184	We have significant recommendations for K all the way to 184 ppm depending on yield goal. We do not give a recommendation above that, but at 184 ppm it could be as high as 95 lbs K_2O ac^{-1}
	Potato	Unknown	2020	Mehlich-3	91-182	184	
	Sunflower	Unknown	2019	Mehlich-3	91-182	145	
	Alfalfa	Unknown	2020	Mehlich-3	91-182	164	

Region & state[a]	Crop[b]	Year current STK field correlation established /validated	Year existing K recs. last revised/ validated	STK method[c]	Critical STK (mg kg^{-1})	Minimum STK where no fertilizer K is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine K recommendations[d]
	Cool-season grass Bermudagrass Pastures						
Maine	All crops	1980-1989	1980-1989	Mod. Morgan	117	195	Critical and Minimum STK based on K saturation of CEC, 3 and 5%, respectively. Values listed assume a CEC of 10 $cmol_c$ kg^{-1}. These were adapted from old Penn State guidelines
	Potato	2005	2005	Mod. Morgan	225	300	Sufficiency level
Maryland	All crops	1980-1989	1980-1989	Mehlich-1	133	133	An index value (FIV) is used, currently a conversion is done from multiple laboratory chemistries to the FIV scale
Massachusetts	-	-	-	-	-	-	
New Hampshire	All crops	1980-1989	2005	Mehlich-3	169-280	280	Varies by crop and expected yield
New Jersey	All crops	Unknown	Unknown	Mehlich-3	73	139	
New York	Alfalfa	Unknown	Unknown	Morgan	48-83	48-83	Recommendations are a function of both STK and soil management group, recognizing impact of soil mineralogy on K supply. Adjusted based on yield potentials.
	Corn	Unknown	2006-2008	Morgan	75-135	75-135	Recommendations are a function of both STK and soil management group, recognizing impact of soil mineralogy on K supply.
Pennsylvania	Corn	1995	2018	Mehlich-3	100	150	
Rhode Island	-	-	-	-	-	-	
Vermont	All crops	Unknown	2017	Mod. Morgan	101-130	161	
West Virginia	All crops	Unknown	2019	Mehlich-3	-	90	Recommendations were revised, not calibrated
SOUTHERN							
Alabama	Corn	2019	2019	Mehlich-1	-	-	We have three crop levels and four soil classes

Region & state[a]	Crop[b]	Year current STK field correlation established /validated	Year existing K recs. last revised/ validated	STK method[c]	Critical STK (mg kg^{-1})	Minimum STK where no fertilizer K is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine K recommendations[d]
	Soybean Cotton	2019	2019	Mehlich-1	-	-	
	Winter wheat Spring wheat Grain sorghum	Unknown	Unknown	Mehlich-1	-	-	
Arkansas	All crops	-	-	Mehlich-3	-	-	Changes made in 2016 were to the recommended fertilizer-K rates for select crops. The critical soil-test K thresholds were not adjusted.
	Corn Winter wheat Grain sorghum Oats Alfalfa Cool-season grass Bermudagrass Pasture	2006	2006		91-130	131	
	Soybean Cotton Rice	2006	2016		91-130	131	
Florida	All crops	2017	2017	Mehlich-3	36-60	60	
Georgia	All crops	1970-1979	Unknown	Mehlich-1	-	-	
	Corn	-	-	-	75-125	125	
	Soybean	-	-	-	85.5-137.5	137.5	
	Winter wheat Spring wheat	-	-	-	30-75	89.5	
	Cotton	-	-	-	35.5-85	100	
	Grain sorghum	-	-	-	75-125	125	
	Barley	-	-	-	30-75	87	
	Sunflower	-	-	-	75-125	125	
	Dry edible beans Sugar beets	-	-	-	85.5-137.5	137.5	
	Peanuts	-	1994	-	15-30	46	

Region & state[a]	Crop[b]	Year current STK field correlation established /validated	Year existing K recs. last revised/ validated	STK method[c]	Critical STK (mg kg^{-1})	Minimum STK where no fertilizer K is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine K recommendations[d]
	Oats	-	-	-	30-75	87	
	Potato	-	-	-	85.5-137.5	197.5	
	Alfalfa	-	-	-	85.5-137.5	137.5	
	Cool-season grass	-	-	-	30-75	87	
	Bermudagrass	-	-	-	75-125	125	
	Rice	Unknown	-	-	-	-	
	Canola						
Kentucky	All crops	Unknown	-	Mehlich-3	-	-	
	Corn Soybean Winter wheat Grain sorghum Barley Oats Bermudagrass Pastures	-	2000	-	-	150	
	Canola	1999	1999	-	-	150	
	Alfalfa Burley tobacco Dark tobacco	-	2000	-	-	225	
	Cool-season grass	-	2000	-	-	210	
	Corn silage	1980-1989	1980-1989	-	-	210	
Louisiana	All crops	2015	2015	Mehlich-3	-	-	Recommendations were reviewed for all crops in 2015. Critical level differs between alluvial soils and upland soils for some crops.
	Corn Soybean Winter wheat Cotton Rice	-	-	-	106-141	141	Values are for alluvial soils. For upland soils, critical STK ranges from 97-141 ppm.

Region & state[a]	Crop[b]	Year current STK field correlation established /validated	Year existing K recs. last revised/ validated	STK method[c]	Critical STK (mg kg^{-1})	Minimum STK where no fertilizer K is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine K recommendations[d]
	Peanuts Alfalfa Bermudagrass	-	-	-	141-158	158	Values are for alluvial soils. For upland soils, critical STK ranges from 106-123 ppm.
Mississippi	All crops	Unknown	-	Lancaster	-	-	Indexed by CEC
	Corn	-	1980-1989	-	-	-	
	Soybean	-	2009	-	-	-	
	Cotton	-	1995	-	-	-	
North Carolina	All crops	1981		Mehlich-3	-	-	Critical level based on general knowledge of research and lab history
	Corn	-	2018	-	30-100	160	Validation studies by Hardy and Crozier, unpublished, and older published data
	Soybean Winter wheat Grain sorghum Barley Sunflower Canola Oats Cool-season grass	-	2018	-	50	160	Soybean validation studies by Hardy and Crozier, unpublished.
	Cotton	-	2002	-	40-160	180	Unpublished validation work by NCDA; and published data
	Peanuts	-	1985-1998	-	40	140	Critical level based on published research
	Potato	-	-	-	-	200	
	Alfalfa	-	-	-	-	240	
	Bermudagrass	-	-	-	50	240	
Oklahoma	All crops	1980-1989	1980-1989	Mehlich-3	125	125	
	Alfalfa	-	-	-	175	175	
	Lawn and gardens	-	-	-	150	150	

Region & state[a]	Crop[b]	Year current STK field correlation established /validated	Year existing K recs. last revised/ validated	STK method[c]	Critical STK (mg kg^{-1})	Minimum STK where no fertilizer K is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine K recommendations[d]
Puerto Rico	All crops	1970-1979	2019	NH_4OAc	156	-	Derived from published and unpublished critical levels
South Carolina	All crops	Unknown	2008	Mehlich-1	-	-	
	Corn	-	-	-	91.5-117.5	117.5	For expected yield of 150 bu ac^{-1}
	Soybean	-	-	-	78.5-91	91.5	For expected yield of 60 bu ac^{-1}
	Spring wheat Grain sorghum Sunflower Canola Oats Cool-season grass Bermudagrass Pastures	-	-	-	78.5-91	91.5	
	Cotton	-	-	-	35.5-78	78.5	Dryland cotton
	Peanuts	-	-	-	20.5-30	30.5	
	Rice Sugar beets Potato Alfalfa	-	-	-	91.5-117.5	117.5	
Tennessee	-	-	-	-	-	-	
Texas	All crops	2004	2004	Mehlich-3	-	-	Recommendations vary with crop species and expected yields
	Cotton	-	2019	-	-	-	
Virginia	All crops	Unknown	Unknown	Mehlich-1	28	155	
WESTERN							
Arizona	-	-	-	-	-	-	
California	Corn	Unknown	1970-1979	NH_4OAc	50-80	-	
	Winter wheat Barley	Unknown	1970-1979	NH_4OAc	40-60	-	
	Potato	Unknown	1970-1979	NH_4OAc	100-150	-	
Colorado	All crops	1996	-	Olsen	60-120	-	
	Corn		2014	-	-	120	

Region & state[a]	Crop[b]	Year current STK field correlation established /validated	Year existing K recs. last revised/ validated	STK method[c]	Critical STK (mg kg^{-1})	Minimum STK where no fertilizer K is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine K recommendations[d]
	Winter wheat Millet						
	Cool-season grass	-	2011	-	-	120	
	Dry edible beans	-	2009	-	-	120	
	Sugar beets	-	2015	-	-	120	
	Potato	-	2019	-	-	180	
Hawaii	Corn	1960-1969	2000	NH_4OAc	250-300	300	In process of changing to Mehlich-3
Idaho	All crops	2000	2000	Morgan	100	100	North Idaho; in south Idaho Olsen is used
Montana	All crops	2003	-	NH_4OAc	250	250	
New Mexico	All crops	1980-1989	2019	NH_4OAc	150-250	250	Smectite soils being evaluated for K response
Oregon	Corn	-	2010	Olsen	150	150	Also recommend ammonium acetate method, 180 ppm as the threshold for this extraction (Ref. PNW 615).
	Winter wheat Spring wheat	-	2010	Olsen	100	100	East of cascades soft white wheat, winter and spring (Ref. 9015E).
	Canola	-	2007	Olsen, NH_4OAc	125	125	Specific to Eastern Oregon (Ref. EM 8943E).
	Sugar beets	-	-	-	-	-	Idaho recommendations used in Oregon
	Potato	-	-	-	-	-	Washington State University recommendations used in Oregon
	Alfalfa	2001	2009	Olsen, Morgan	200	200	For Eastern Oregon, Eastern Washington, and Idaho. Morgan's threshold also listed, 6 ppm (Ref. PNW0611).
	Cool-season grass Pastures	1950-1959	2019	Unknown	200	200	Specific to Western Oregon and Western Washington (Ref. EM 9224).
	Perennial & annual grass seed (W OR)	2005	2014	NH_4OAc	150	150	See Ref. EM 9099, EM 8854, EM 9086, and 20112014 for last updated depending on the guide

Region & state[a]	Crop[b]	Year current STK field correlation established /validated	Year existing K recs. last revised/ validated	STK method[c]	Critical STK (mg kg^{-1})	Minimum STK where no fertilizer K is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine K recommendations[d]
	Soft white winter wheat, winter and spring (W OR)	-	2011	NH_4OAc	100	100	Ref. EM 8963
Utah	All crops	1980-1989	-	Olsen	-	-	Critical values are considered the zero fertilizer threshold
	Corn Winter wheat Spring wheat Barley Oats Alfalfa Cool-season grass	-	-	-	150	-	
	Potato	-	-	-	140	-	
	Pastures Dryland alfalfa	-	-	-	100	-	Dryland
	Tree fruit	-	-	-	75	-	
	Lawn & port turf	-	-	-	125	-	
Washington	-	-	-	-	-	-	
Wyoming	All crops	1996	1996	Olsen	-	-	
	Corn	-	-	-	81-100	101	8 lbs K_2O ton^{-1} silage; 1.2 lbs bu^{-1} grain
	Winter wheat Spring wheat	-	-	-	71-73	74	2 lbs K_2O bu^{-1}
	Barley	-	-	-	61-73	74	1.6 lbs K_2O bu^{-1}
	Oats	-	-	-	61-73	74	1.33 lbs K_2O bu^{-1}
	Sunflower	-	-	-	61-120	121	2 lbs K_2O cwt^{-1}
	Dry edible beans	-	-	-	37-45	46	4 lbs K_2O cwt^{-1}
	Sugar beets	-	-	-	101-120	121	9 lbs K_2O ton^{-1}
	Potato	-	-	-	131-150	151	1 lbs K_2O cwt^{-1}
	Alfalfa	-	-	-	121-150	151	40 lbs K_2O ton^{-1}
	Cool-season grass	-	-	-	91-120	121	35 lbs K_2O ton^{-1}

Region & state[a]	Crop[b]	Year current STK field correlation established /validated	Year existing K recs. last revised/ validated	STK method[c]	Critical STK (mg kg^{-1})	Minimum STK where no fertilizer K is recommended (mg kg^{-1})	Comments and/or other soil-test information used to refine K recommendations[d]
	Fruits, ornamentals, trees, & veggies	-	-	-	60-120	121	
	Millet	-	-	-	60	61	Dryland millet; 1.7 lbs K_2O bu^{-1}
	Safflower	-	-	-	81-120	121	Dryland safflower; 2 lbs K_2O cwt^{-1}

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.
[b]Information in "All crops" rows apply to all crops (listed or otherwise) unless over-riding crop-specific information is supplied in a separate row within the same state
[c]Mod. Morgan, Modified Morgan
[d]CEC, cation exchange capacity; Yield/removal: the total amount of plant nutrient removed from the field in the harvested portion of the crop; Yield goal: pre-planting metric used to make the best growing and economic decisions throughout the growing season for a desired crop yield. See Table 18 for SI unit conversions.

Table 6a. Qualitative categories for soil test nutrients used by soil test laboratories including expected yield response and whether fertilizer is recommended. Responses given in 2020 and 2021 (Questions 4.2 and 4.3)

Region & state[a]	Soil test category	Yield response to fertilizer expected?	Fertilizer recommended?	Comments[b]
NORTH CENTRAL				
Illinois	None	-	-	Soil test categories not used
Indiana	Build-up	Yes	Yes	No estimates of response frequency or magnitude
	Maintenance	No	Yes	Crop removal in case of P or crop removal plus 20 lbs ac^{-1} in case of K
	Draw-down	No	Yes	Less than crop removal recommended
Iowa	Very Low	Yes	Yes	
	Low	Yes	-	
	Optimum	Yes	-	
	High	-	-	
	Very High	-	-	
Kansas	Very Low	Yes	Yes	
	Low	Yes	Yes	
	Medium	Yes	Yes	
	Optimum	No	Yes	Fertilizer recommendations are only for Build and Maintain
	Above Optimum	No	No	
	Very High	No	No	
Michigan	Build-up	Yes	Yes	
	Maintain	No	No	Banded recommendation if wish to apply
	Draw-down	No	No	Economics at play; there can be economical reasons to apply based on STK or STP levels, such as price of fertilizer.
Minnesota	-	-	-	Soil test categories used but information not provided
Missouri	Very Low	Yes	Yes	
	Low	Yes	Yes	
	Medium	Yes	Yes	
	High	-	-	Maintenance rate is applied
	Very High	No	No	
Nebraska	Very Low	Yes	Yes	
	Low	Yes	Yes	
	Medium	Yes	Yes	Only Low and Very Low for corn
	High	-	-	
	Very High	-	-	
North Dakota	Very Low	Yes	Yes	Response is highly dependent on crop
	Low	Yes	Yes	
	Medium	Yes	Yes	

Region & state[a]	Soil test category	Yield response to fertilizer expected?	Fertilizer recommended?	Comments[b]
	High	Yes	Yes	
	Very High	No	No	
Ohio	Deficient (Build-up)	Yes	Yes	Fertilize before next crop grown
	Optimal (Maintenance range)	No	Yes	Fertilize sometime in rotation to replace nutrient removal with harvest
	Sufficient (Above Maintenance)	No	No	No agronomic reason to fertilize
South Dakota	Very low	Yes	Yes	
	Low	Yes	Yes	
	Medium	Yes	Yes	
	High	Yes	Yes	
	Very High	No	No	
Wisconsin	Very Low	Yes	Yes	Build soil test levels to optimum over a 4- to 8-year period.
	Low	Yes	Yes	Build soil test levels to optimum over a 4- to 8-year period.
	Optimum	Yes	Yes	Maintain soil test levels. Recommended rate is approximately crop removal.
	High	No	Yes	Draw-down soil test levels. Recommended rate is 50% of optimum.
	Very High	No	Yes	Draw-down soil test levels. Recommended rate is 20% of optimum.
	Excessively High	No	No	Draw-down soil test levels. No fertilizer is recommended, except for potato and the establishment of turfgrass (sod farms).
NORTHEASTERN				
Connecticut	Below Optimum	Yes	Yes	
	Optimum	Yes	Yes	
	Above Optimum	No	No	
Delaware	Low	Yes	Yes	
	Medium	Yes	Yes	
	Optimum	No	Yes	
	Excessive	No	No	
Maine	Low	Yes	Yes	
	Medium	Yes	Yes	
	Optimum	No	Yes	Maintenance
	Above Optimum	No	No	
Maryland	Low	Yes	Yes	
	Medium	Yes	Yes	
	Optimum	No	Yes	Maintenance recommendation
	Excessive	No	No	
Massachusetts	Very Low	-	Yes	
	Low	-	Yes	

Region & state[a]	Soil test category	Yield response to fertilizer expected?	Fertilizer recommended?	Comments[b]
	Optimum	-	Yes	
	Above Optimum	-	No	
	Excessive	-	No	P only
New Hampshire	Very Low	Yes	Yes	Varies by commodity
	Low	Yes	Yes	
	Optimum	Yes	Yes	
	High	No	Yes	Varies by commodity and crop
	Very High	No	No	
New Jersey	Below Optimum	Yes	Yes	Build-up
	Optimum	No	Yes	Maintenance
	Above Optimum	No	No	Draw-down
New York	Very Low	Yes	Yes	
	Low	Yes	Yes	
	Medium	Yes	Yes	
	High (Optimum)	Sometimes	Yes	Small starter application only
	Very High	No	No	
Pennsylvania	Below Optimum	Yes	Yes	
	Optimum	No	Yes	
	Above Optimum	No	No	
Rhode Island	None	-	-	Soil test categories not used
Vermont	Low	Yes	Yes	
	Medium	Yes	Yes	
	Optimum	No	Yes	
	High	No	No	
	Excessive	No	No	
West Virginia	Low	Yes	Yes	Not all crops are based on expected yields; has three categories (Low-, Low, Low+)
	Medium	Yes	-	Not all crops are based on expected yields; has three categories (Medium-, Medium, Medium+)
	Optimum	-	-	Has three categories (Optimum-, Optimum, Optimum+)
	Excess	-	-	
SOUTHERN				
Alabama	-	-	-	Soil test categories used but information not provided
Arkansas	Very low	Yes	Yes	
	Low	Yes	Yes	
	Medium	Yes	Yes	
	Optimum	No	No	Optional fertilizer recommendation for maintenance

Region & state[a]	Soil test category	Yield response to fertilizer expected?	Fertilizer recommended?	Comments[b]
	Above Optimum	No	No	
Florida	Low	Yes	Yes	
	Medium	-	Yes	
	High	No	No	
Georgia	Low	Yes	Yes	
	Medium	Yes	Yes	
	High	Yes	-	Fertilizer sometimes recommended at the high level; it depends on the crop
	Very High	No	-	Fertilizer sometimes recommended at the very high level; it depends on the crop
Kentucky	Very Low	Yes	Yes	Fertilizer sometimes not recommended when soil test P or K in the upper part of the medium category
	Low	Yes	Yes	
	Medium	Yes	Yes	
	High	No	No	
	Very High	No	No	
Louisiana	Very Low	Yes	Yes	
	Low	Yes	Yes	
	Medium	Yes	Yes	
	Optimum	No	No	
	High	No	No	
Mississippi	Very Low	Yes	Yes	
	Low	Yes	Yes	
	Medium	Yes	Yes	
	High	No	No	
	Very High	No	No	
North Carolina	Very low	Yes	Yes	
	Low	Yes	Yes	
	Medium	Yes	Yes	
	High	No	Yes	Applications will continue at low values of high but taper off at higher values; Probability of response more likely in high yield environments
	Very High	No	No	
Oklahoma	Low	Yes	Yes	
	Medium	Yes	Yes	
	High	No	No	
Puerto Rico	Low	Yes	Yes	
	Medium	Yes	Yes	
	High	No	No	
South Carolina	Low	Yes	Yes	

Region & state[a]	Soil test category	Yield response to fertilizer expected?	Fertilizer recommended?	Comments[b]
	Medium	Yes	Yes	
	Sufficient	Yes	Yes	
	High	No	No	
	Excessive	No	No	
Tennessee	Low	Yes	Yes	
	Medium	Yes	Yes	
	High	No	No	
	Very High	No	No	
Texas	Very Low	Yes	Yes	
	Low	Yes	Yes	
	Medium	Yes	Yes	
	High	No	No	
	Very High	No	No	
	Excessive	No	No	
Virginia	Low	Yes	Yes	
	Medium	Yes	Yes	
	High	Yes	Yes	
	Very High	No	No	
WESTERN				
Arizona	-	-	-	No information about soil test categories provided
California	Unknown	-	-	No information about soil test categories provided
Colorado	Low	Yes	Yes	
	Medium	Yes	Yes	
	High	No	-	
Hawaii	Low	Yes	Yes	
	Medium	Yes	Yes	
	High	No	No	
Idaho	None	-	-	Soil test categories not used
Montana	None	-	-	Soil test categories not used
New Mexico	Very Low	Yes	Yes	
	Low	Yes	Yes	
	Medium	No	Yes	
	Sufficient	No	No	
Oregon	Unknown	-	-	No information about soil test categories provided
Utah	Very Low	Yes	Yes	
	Low A	Yes	Yes	
	Low B	Yes	Yes	

Region & state[a]	Soil test category	Yield response to fertilizer expected?	Fertilizer recommended?	Comments[b]
	Marginal	Yes	Yes	
	Adequate	No	No	
	High	No	No	
Washington	-	-	-	No information about soil test categories provided
Wyoming	None	-	-	Soil test categories not used

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.
[b]See Table 18 for SI unit conversions.

Table 6b. Soil fertilization philosophies used by each state. The philosophies were pre-defined for respondents. “Sufficiency” (or “feed the crop”) leads to more conservative nutrient applications that meet crop requirements without exceeding the critical soil test level, possibly resulting in more economically optimum rates. “Build and Maintain” (or “feed the soil”) leads to recommendations that build soil nutrient levels over time into the optimum range, followed by nutrient applications that approximate crop removal. “Hybrid” represents a combination of Sufficiency and Build and Maintain. States that use a variety of philosophies for different crops or purposes are grouped under “Multiple”. Responses given in 2020 and 2021 (Question 4.4)

Nutrient recommendation philosophy					
Sufficiency	Build and Maintain	Hybrid[a]	Unknown	Multiple	Description of multiple philosophies
Alabama	Hawaii	Arkansas	Indiana	California	
Arizona	Illinois	Connecticut	Washington	Florida	Crop nutrient requirement
Colorado	Massachusetts	Delaware		Kansas	Both Build-and-Maintain and Sufficiency provided
Georgia	Michigan	Iowa		Kentucky	Both Sufficiency and Maintenance, depending on soil test level
Idaho	Missouri	Maryland		Maine	BCSR[b], Build-and-Maintain, or Sufficiency depending on crop
Louisiana	Ohio	Mississippi		Nebraska	Sufficiency except for Hybrid for high yield corn
Minnesota	Pennsylvania	New Hampshire		New Jersey	
Montana	Rhode Island	North Carolina		Puerto Rico	Mix of crop nutrient extraction and crop response
New Mexico	Vermont	Texas		South Carolina	Sufficiency and Best Yield
New York		Wisconsin		West Virginia	Build-and-Maintain and Sufficiency
North Dakota					
Oklahoma					
Oregon					
South Dakota					
Tennessee					
Utah					
Virginia					
Wyoming					

[a]Hybrid between Sufficiency and Build-and-Maintain
[b]BCSR, Base cation saturation ratio

Table 7. State collaborations to unify soil test P and K recommendations for selected crops. States without collaboration are marked N/A (not applicable). Responses given in 2020 and 2021 (Question 4.27 and 4.28)

Region & state[a]	Collaboration-state	Collaboration-crop	What issues were addressed and/or actions taken?	What factors complicated collaboration?
NORTH CENTRAL				
Illinois	N/A	-	-	-
Indiana	OH, MI	Corn, soybean, wheat, alfalfa	Consistent recommendations	-
Iowa	MN, NE, WI, IL, MO	Corn, soybean, alfalfa	Soil-test interpretations, concepts for making nutrient recommendations. Little action, agreed on few concepts or soil-test interpretations for P and K, a bit better for micronutrients.	Each state wants to keep its own "version" or "modifications", typically due to differences in soil type or a lack of state field calibration money or research.
Kansas	Unknown	-	-	-
Michigan	MI, OH, IN	Corn, soybean, wheat, alfalfa	Reinforced that P critical levels have not changed; Dropped the drawdown for P and K; Removed critical K based on CEC other than coarse textured soils.	The tri-state region is quite varied in both soils and latitude so unlikely to have one recommendation across all three states and production systems.
Minnesota	N/A	-	-	-
Missouri	N/A	-	-	-
Nebraska	N/A	-	-	-
North Dakota	N/A	-	-	-
Ohio	IN, MI	Corn, soybean, winter wheat, silage corn, alfalfa	OH-IN-MI have unified recommendations since 1995.	Everything. Not sure what did not complicate things! This requires more space than this box allows.
South Dakota	ND	Sunflowers	-	Weather and soil differences.
Wisconsin	IA, MN, IL	Corn, soybean, alfalfa	Discussion of philosophy and history of recommendations in each state.	Priorities, direction of individual faculty research programs, funding, and availability of new data.
NORTHEASTERN				
Connecticut	VT, ME, NH	Field crops	Compared recommendations, discussions.	Differing recommendations by different institutions.
Delaware	MD, PA, NJ, VA, WV	Vegetables, some agronomic crops	To make more consistent recommendations across state lines.	Codified recommendations in Maryland make it difficult for them to make changes, so we end up changing. Also, differences in soil test method and interpretation can lead to confusion about the correct rate of recommended fertilizer at a given soil test level.
Maine	NH, VT, MA, RI, VT	High tunnel tomatoes	N-P-K yield-dependent recommendation tables	High variability in yield responses.

Region & state[a]	Collaboration-state	Collaboration-crop	What issues were addressed and/or actions taken?	What factors complicated collaboration?
Maryland	DE, PA, VA, WV, NJ	Vegetables	Unknown	Unknown
Massachusetts	Unknown	-	-	-
New Hampshire	N/A	-	-	-
New Jersey	CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT, WV	Field corn	It was an excellent example of regional collaboration that was funded by a USDA-SARE Grant in 1998. For more detail see published articles: Heckman, J.R., W. Jokela, T. Morris, D. Beegle, T. Sims, F. Coale, S. Herbert, T. Griffin, B. Hoskins, J. Jemison, M. Sullivan, D.K. Bhmumla, G. Estes, and W.S. Reid. 2006. Calibration of Soil Test Phosphorus for Corn in the Northeast USA. Agronomy Journal. 98: 280-288. and Heckman, J.R., J.T. Sims, D.E. Beegle, F.J. Coale, S.J. Herbert, T.W. Bruulsema, and W.J. Bamka. 2003. Nutrient Removal by Corn Grain Harvest. Agronomy Journal. 95:587-591.	Good research sites with soils testing low in P are not easy to find.
New York	Northeast	Field crops, but more focused on risk assessment tools including the P index	We build in four categories in our new NY-PI 2.0, corresponding with cutoffs around 11, 23 and 35% P sat (40, 100 and 160 lbs P ac^{-1} Morgan). See Crittenden et al., 2017 (Soil Science 182: 36-44. doi: 10.1097/SS.0000000000000192)	Our regional group cannot apply for research funding. Would like to be able to do trials across states but we have to generate research and not an information exchange group to qualify for federal formula funds. Has not been a priority among colleagues in the past, also reflecting turnover in faculty/staff in some states, so this might be resolved in the future.
Pennsylvania	MD, DE ,VA, NC[b]	1) Various 2) Corn	1) Development of consistent interpretive categories for soil test results. Adoption of consistent reporting units 2) Better alignment of fertilizer recommendations	"Institutional imperialism," differences in soil and climate among states.
Rhode Island	N/A	-	-	-
Vermont	Northeast	Corn, forage crops	Initially, recommendations that were way out of whack were adjusted. Common language on soil test categories was mostly attained. Field	Many different extractants and reluctance to make large changes.

Region & state[a]	Collaboration-state	Collaboration-crop	What issues were addressed and/or actions taken?	What factors complicated collaboration?
			trials for P response on corn were performed but responses were difficult to find.	
West Virginia	N/A	-	-	-
SOUTHERN				
Alabama	N/A	-	-	-
Arkansas	N/A	-	-	-
Florida	N/A	-	-	-
Georgia	N/A	-	-	-
Kentucky	N/A	-	-	-
Louisiana	N/A	-	-	-
Mississippi	N/A	-	-	-
North Carolina	N/A	-	-	-
Oklahoma	N/A	-	-	-
Puerto Rico	N/A	-	-	-
South Carolina	GA	-	-	-
Tennessee	N/A	-	-	-
Texas	OK, AR, LA	Bermudagrass, cotton, wheat, corn	Not much of anything.	Texas is a big state and nearby states are typically in very different climatic regions. Much of the differences in recommendations across states represent differences in philosophies.
Virginia	Unknown	-	-	-
WESTERN				
Arizona	Unknown	-	-	-
California	Unknown	-	-	-
Colorado	N/A	-	-	-
Hawaii	Unknown	-	-	-
Idaho	WA, OR	Wheat, peas, lentils, alfalfa in the north; potatoes, sugar beets, wheat, corn onions, mint in the south.	-	-
Montana	N/A	-	-	-
New Mexico	N/A	-	-	-
Oregon	WA, OR, ID[c]	Pastures, Christmas trees, potatoes,	Doing this allows us to streamline recommendations. Because we have so many crops and microclimates with so	The Pacific Northwest (PNW) publication process is more time consuming (more review steps) than publishing with Oregon State University, so that may

Region & state[a]	Collaboration-state	Collaboration-crop	What issues were addressed and/or actions taken?	What factors complicated collaboration?
		field corn, alfalfa, camelina[d]	few fertility scientists, it is already in our culture to work across state lines to keep up with the demand for fertilizer recommendations.	prevent a few publications that could pertain to WA, OR, and ID from moving beyond their state's extension catalog. Otherwise, collaboration across state lines is a natural part of our culture here.
Utah	ID, CO	Alfalfa, corn, wheat, and tree fruit	Mostly review and comparison for regional context. No major actions have been taken. Changes in Utah N crediting for previous alfalfa to corn silage and small grain rotational crops is being considered.	-
Washington	-	-	-	-
Wyoming	Unknown	-	-	-

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.
[b]Pennsylvania: 1) State participating in the NECC 1812 coordinating committee. 2) MD, DE, VA, NC (Communications in Soil Science and Plant Analysis, 36:331-340)
[c]Oregon: WA, OR, ID are the common ones. We'll often do Western Oregon and Washington together, and Eastern Washington and Oregon together. Our Pacific Northwest (PNW) series is for extension material and recommendations that apply to WA, OR, and ID
[d]Oregon: Pastures and Christmas trees, (Western OR and Western WA), Potatoes (Columbia Basin which includes WA and OR), Field corn and alfalfa and camelina (WA/OR/ID).

Table 8. Soil test lime recommendations and target pH. Year lime recommendations were last revised or validated, information about maximum, one-time lime recommendations (rec.), and how lime recommendations are tied to neutralizing values (NV) or calcium carbonate equivalents (CCE). Responses given in 2020 and 2021 (Questions 4.5 through 4.11)

Region & state[a]	Year last revised/ validated	Maxim, one-time lime rec. (lbs ac^{-1})[b]	NV or CCE used for lime rec.?	Description of how NV and/or CCE are specified with lime recommendation[b]	Target pH-Corn
NORTH CENTRAL					
Illinois	Unknown	Unknown	Yes	"Typical limestone: 10% of the particles are greater than 8-mesh; 30% pass an 8-mesh and are held on 30-mesh; 30% pass a 30-mesh and are held on 60-mesh; and 30% pass a 60-mesh. A calcium carbonate equivalent (total neutralizing power) of 90%. Effective neutralizing value (ENV) of this material is 46.35 for 1 year after application, and 67.5 for 4 years after application." Calculations that correct the rate of application based on the ENV of a given material outlined in Ch. 8 of the Illinois Agronomy Handbook.	6.0-6.5
Indiana	Unknown	16,000	Yes	Relative neutralizing value = [(% passing 8 mesh + % passing 60 mesh)/2] x calcium carbonate equivalence/100.	6.0-6.5
Iowa	2016	None	Yes	Effective Calcium Carbonate Equivalent, the CCE is adjusted by a wet sieving procedure using four screens for particle size and "efficiency factors" for each. Recommendations are based on buffer pH and Effective CCE.	6.0 for calcareous subsoil, 6.5 for others
Kansas	2005	Unknown	Yes	All recommendations are for 100% Effective Calcium Carbonate (ECC). ECC=CCE*FF; CCE = calcium carbonate equivalent; FF = Fineness factor. <; 60 mesh = 100%, 8 to 60 mesh = 50%	6.0
Michigan	Early 2000s	8,000	Yes	(Lime rate x 90) / NV of liming material	6.5
Minnesota	Unknown	None	Yes	-	6.0
Missouri	1998	None	No	-	6.0
Nebraska	2010	None	Yes	Recommendations assume 60% effective calcium carbonate equivalence.	>5.2, corn monoculture
North Dakota	In progress	Unknown	Unknown	-	6.0
Ohio	1995	8,000	Yes	In Ohio, liming materials are labeled based on their effective neutralizing power (ENP), which is reported in lbs./ton. The ENP considers the total neutralizing power (TNP), fineness of grind, and percent moisture of a liming material (Ohio Aglime Council, 2003), and is calculated: ENP (lbs ton^{-1}) = TNP/100 * FI/100 * %DW/100 * 2000 lbs ton^{-1}	6.0-6.5
South Dakota	2002	None	Yes	Lime recommendations are given based on a calcium carbonate equivalent of 90% and a total effectiveness of 70%	6.0

Region & state[a]	Year last revised/ validated	Maxim, one-time lime rec. (lbs ac^{-1})[b]	NV or CCE used for lime rec.?	Description of how NV and/or CCE are specified with lime recommendation[b]	Target pH-Corn
Wisconsin	2006	24,000	Yes	Lime recommendations calculated based on lime with a neutralizing index of 60-69. A formula can be used to convert to other grades of lime.	6.0
NORTHEASTERN					
Connecticut	1960s	12,000	No	-	6.6
Delaware	1989 or 1990	4,000 (top-dress) 8,000 (incorp)	Yes	Our tables are based on the use of AG lime with a 67% effective calcium carbonate content (ECCC). We provide equations to convert based on the actual materials used.	6.0
Maine	2000	4,000 (top-dress)	Yes	Specify 100 % CCE, adjust if < 90 % CCE	6.5
Maryland	1997	3,000 for no-till only	Yes	Max lime rec. assumes 50% oxide equivalence. The calcium carbonate equivalent (CCE) expresses the relative ability of a liming material to neutralize acid as compared to pure calcium carbonate (pure pulverized limestone). The CCE is determined by the chemical composition of the liming material. Table 1 in SFM-5 presents average acid neutralizing values, expressed as CCE, for some common liming materials. https://extension.umd.edu/sites/default/files/2021-04/SFM-5.pdf	6.5
Massachusetts	Unknown	2,000	No	-	6.5
New Hampshire	2008?	4,000 unless tilled	No	-	6.5
New Jersey	2002 Blueberry, 2019 Pumpkin	None	Yes	Calcium Carbonate Equivalent is defined by New Jersey State Law.	6.5
New York	2009	6,000	Yes	Recommendations are given in 100% ENV (with ENV = CCE x fineness factor). Client is told to adjust actual lime application rate to the ENV of the liming material at hand.	6.2
Pennsylvania	2000	10,000	Yes	Lime recommendations are made in lbs CCE ac^{-1} (fineness is assumed to be at least >95% passing 20-mesh, >60% passing 60-mesh, and >50% passing 100-mesh.)	6.5
Rhode Island	Unknown	-	Unknown	-	-
Vermont	2017	8,000	No	-	6.2

Region & state[a]	Year last revised/ validated	Maxim, one-time lime rec. (lbs ac^{-1})[b]	NV or CCE used for lime rec.?	Description of how NV and/or CCE are specified with lime recommendation[b]	Target pH-Corn
West Virginia	2020	8,000	Yes	Different limestone sources are evaluate based on their total neutralizing value (TNV) as calcium carbonate equivalence (CCE) and effective neutralizing value (ENV) due to fineness of the lime.	6.6
SOUTHERN					
Alabama	Unknown	None	No	-	6.5
Arkansas	Unknown	8,000	Yes	The Effective Calcium Carbonate Equivalent (ECCE) value for the recommended lime rate is not stated in the recommendation. The origin of the logic (pH and extractable Ca) for lime recommendations is undocumented. We assume the recommendation is based on the average lime quality in the state which is 57.	6.5
Florida	Unknown	None	No	-	6.5
Georgia	2004	10,500	No	-	6.0
Kentucky	Unknown	None	Yes	Lime rate recommendations are given in tons of 100% effective limestone per acre.	6.4
Louisiana	2010	None	Yes	In LSU soil testing report, it specifies that "the reported liming rate presumes effective calcium carbonate equivalent (ECCE) or relative neutralizing value (RNV) of the liming material to be at 50%". Since the lab does not grade lime quality, we simply give the recommendation rate at 50% effectiveness.	None
Mississippi	Unknown	4,000	No	-	-
North Carolina	1974	None	Yes	Based on a 90% CCE with following screen sizes per lime source: Dolomitic: % passing 20 Mesh- 90%; % passing 100 Mesh- 35%. Calcitic: % passing 20 Mesh- 90%; % passing 100 Mesh- 25%. Suspension: % passing 20 Mesh- 100%; % passing 100 Mesh- 80%. Pelletized: % passing 20 Mesh- 90%; % passing 100 Mesh- 35%. Information from state lime law.	6.0, 5.0, and 5.5 for mineral, organic, and mineral-organic, respectively
Oklahoma	Unknown	8,000	Yes	Recommendations are in ECCE (effective calcium carbonate equivalent)	6.3
Puerto Rico	N/A	None	No	-	5.5
South Carolina	Unknown	10,000	No	-	6.0-6.5
Tennessee	2010	16,000	Yes	Based on 65% relative neutralizing value.	6.1
Texas[c]	-	None	Yes	100% ECCE (effective calcium carbonate equivalent)	6.0
Virginia	2005	4,000	Yes	Conversion equation for CCE given in recommendations book.	6.2
WESTERN					
Arizona	N/A	-	-	-	N/A
California	N/A	-	-	-	-

Region & state[a]	Year last revised/ validated	Maxim, one-time lime rec. (lbs ac^{-1})[b]	NV or CCE used for lime rec.?	Description of how NV and/or CCE are specified with lime recommendation[b]	Target pH-Corn
Colorado[d]	N/A	None	N/A	-	6.5
Hawaii	2000	None	Unknown	-	6.2
Idaho	2000	None	Yes	This would be tailored to individual farmers. Traditionally lime recommendation in north Idaho is based on soil pH (surface 12 inches). In north Idaho we have acid surface soils and neutral pH subsoils. Cereal crops are not impacted by low surface soil pH values. Legume crops and alfalfa get lime recommendations based on soil pH, usually 1-2 tons of lime when surface pH values are less that 5.3.	-
Montana	In progress[e]	N/A	-	-	-
New Mexico	N/A	N/A	No	-	7.6
Oregon	In progress	N/A	Yes	For most of our fertilizer guides, we make the caveat that lime recommendations assume a specific lime score value that is typical for the ag lime sold in Oregon. the different CCE % are listed for various lime products in publication EM 9057.	5.5 is the minimum 5.5[f]
Utah[g]	N/A	-	-	-	-
Washington	N/A	-	-	-	-
Wyoming[g]	N/A	-	-	-	-

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.
[b]See Table 18 for SI unit conversions.
[c]Texas: Mehlich-3 K, Ca, Mg, Na and some pH specific algorithm based on 17500 incubated soil samples
[d]Colorado: Less than 1% of soils in Colorado need lime
[e]Montana: Lime has not been used until recently in Montana so there are no established recommendations
[f]Oregon: 5.5 is the minimum pH (EM 9057 page 1). We don't have a target pH listed in here or in the corn guide (PNW 615).
[g]Utah and Wyoming: No recommendations for lime as soils are strongly alkaline

Table 9a. Recommended methods for testing soil pH and buffer pH (BpH) for each state. Responses given in 2020 and 2021 (Questions 8.16 through 8.21)

	Soil pH[b]			Buffer pH[b]			
Region & state[a]	Method (soil:water ratio)	Measured while stirring?[c]	Electrode rinsed?[d]	Method[e]	Electrode rinsed?[d]	Measured for every sample?[f]	Notes/comments
NORTH CENTRAL							
Illinois[g]	-	-	-	-	-	-	
Indiana[g]	-	-	-	-	-	-	
Iowa[g]	Water 1:1	-	-	SMP, Sikora	-	-	SMP or Sikora recommended
Kansas	Water 1:1	Unknown	Unknown	Sikora	Unknown	Yes	
Michigan	Water 1:1	Yes	Yes	SMP, Sikora	Unknown	Unknown	
Minnesota	Water 1:1	Unknown	Yes	Sikora	Yes	No	
Missouri	0.01 M $CaCl_2$ 1:1	Yes	No	Modified Woodruff	No	Yes	
Nebraska[g]	-	-	-	SMP, Woodruff	-	-	
North Dakota	Water 1:1	No	Yes	-	-	-	
Ohio[g]	Water 1:1	-	-	SMP, Sikora	-	-	
South Dakota[g]	Water 1:1	-	-	SMP	-	-	
Wisconsin	Water 1:1	Yes	Yes	Sikora	Yes	No	
NORTHEASTERN							
Connecticut	Water 1:1	Yes	Yes	Modified Mehlich	No	Yes	
Delaware	Water 1:1	Yes	Yes	Adams-Evans	Yes	Yes	
Maine	Water 1:1	Yes	Yes	Modified Mehlich	Yes	No	BpH tested for all samples with $pH_w < 7.0$
Maryland[g]	-	-	-	-	-	-	
Massachusetts	Water 1:1	Yes	Yes	Modified Mehlich	No	No	
New Hampshire[g]	Water 1:1	Yes	Other	Modified Mehlich	No	No	pH electrode rinsed only when pH < 5 or pH > 7. Follows Pennsylvania protocol.
New Jersey	Water 1:1	Yes	Yes	Adams-Evans	Yes	No	
New York[g]	Water 1:2	No	Yes	Modified Mehlich	No	No	Studies conductd in 2009 resulted in the switch from exchangeable acidity to use of the Modified Mehlich buffer
Pennsylvania	Water 1:1	Yes	Other	Modified Mehlich	No	No	pH electrode rinsed only when pH < 5 or pH > 7; BpH tested for all samples with $pH_w < 7.0$
Rhode Island[g]	Water 1:2	-	-	-	-	-	

	Soil pH[b]			Buffer pH[b]			
Region & state[a]	Method (soil:water ratio)	Measured while stirring?[c]	Electrode rinsed?[d]	Method[e]	Electrode rinsed?[d]	Measured for every sample?[f]	Notes/comments
Vermont	0.01 M $CaCl_2$ 1:2	No	Yes	Modified Morgan Al	-	-	
West Virginia	Water 1:1	-	Yes	Mehlich	Yes	No	
SOUTHERN							
Alabama	Water 1:1	Yes	Yes	Modified Adams-Evans	Yes	Yes	
Arkansas	Water 1:2	Yes	No	Other	-	-	
Florida	Water 1:2	Yes	Yes	Adams-Evans	Yes	No	
Georgia	0.01 M $CaCl_2$ 1:1	Yes	No	Single Titration $Ca(OH)_2$	No	Yes	
Kentucky	1.0 M KCl 1:1	Yes	Yes	Sikora-2	Yes	Yes	
Louisiana	Water 1:2	Yes	Yes	Titratable Acidity	-	No	
Mississippi	Water 1:2	No	Yes	Woodruff	Yes	No	
North Carolina	0.01 M $CaCl_2$ 1:1	Yes	Yes	Modified Mehlich	Yes	Yes	15-minute equilibration time
Oklahoma	Water 1:1	Yes	Yes	Sikora	Yes	No	
Puerto Rico[g]	Water 1:2	-	-	-	-	-	
South Carolina	Water 1:1	No	Other	Sikora-Moore	Yes	Yes	pH electrode rinsed if above threshold
Tennessee	Water 1:1	No	Yes	Sikora-Moore	Yes	No	
Texas	Water 1:2	Yes	Yes	-	-	No	
Virginia	Water 1:1	Yes	Other	Mehlich	No	Yes	pH electrode rinsed only when pH < 4.5 or pH > 7.5
WESTERN							
Arizona[g]	Water 1:1	-	-	Not measured	-	-	
California[g]	-	-	-	-	-	-	
Colorado	Water 1:1	Yes	Yes	SMP	Yes	No	
Hawaii	Water 1:1	No	Yes	Lime titration curve	-	No	
Idaho	Unknown	-	-	Not measured	-	-	
Montana[g]	Water 1:1	-	-	Other	-	-	We're still evaluating BpH as acid soils are new to Montana. So far pH looks like a better predictor than buffer methods.
New Mexico[g]	Saturated Paste	-	-	Not measured	-	-	
Oregon[g]	Water 1:2	-	-	SMP	-	-	
Utah	Saturated Paste	No	Yes	Not measured	-	-	
Washington[g]	-	-	-	-	-	-	
Wyoming[g]	Water 1:1	-	-	Not measured	-	-	

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.
[b]Procedural specifics not applicable to states without a public service laboratory
[c]Is pH measured while the sample is being stirred?
[d]Are electrodes rinsed between measurements?
[e]SMP: Shoemaker, McLean, and Pratt buffer
[f]Is BpH or exchangeable acidity measured for every sample?
[g]No public service lab. May have recommended methods but analysis details may not be available.

Table 9b. Recommended soil-to-solution ratios and equilibration times for soil electrical conductivity measurements (EC). Responses given in 2020 and 2021 (Questions 8.22 through 8.24)

Region & state[a]	Soil:solution ratio	Equilibration time (min)	Routine test?
NORTH CENTRAL			
Illinois	-	-	-
Indiana	Unknown	Unknown	No
Iowa	Unknown	Unknown	No
Kansas	Unknown	Unknown	No
Michigan	Unknown	Unknown	No
Minnesota	Unknown	Unknown	No
Missouri	1:1	20	No
Nebraska	1:1	30	Yes
North Dakota	1:1	20	No
Ohio	Unknown	Unknown	No
South Dakota	Unknown	Unknown	No
Wisconsin	1:2	15	No
NORTHEASTERN			
Connecticut	1:2	20	No
Delaware	1:2	30	No
Maine	Saturated paste	60	No
Maryland	Unknown	Unknown	Unknown
Massachusetts	1:2	30	No
New Hampshire	1:2	30	No
New Jersey	1:2	15	No
New York	1:2	6	Yes
Pennsylvania	1:2	30	No
Rhode Island	2:1	10	Unknown
Vermont	Unknown	Unknown	No
West Virginia	1:1	30	No
SOUTHERN			
Alabama	1:2	30	No
Arkansas	1:2	15	No
Florida	1:2	240	No
Georgia	1:2	15	No
Kentucky	1:2	30	No
Louisiana	1:2	16	No
Mississippi	1:2	0.2	No
North Carolina	1:2	30	No
Oklahoma	1:1	180	No
Puerto Rico	Saturated paste	1440	Yes
South Carolina	1:2	60	No
Tennessee	1:2	20	No
Texas	1:2	30	Yes
Virginia	1:2	60	No
WESTERN			
Arizona	Saturated paste	Unknown	Yes
California	Saturated paste	Unknown	Unknown
Colorado	1:1 or Saturated paste	75	Yes
Hawaii	1:1	30	No
Idaho	Unknown	Unknown	No
Montana	1:1	30	Yes
New Mexico	Saturated paste	Unknown	Yes
Oregon	Saturated paste	-	-

Region & state[a]	Soil:solution ratio	Equilibration time (min)	Routine test?
Utah	Saturated paste	Unknown	Yes
Washington	-	-	-
Wyoming	1:1	60	Unknown

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.

Table 9c. Soil cation exchange capacity (CEC). Methods included estimated CEC by Cation Summation (ECEC-CationSum), 1*M* ammonium acetate, and others noted. Responses given in 2020 and 2021 (Questions 8.28 and 8.29)

Region & state[a]	Routinely reported?	Method	Notes
NORTH CENTRAL			
Illinois	-	-	
Indiana	Yes	ECEC-CationSum	
Iowa	Yes	ECEC-CationSum	
Kansas	No	N/A	
Michigan	Yes	ECEC-CationSum	
Minnesota	No	N/A	
Missouri	Yes	ECEC-CationSum	Based on texture measurement
Nebraska	No	N/A	
North Dakota	No	N/A	
Ohio	Yes	ECEC-CationSum	
South Dakota	No	N/A	
Wisconsin	No	N/A	
NORTHEASTERN			
Connecticut	Yes	ECEC-CationSum	
Delaware	Yes	ECEC-CationSum	
Maine	Yes	ECEC-CationSum	
Maryland	Unknown	-	
Massachusetts	Yes	ECEC-CationSum	
New Hampshire	Yes	ECEC-CationSum	
New Jersey	Yes	ECEC-CationSum	
New York	No	NH_4OAc, (unbuffered), NH_4Cl (unbuffered), or $SrCl_2$ extractable bases, all unbuffered	Client can choose method. Reference: Soil Science 179:230-236.
Pennsylvania	Yes	ECEC-CationSum	
Rhode Island	-	-	
Vermont	Yes	ECEC-CationSum	
West Virginia	No	N/A	
SOUTHERN			
Alabama	No	N/A	
Arkansas	Yes	ECEC-CationSum	
Florida	No	N/A	
Georgia	No	N/A	
Kentucky	Yes	ECEC-CationSum	
Louisiana	Yes	Other	Based on texture measurement
Mississippi	Yes	ECEC-CationSum	
North Carolina	Yes	ECEC-CationSum	Exclude Na from summation
Oklahoma	No	N/A	
Puerto Rico	Yes	ECEC-CationSum	Sum of bases with 1 *M* NH4OAc and acids with 1 *M* KCl
South Carolina	Yes	ECEC-CationSum	
Tennessee	No	N/A	
Texas	No	N/A	
Virginia	Yes	ECEC-CationSum	
WESTERN			
Arizona	Yes	Other	Buffered at pH 8.5
California	Unknown	-	
Colorado	No	N/A	

Region & state[a]	Routinely reported?	Method	Notes
Hawaii	No	N/A	
Idaho	No	N/A	
Montana	-	-	
New Mexico	Yes	1*M* NH_4OAc	
Oregon	-	-	
Utah	No	N/A	
Washington	-	-	
Wyoming	No	-	

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.

Table 9d. Are soil testing methods listed or footnoted on the soil test reports? This question is not applicable (N/A) to states that do not have a public service laboratory. Responses given in 2020 and 2021 (Question 8.30)

Region & state[a]	Soil test methods reported?	Notes/comments
NORTH CENTRAL		
Illinois	N/A	-
Indiana	N/A	-
Iowa	N/A	-
Kansas	Other	For some measurements
Michigan	Yes	-
Minnesota	Yes	-
Missouri	No	-
Nebraska	N/A	-
North Dakota	Yes	-
Ohio	N/A	-
South Dakota	N/A	-
Wisconsin	No	-
NORTHEASTERN		
Connecticut	Other	For Modified Morgan extractable nutrients
Delaware	Other	Methods listed on a note included with reports
Maine	Yes	-
Maryland	N/A	-
Massachusetts	Yes	-
New Hampshire	N/A	-
New Jersey	Yes	-
New York	Yes	Included on soil report. Many factsheets are developed for field crop soil fertility management (http://nmsp.cals.cornell.edu/guidelines/factsheets.html).
Pennsylvania	Yes	-
Rhode Island	N/A	-
Vermont	Yes	-
West Virginia	No	-
SOUTHERN		
Alabama	Yes	-
Arkansas	Yes	-
Florida	Yes	-
Georgia	Other	A link to a bulletin that discusses methods is provided
Kentucky	Yes	-
Louisiana	Yes	-
Mississippi	No	-
North Carolina	Yes	-
Oklahoma	No	A fact sheet on methods used is availalbe
Puerto Rico	N/A	-
South Carolina	No	-
Tennessee	Yes	-
Texas	Yes	-
Virginia	No	-
WESTERN		
Arizona	N/A	-
California	N/A	-
Colorado	Other	OM and nutrients
Hawaii	Unknown	-
Idaho	Yes	For some measurements
Montana	N/A	-

Region & state[a]	Soil test methods reported?	Notes/comments
New Mexico	N/A	-
Oregon	N/A	-
Utah	No	-
Washington	N/A	-
Wyoming	N/A	-

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.

Table 10. Sulfur testing and correlation and calibration research. Responses given in 2020 and 2021 (Questions 4.12 through 4.16)

Region & state[a]	Deficiency common?[b]	Routine test?	Does your institution make S recommendations based on soil test results? If yes, provide a brief description of the approach used.[c]	Research trials within last 10 years?[d]	Brief description of soil test S correlation and calibration research[c]
NORTH CENTRAL					
Illinois	Yes	Unknown	No	Yes	On-farm strip trials by Fabian Fernandez prior to 2017. https://www.ifca.com/media/files/frec_358_fernandez_2012_report.pdf
Indiana	Yes	No	No. We are working on identifying regions, soil types, soil characteristics likely to result in S deficiency.	Yes	Sulfur response corn and soybean since 2017 - Camberato, Nielsen, Casteel
Iowa	Yes	No	No. Soil-testing for sulfur is unreliable, at least in Iowa. Use a combination of crop to be fertilized, organic matter, erosion, soil sandy/not sandy, and use or not of manure. Tissue testing is used and recommended only for alfalfa.	Yes	Corn and Soybean: Mainly John Sawyer (many years, sites, rates), Antonio Mallarino (fewer years and sites, and many rates), simple Yes/No strip trials several regional field extension agronomists. Alfalfa: John Sawyer and regional field extension agronomist Brian Lang (many years, sites, rates). Current S recommendations and summary of recent research: Extension Publication CROP 3072, https://store.extension.iastate.edu/product/15819
Kansas	Yes	No	Yes. We test for profile sulfate using Ca-phosphate extraction (0 to 24 inches). Sulfur recommendation is a mass balance where S requirement is crop yield times a factor. The fertilizer recommendation is the S requirement minus the profile S and S that will mineralize from soil organic matter (soil organic matter*mineralization coefficient).	Yes	Nathan Nelson 7 to 8 site-years of data for wheat (2017-2020). Dorivar Ruiz-Diaz, wheat response studies, some with corn in recent years.
Michigan	Yes	No	No. S recommended for small grains and corn, especially in wet falls or springs. Focused on loam and coarser soils.	No	None
Minnesota	Yes	No	The monobasic calcium phosphate test has been suggested for use with sandy soils. Corn, wheat, and alfalfa guidelines were updated within the last ten years, but	No	None

Region & state[a]	Deficiency common?[b]	Routine test?	Does your institution make S recommendations based on soil test results? If yes, provide a brief description of the approach used.[c]	Research trials within last 10 years?[d]	Brief description of soil test S correlation and calibration research[c]
			sulfur application has been focused on organic matter concentration in the top six inches.		
Missouri	No	No	On sandy soils low in organic matter, if the SO_4-S test is less than 6 ppm, S is recommended.	No	None
Nebraska	No	Yes	S application is recommended for corn only on sandy soil if soil organic matter is < 1% and soil test S < 9 ppm.	No	None
North Dakota	Yes	Yes	I strongly discourage the sulfur soil test, as it is grossly non-diagnostic. S is recommended state-wide for canola always. S is recommended state-wide for small grains and corn after one or more of the following- wet fall, normal to above-average snowfall, wet spring, loam soils or coarser.	Yes	Ed Deibert (retired), Jasper Teboh, Carrington Research Extension Center, Amitava Chatterjee
Ohio	Yes	Yes	No. We have run approximately 100 field trials over the past 8 years and have found very few responses (<10% of trials).	Yes	Various faculty using gypsum. This is currently being summarized and will be released as factsheet/publication in 2021.
South Dakota	Yes	No	Yes. Sulfur test is based on monobasic calcium phosphate extractant. Soil samples are recommended to be taken to a depth of 2 ft. Sulfur recommendations are then based on soil test level along tillage type and soil texture.	Unknown	Unknown
Wisconsin	Yes	No	No. Because the S soil test was not very useful, a sulfur availability index (SAI) was developed in the late 1990s. The index accounted for soil test S, estimate of subsoil S, estimate of atmospheric S deposition, organic matter, and manure S. The SAI was used to provide a S fertilizer recommendation. It was updated in the early 2000s. However, continued reductions in atmospheric deposition and	Unknown	Some alfalfa S research was conducted in the early 2010s; but field conditions were not suitable for observing clear responses. As of 2021, there are more reports of S deficiency on alfalfa and corn in many areas of the state.

Region & state[a]	Deficiency common?[b]	Routine test?	Does your institution make S recommendations based on soil test results? If yes, provide a brief description of the approach used.[c]	Research trials within last 10 years?[d]	Brief description of soil test S correlation and calibration research[c]
			perhaps other factors were causing the SAI to not be predictive of S need. Therefore, it's use was discontinued in 2012. Instead, the recommendation bulletin describes how one might consider various factors in determining if S use is needed.		
NORTHEASTERN					
Connecticut	Unknown	Yes	No	No	None
Delaware	Yes	Yes	No. Our recommendations are crop specific and some are based on results of a tissue test and field history.	Unknown	Unknown
Maine	Yes	Yes	Promote S sources if below optimum (ammonium sulfate, K-Mag, K-sulfate). Specific lbs ac^{-1} recommendations only for canola.	No	None
Maryland	Yes	No	No	No	None
Massachusetts	No	Yes	No	No	None
New Hampshire	No	Yes	Sulfur recommendations would normally be based on tissue analysis, not soil analysis. We would mostly use sulfur to lower pH for blueberries and other acidic friendly crops.	No	None
New Jersey	Yes	No	Sulfur recommendations are based on field history, soil texture, and crop demand for S.	No	None
New York	Yes	Yes	Yes, for alfalfa. We calibrated the 0.01 M CaCl2 (or $SrCl_2$ if the client wants to know CEC as well) for S management for alfalfa.	Yes	Ketterings, Q.M., S. Gami, R.R. Mathur, and M. Woods (2014). A simple method for estimating effective cation exchange capacity, cation saturation ratios and sulfur across a wide range of soils. Soil Science 179:230-236. Ketterings, Q.M., G. Godwin, S. Gami, K. Dietzel, J. Lawrence, P. Barney, T. Kilcer, M. Stanyard, C. Albers, J.H. Cherney, D. Cherney, K.J. Czymmek (2012). Soil and tissue testing for sulfur management of alfalfa in New York

Region & state[a]	Deficiency common?[b]	Routine test?	Does your institution make S recommendations based on soil test results? If yes, provide a brief description of the approach used.[c]	Research trials within last 10 years?[d]	Brief description of soil test S correlation and calibration research[c]
					State. Soil Science Society of America Journal 76(1): 298-306. Ketterings, Q.M., C. Miyamoto, R.R. Mathur, K. Dietzel, and S. Gami (2011). A comparison of soil sulfur extraction methods. Soil Science Society of America Journal 75(4): 1578-1583.
Pennsylvania	Yes	Yes	Mehlich-3 S level is below 15 ppm, there is an approximately 50% chance that corn yield will increase by adding S fertilizer. Apply S at a rate of 1 to 2x removal and/or collect tissue samples to verify need.	Yes	30 site-years of S response for corn, 2016-2018, Beegle and Spargo, unpublished
Rhode Island	No	-	-	No	None
Vermont	Unknown	Yes	No, we just provide the result and the average for Vermont soils	No	None
West Virginia	Unknown	No	No	No	None
SOUTHERN					
Alabama	Yes	No	16 lbs S ac^{-1} on sandy soils	No	None
Arkansas	No	Yes	S is not recommended on soil-test S alone. A suggestion for fertilizer S addition is made as a comment to the report: *"If S-deficiency has occurred on this soil before apply 20 lbs SO4-S ac^{-1}"*	Yes	Sources and rates for corn (Mozaffari) and limited research with soybean, wheat, and rice have been conducted mostly with new fertilizer products from industry protocols. Mostly unpublished research by Drs. Roberts, Mozaffari, and Slaton. We have recently examined trends in the median soil-test S over the past 10+ years and noted a linear decline of 0.3 to 0.6 ppm $year^{-1}$ across most agricultural crop codes. The summary will be published in 2020.
Florida	-	Yes	Yes/No recommendations. Not interpreted for Low, Medium or High. Calibration studies not done. Use Mehlich-3 extraction.	No	None
Georgia	Unknown	No	No. Most are blanket recommendations depending on the crop. For example, we always recommend 10 lbs S ac^{-1} for corn.	No	None

Region & state[a]	Deficiency common?[b]	Routine test?	Does your institution make S recommendations based on soil test results? If yes, provide a brief description of the approach used.[c]	Research trials within last 10 years?[d]	Brief description of soil test S correlation and calibration research[c]
Kentucky	No	No	No. We do not have a valid soil sampling and testing protocol to support an S recommendation in Kentucky. Though we hear of/see a few more S deficiencies each year, not enough to support an S correlation/calibration research program for all crops.	No	Dr. John Grove working on wheat S responses across the state
Louisiana	Yes	Yes	Sulfur testing is included in Mehlich-3 test and make recommendation if below 12 ppm.	Yes	Syam Dodla, cotton/soybean, North Louisiana; Brenda Tubana, sugarcane/corn, North and South Louisiana
Mississippi	Yes	No	No	No	None
North Carolina	Yes	Yes	A sulfur recommendation is made for major agricultural crops at a soil test level of less than or equal to 12 mg dm^{-3}, Mehlich 3. This is documented by visual symptoms of S deficiency and actual plant tissue data, especially in small grain and corn, when soil S levels were found to be less than or equal 12 mg dm^{-3}; these samples were submitted as diagnostic. If S was not limiting in the plant, the N:S ratio in the leaf was high, generally greater than 18:1. Our recommendations are 15 to 25 lbs ac^{-1} depending on humic matter content. For organic-classed soils, we recommend 15 to 20 lbs ac^{-1} expecting some mineralization to occur. For mineral soils, we recommend 20 to 25 lbs ac^{-1}. This was initiated in 2004.	No	None
Oklahoma	No	No	Yes. 1/10 of the N requirement less soil sulfate S if tested.	Yes	No response to S for most field tests.
Puerto Rico	Unknown	No	S recommendation is not considered	No	None
South Carolina	Unknown	No	No	Unknown	Unknown
Tennessee	Unknown	No	-	Yes	Frank Yin, Jackson TN, Cotton, 2 to 3 years 2015 to maybe 2018

Region & state[a]	Deficiency common?[b]	Routine test?	Does your institution make S recommendations based on soil test results? If yes, provide a brief description of the approach used.[c]	Research trials within last 10 years?[d]	Brief description of soil test S correlation and calibration research[c]
Texas	Yes	Yes	Mehlich-3, 0-6 in depth. Indicate deeper sulfur maybe in profile.	No	None
Virginia	Yes	No	-	Unknown	Unknown
WESTERN					
Arizona	No	-	Sulfur is rarely if ever needed.	No	None
California	Unknown	Unknown	-	Unknown	Unknown
Colorado	No	Yes	If SO_4-S = 10 ppm or less, the recommendation is 20 lbs S ac^{-1}. If SO_4-S = 11-20 ppm, the recommendation is 10 lbs S ac^{-1}.	No	None
Hawaii	Unknown	No	No recommendations for sulfur.	No	None
Idaho	No	Yes	Yes, water extractable S. Less than 10 ppm SO_4-S provides a recommendation of 20 lbs S ac^{-1} for all north Idaho crops. There is plenty of S in irrigation water in southern Idaho to meet S needs - so S applications are rare in southern Idaho.	No	None
Montana	Yes	-	No	Yes	Glunk forages. Not published to my knowledge. She has moved on.
New Mexico	No	No	Only when grasses are being grown. Refer to Circular CR 650	No	None
Oregon	Unknown	No	Rarely for western Oregon, more commonly for eastern Oregon. More info in EC1478 page 5.	No	None
Utah	Yes	No	Yes, but it is a fairly blanket recommendation (ex. if soil test is below 8 ppm S as sulfate from a saturation extraction, then a blanket 25-50 lbs S ac^{-1} recommendation is made for all crops). We consider the soil test for S to be somewhat limited in predictive value and encourage tissue testing if symptoms persist regardless of soil test level.	Yes	Cardon and Barnhill, review of Utah vs regional soil and tissue test S threshold values for alfalfa and an in-state inventory of paired soil and hay tissue samples from 35 locations. This is summarized in a USU Extension Research Bulletin: Northern Utah Alfalfa Nutrient Survey 2008. December 2009. AG/Crops/2009-01pr J. Barnhill, G. Cardon, M. Pace, C. Israelsen, D. Miner, L. Greenhalgh, S. Banks, M. Shao, D. Rothlisberger, and S. Olsen; Collaborator: P. Hole
Washington	-	-	-	-	-

Region & state[a]	Deficiency common?[b]	Routine test?	Does your institution make S recommendations based on soil test results? If yes, provide a brief description of the approach used.[c]	Research trials within last 10 years?[d]	Brief description of soil test S correlation and calibration research[c]
Wyoming	Unknown	No	-	Unknown	Unknown

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.

[b]Has S deficiency become more common over the last ten years?

[c]See Table 18 for SI unit conversions.

[d]Have any soil test correlation and calibration trials for S been conducted within the last 10 years?

Table 11. Soil Mg and micronutrient (micro; e.g. Zn, Cu, etc.) testing and recommendations (recs.). Responses given in 2020 and 2021 (Questions 4.17 through 4.25)

Region & state[a]	Soil test Mg levels changed?[b]	Soil test Mg recs. provided?[c]	Recent Mg fertility research?[d]	Micro recs. made based on soil test?[e]	Soil-test-based rec. micros[f]	Micro recs. recently validated or reviewed?[g]	Routinely reported micros[h]	Notes
NORTH CENTRAL								
Illinois	Unknown	Unknown	No	Unknown	-	Unknown	-	
Indiana	Unknown	No Lab	No	Yes	Mn, Zn	No	-	Micro results provided by special request
Iowa	No	No Lab	No	Yes	Zn	Yes	-	
Kansas	Unknown	Unknown	Unknown	Yes	Zn	Yes	Zn	
Michigan	No	Yes	Yes	Yes	Mn, Zn, B	Yes	Not Reported	
Minnesota	No	Yes	No	Yes	B, Cu, Zn, Cl	No	Zn	
Missouri	No	No	No	Yes	B, Zn	No	Not Reported	
Nebraska	Unknown	No	No	Yes	Fe, Zn	Yes	Zn	Micro results provided by special request
North Dakota	Unknown	No	No	Yes	Cu, Zn, Cl	Yes	Cu, Fe, Mn, Zn, Cl	
Ohio	Unknown	Yes	No	Yes	Cu, Mn, Zn	Yes	-	
South Dakota	Unknown	No	No	Yes	Zn	Yes	Zn	
Wisconsin	Unknown	Yes	Unknown	Yes	B, Mn, Zn	Yes	Not Reported	Micro results provided by special request
NORTHEASTERN								
Connecticut	Unknown	No	No	No	-	No	B, Cu, Fe, Mn, Zn	
Delaware	Unknown	Yes	No	Yes	B, Mn, Zn	Yes	B, Mn, Zn	
Maine	No	Yes	No	Yes	B, Zn	No	B, Cu, Fe, Mn, Zn	
Maryland	Unknown	No	No	No	-	No	-	Micro results provided by special request
Massachusetts	Unknown	No	Unknown	No	-	No	B, Cu, Fe, Mn, Zn	
New Hampshire	No	Yes	No	No	-	Unknown	-	Micro results provided by special request
New Jersey	Unknown	Yes	No	Yes	B, Cu, Fe, Mn, Zn	Yes	B, Cu, Fe, Mn, Zn	
New York	Unknown	Yes	No	Yes	B, Mn, Zn	Yes	B, Fe, Mn, Zn	
Pennsylvania	No	Yes	No	No	-	No	Cu, Zn	Micro results provided by special request
Rhode Island	Unknown	No Lab	No	No	-	No	-	

Region & state[a]	Soil test Mg levels changed?[b]	Soil test Mg recs. provided?[c]	Recent Mg fertility research?[d]	Micro recs. made based on soil test?[e]	Soil-test-based rec. micros[f]	Micro recs. recently validated or reviewed?[g]	Routinely reported micros[h]	Notes
Vermont	Unknown	Yes	No	Yes	Zn	Yes	B, Cu, Fe, Mn, Zn	
West Virginia	No	Yes	No	No	-	No	Not Reported	
SOUTHERN								
Alabama	No	Yes	No	No	-	No	Not Reported	Micro results provided by special request
Arkansas	Unknown	No	Yes	Yes	Zn	No	B, Cu, Fe, Mn, Zn	Dr. Trent Roberts initiated some Mg research with corn in 2019 and a report of that research will be published in 2020 (Wayne E Sabbe Arkansas Soil Fertility Studies). The research was done at the Milo Shult Agric. Research and Extension Center in Fayetteville as many soils in western Arkansas are low in Mg. https://agcomm.uark.edu/agnews/publications/666_Sabbe_Arkansas_Soil_Fertility_Studies_2019.pdf
Florida	Unknown	Yes	No	Yes	Cu, Mn, Zn	No	Cu, Mn, Zn	
Georgia	Yes	Yes	Unknown	No	-	No	Mn, Zn	Decline in Mg of about 13%.
Kentucky	Unknown	Yes	No	Yes	B, Zn	Yes	Zn	Dr. John Grove looking at wheat B and Zn responses across state as well as irrigated corn B and Zn responses.
Louisiana	No	No	No	Yes	Cu, Zn	Yes	Cu, Zn	
Mississippi	No	No	No	No	-	Yes	Zn	
North Carolina	Unknown	Yes	No	Yes	Cu, Mn, Zn	No	Cu, Mn, Zn	

Region & state[a]	Soil test Mg levels changed?[b]	Soil test Mg recs. provided?[c]	Recent Mg fertility research?[d]	Micro recs. made based on soil test?[e]	Soil-test-based rec. micros[f]	Micro recs. recently validated or reviewed?[g]	Routinely reported micros[h]	Notes
Oklahoma	No	Yes	No	Yes	B, Cu, Fe, Mn, Zn, Mo, Cl	Yes	B, Fe, Mn, Zn	
Puerto Rico	Unknown	Yes	Yes	Yes	B, Cu, Fe, Mn, Zn	Yes	B, Cu, Fe, Mn, Zn	Gustavo Martínez, 25+ research years, plantain, banana response to soil Mg and fertilizer-Mg Heber Irizarry, retired, plantain, banana Mg uptake.
South Carolina	Unknown	Yes	Unknown	Yes	B, Fe, Mn, Zn	No	B, Cu, Fe, Mn, Zn	
Tennessee	Unknown	Yes	No	Yes	B, Mn, Zn	Yes	B, Fe, Mn, Zn	
Texas	Yes	Yes	No	Yes	B, Cu, Fe, Mn, Zn	Yes	-	Mg has dropped significantly in forage systems where hay is removed.
Virginia	Unknown	Yes	Unknown	Yes	B, Mn, Zn, Mo	Unknown	B, Cu, Fe, Mn, Zn, Mo	
WESTERN								
Arizona	-	No Lab	No	Yes	B, Mn, Zn	Yes	-	
California	Unknown	Unknown	Unknown	Unknown	-	Unknown	-	
Colorado	Unknown	No	No	Yes	Fe, Zn	No	B, Cu, Fe, Mn, Zn	Micro results provided by special request
Hawaii	Unknown	Yes	Unknown	No	-	Unknown	Not Reported	Micro results provided by special request
Idaho	No	No	No	Yes	B, Zn	Yes	B, Zn	
Montana	Unknown	No Lab	No	Yes	B, Cu, Fe, Mn, Zn	No	-	
New Mexico	Unknown	No	No	Yes	B, Cu, Fe, Zn, Cl	Yes	Cu, Fe, Mn, Zn	
Oregon	Unknown	-	Unknown	Yes	B, Cu, Mn, Zn, Cl	Yes	-	
Utah	Unknown	No	No	Yes	Fe, Zn	Yes	Cu, Fe, Mn, Zn	
Washington	-	-	-	-	-	-	-	
Wyoming	Unknown	No Lab	No	Yes	Fe, Zn	Yes	-	

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.

[b]Has average soil test Mg changed over the last ten years?

[c]Does your state/lab provide soil test Mg recommendations?

[d]Has there been field research to evaluate Mg fertility in the last 10 years?

[e]Does your lab/state make micronutrient recommendations based on soil test results?

[f]Micronutrients for which soil-test based recommendations are made by your lab/state.

[g]Has your institution validated and/or reviewed recommendations for micronutrient fertilization in the last 10 years?

[h]Micronutrients that are routinely reported on your state/lab soil test report.

Table 12. Nitrate-N testing methods and recommendations. Responses given in 2020 and 2021 (Questions 8.25 through 8.27)

Region & state[a]	Standard lab test?[b]	Method			NO_3-N used for N recommendations?[c]
		Flow injection Cd-reduction	Ion specific electrode	Other	
NORTH CENTRAL					
Illinois	N/A	-	-	-	-
Indiana	No	-	-	-	-
Iowa	No	-	-	-	-
Kansas	Yes	X	-	-	Yes
Michigan	No	-	-	-	-
Minnesota	Yes, but not routinely	X	-	-	Sometimes
Missouri	No	-	-	-	-
Nebraska	Yes, but not routinely	-	-	Other	Yes
North Dakota	Yes	-	X	-	Yes
Ohio	No	-	-	-	-
South Dakota	Yes, but not routinely	-	X	-	Yes
Wisconsin	Yes, but not routinely	X	-	-	Used to adjust N recommendations for corn and wheat if samples are collected. Not required for a N recommendation.
NORTHEASTERN					
Connecticut	No	-	-	-	-
Delaware	No	-	-	-	-
Maine	Yes, but not routinely	X	-	-	Yes, in high tunnel soil test
Maryland	No	-	-	-	Yes, for PSNT and FSNT if provided
Massachusetts	No	-	-	-	-
New Hampshire	No	-	-	-	-
New Jersey	No	-	-	-	-
New York	Yes, but not routinely	X	-	-	Yes, for PSNT. Recommendations for PSNT documented in agronomy factsheet.
Pennsylvania	Yes, but not routinely	X	X	-	Yes, for PSNT
Rhode Island	N/A	-	-	-	-
Vermont	No	-	-	-	-
West Virginia	No	-	-	-	-
SOUTHERN					
Alabama	Yes, but not routinely	-	X	Colorimeter	No
Arkansas	Yes, but not routinely	-	X	-	No
Florida	No	-	-	-	-
Georgia	No	-	-	-	-
Kentucky	No	-	X	-	Yes, for PSNT

Region & state[a]	Standard lab test?[b]	Method			NO_3-N used for N recommendations?[c]
		Flow injection Cd-reduction	Ion specific electrode	Other	
Louisiana	No	-	-	-	-
Mississippi	No	-	-	-	-
North Carolina	No	-	-	-	-
Oklahoma	Yes	X	-	-	Yes
Puerto Rico	Yes	X	-	-	No
South Carolina	No	-	-	-	-
Tennessee	No	-	-	-	-
Texas	Yes	X	-	-	Yes
Virginia	No	-	-	-	-
WESTERN					
Arizona	Yes	X	-	-	Unknown
California	N/A	-	-	-	-
Colorado	Yes, but not routinely	X	-	-	Unknown
Hawaii	No	-	-	-	-
Idaho	Yes	-	-	Other	No
Montana	Yes	X	-	-	Yes
New Mexico	Yes	-	-	Ca-P	Yes
Oregon	N/A	-	-	-	-
Utah	Yes, but not routinely	X	-	-	Yes, but not routinely
Washington	N/A	-	-	-	-
Wyoming	Yes	-	-	Other[d]	Yes

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.

[b]N/A listed for those states without public service labs and that did not provide other information.

[c]FSNT, fall soil nitrate test; PSNT, pre-sidedress soil nitrate test.

[d]Wyoming: Microplate, Vanadium chloride extraction

Table 13. Nutrients and methodologies recommended for routine analysis. Responses given in 2020 and 2021 (Question 7.3)

Region & state[a]	Nutrient	Recommended?[b]	Method[c]	Years used	Reporting units[d]	Comments
NORTH CENTRAL						
Illinois	P	-	Bray-1	-	-	
	K	-	Mehlich-3, NH_4Oac	-	-	
Indiana	P	Yes	Mehlich-3, Bray-1	20	ppm, lbs ac^{-1}	
	K	Yes	Mehlich-3, NH_4OAc	20	ppm, lbs ac^{-1}	
	Ca	Yes	Mehlich-3	20	ppm, lbs ac^{-1}	
	Mg	Yes	Mehlich-3	20	ppm, lbs ac^{-1}	
	Na	No	Mehlich-3	20	-	
	S	No	Mehlich-3	20	-	
	Fe	No	Mehlich-3	20	-	
	Zn	No	Mehlich-3, 0.1 *M* HCl	20	-	
	Cu	No	Mehlich-3, 0.1 *M* HCl	20	-	
	Mn	No	Mehlich-3, 0.1 *M* HCl	20	-	
	B	No	Mehlich-3	20	-	
	Al	No	Mehlich-3	20	-	
	Cl	No	Mehlich-3	20	-	
Iowa	P	Yes	Mehlich-3, Mehlich-3_{col}	20	mg kg^{-1}	Bray-1 (pH <7.3) and Olsen (pH>7.3) are also used for P. NH_4OAc is also used for K. Moist sample handling is recommended for K, but not offered by many labs. No deficiencies observed or soil tests recommended for Ca, Mg, Na, S, Fe, Zn, Cu, Mn, B, Al, or Cl in Iowa.
	K	-	Mehlich-3	20	mg kg^{-1}	
	Zn	-	DTPA	40	mg kg^{-1}	
Kansas	P	Yes	Mehlich-3_{col}	-	mg kg^{-1}	
	K	Yes	NH_4OAc	-	mg kg^{-1}	
	Ca	No	NH_4OAc	-	mg kg^{-1}	
	Mg	No	NH_4OAc	-	mg kg^{-1}	
	Na	No	NH_4OAc	-	mg kg^{-1}	

Region & state[a]	Nutrient	Recommended?[b]	Method[c]	Years used	Reporting units[d]	Comments
	S	No	Ca Phosphate	-	mg kg^{-1}	
	Fe	No	DTPA	-	mg kg^{-1}	
	Zn	No	DTPA	-	mg kg^{-1}	
	Cu	No	DTPA	-	mg kg^{-1}	
	Mn	No	DTPA	-	mg kg^{-1}	
	Cl	No	$Ca(NO_3)_2$	-	mg kg^{-1}	
Michigan	P	Yes	Bray-1	-	-	
	K	Yes	NH_4OAc	-	-	
	Ca	Yes	NH_4OAc	-	-	
	Mg	Yes	NH_4OAc	-	-	
	Na	No	-	-	-	
	S	No	-	-	-	
	Fe	No	-	-	-	
	Zn	No	HCl	-	-	
	Cu	No	HCl	-	-	
	Mn	No	HCl	-	-	
	B	No	Hot water	-	-	
	Al	No	-	-	-	
	Cl	No	-	-	-	
Minnesota	P	Yes	Bray-1	-	mg kg^{-1}	For P, Olsen suggested if pH > 7.4
	K	Yes	NH_4OAc	-	mg kg^{-1}	
	Ca	No	NH_4OAc	-	mg kg^{-1}	
	Mg	No	NH_4OAc	-	mg kg^{-1}	
	Na	No	NH_4OAc	-	mg kg^{-1}	
	S	No	Ca Phosphate	-	mg kg^{-1}	
	Fe	No	DTPA	-	mg kg^{-1}	
	Zn	Yes	DTPA	-	mg kg^{-1}	
	Cu	No	DTPA	-	mg kg^{-1}	
	Mn	No	DTPA	-	mg kg^{-1}	
	B	No	DTPA	-	mg kg^{-1}	
	Al	No	DTPA	-	mg kg^{-1}	
	Cl	No	Other	-	mg kg^{-1}	
Missouri	P	Yes	Bray-1	-	lbs ac^{-1}	
	K	Yes	NH_4Oac	-	lbs ac^{-1}	
	Ca	Yes	NH_4OAc	-	lbs ac^{-1}	
	Mg	Yes	NH_4OAc	-	lbs ac^{-1}	

Region & state[a]	Nutrient	Recommended?[b]	Method[c]	Years used	Reporting units[d]	Comments
Nebraska	P	Yes	Bray-1	60	-	For P, Olsen, Mehlich-2, and Mehlich-3 are also used
	K	Yes	NH_4OAc	60	-	
	Ca	Yes	NH_4OAc	60	-	
	Mg	Yes	NH_4OAc	60	-	
	Na	Yes	NH_4OAc	60	-	
	S	Yes	Ca Phosphate	60	-	
	Fe	Yes	DTPA	60	-	
	Zn	Yes	DTPA	60	-	
	Cu	Yes	DTPA	60	-	
	Mn	Yes	DTPA	60	-	
	B	Yes	Hot water	60	-	
	Al	No	-	-	-	
	Cl	No	-	-	-	
North Dakota	P	Yes	Olsen	>50	mg kg^{-1}	S not recommended. For Zn, critical value of 1ppm for corn, flax, potato, and dry bean only. Cu and Cl tests recommended for wheat and barley only.
	K	Yes	NH_4OAc	>50	mg kg^{-1}	
	Ca	Yes	NH_4Oac	>50	mg kg^{-1}	
	Mg	Yes	NH_4OAc	>50	mg kg^{-1}	
	Na	Yes	NH_4OAc	>40	mg kg^{-1}	
	S	No	Ca Phosphate	>40	lbs ac^{-1}	
	Fe	Yes	DTPA	>30	mg kg^{-1}	
	Zn	Yes	DTPA	>30	mg kg^{-1}	
	Cu	Yes	DTPA	>30	mg kg^{-1}	
	Mn	Yes	DTPA	>30	mg kg^{-1}	
	B	Yes	Hot water	>30	mg kg^{-1}	
	Al	No	-	-	-	
	Cl	Yes	Other	>40	lbs ac^{-1}	
Ohio	P	Yes	Mehlich-3	1	-	
	K	Yes	Mehlich-3	1	-	
	Ca	Yes	Mehlich-3	1	-	
	Mg	Yes	Mehlich-3	1	-	
	Na	-	Mehlich-3	-	-	
	S	-	Mehlich-3	-	-	
	Fe	-	Mehlich-3	-	-	
	Zn	Yes	HCl	25	-	
	Cu	Yes	HCl	25	-	
	Mn	Yes	HCl	25	-	

Region & state[a]	Nutrient	Recommended?[b]	Method[c]	Years used	Reporting units[d]	Comments
	B	-	Mehlich-3	-	-	
	Al	-	Mehlich-3	-	-	
	Cl	-	Mehlich-3	-	-	
South Dakota	P	Yes	Olsen	-	mg kg^{-1}	
	K	Yes	NH_4OAc	-	mg kg^{-1}	
	Ca	No	NH_4OAc	-	mg kg^{-1}	
	Mg	No	DTPA	-	mg kg^{-1}	
	Na	No	-	-	-	
	S	Yes	MBCP	-	lbs ac^{-1}	
	Fe	No	DTPA	-	mg kg^{-1}	
	Zn	Yes	DTPA	-	mg kg^{-1}	
	Cu	No	DTPA	-	mg kg^{-1}	
	Mn	No	DTPA	-	mg kg^{-1}	
	B	No	Hot water	-	mg kg^{-1}	
	Al	No	-	-	mg kg^{-1}	
	Cl	No	0.01 *M* $Ca(NO_3)_2$	-	lbs ac^{-1}	
Wisconsin	P	Yes	Bray-1	60	mg kg^{-1}	
	K	Yes	Bray-1	60	mg kg^{-1}	
	Ca	No	NH_4OAc	55	mg kg^{-1}	
	Mg	No	NH_4OAc	55	mg kg^{-1}	
	S	No	Ca Phosphate	45	mg kg^{-1}	Ca Phosphate plus acetic acid
	Zn	No	0.1 *M* HCl	50	mg kg^{-1}	
	Mn	No	Phosphoric acid	55	mg kg^{-1}	0.1 N (0.03 *M*) phosphoric acid
	B	No	Hot water	55	mg kg^{-1}	
NORTHEASTERN						
Connecticut	P	Yes	Modified $Morgan_{col}$	>50	lbs oxide ac^{-1}	K, Ca, and Mg previously determined using a flame photometer.
	K	Yes	Modified Morgan	>50	lbs oxide ac^{-1}	
	Ca	Yes	Modified Morgan	>50	lbs oxide ac^{-1}	
	Mg	Yes	Modified Morgan	>50	lbs oxide ac^{-1}	
	Na	No	-	-	-	
	S	Yes	Modified Morgan	4	mg kg^{-1}	
	Fe	Yes	Modified Morgan	10	mg kg^{-1}	
	Zn	Yes	Modified Morgan	10	mg kg^{-1}	
	Cu	Yes	Modified Morgan	10	mg kg^{-1}	
	Mn	Yes	Modified Morgan	10	mg kg^{-1}	
	B	Yes	Modified Morgan	10	mg kg^{-1}	

Region & state[a]	Nutrient	Recommended?[b]	Method[c]	Years used	Reporting units[d]	Comments
	Al	Yes	Modified Morgan	10	mg kg^{-1}	
	Cl	No	-	-	-	
Delaware	P	Yes	Mehlich-3	25	Unitless index	Fe and Al only used to calculate degree of P saturation, unless otherwise requested.
	K	Yes	Mehlich-3	25	Unitless index	
	Ca	Yes	Mehlich-3	25	Unitless index	
	Mg	Yes	Mehlich-3	25	Unitless index	
	Na	No	-	-	-	
	S	Yes	Mehlich-3	25	lbs ac^{-1}	
	Fe	Yes	Mehlich-3	25	lbs oxide ac^{-1}	
	Zn	Yes	Mehlich-3	25	lbs ac^{-1}	
	Cu	Yes	Mehlich-3	25	lbs ac^{-1}	
	Mn	Yes	Mehlich-3	25	lbs ac^{-1}	
	B	Yes	Mehlich-3	25	lbs ac^{-1}	
	Al	Yes	Mehlich-3	25	lbs ac^{-1}	
	Cl	No	-	-	-	
Maine	P	Yes	Modified $Morgan_{col}$	10	mg kg^{-1}	% saturation also used on K, Ca, Mg on request. Al tested on request.
	K	Yes	Modified Morgan	40	mg kg^{-1}	
	Ca	Yes	Modified Morgan	40	mg kg^{-1}	
	Mg	Yes	Modified Morgan	40	mg kg^{-1}	
	Na	Yes	Modified Morgan	40	mg kg^{-1}	
	S	Yes	Modified Morgan	20	mg kg^{-1}	
	Fe	Yes	Modified Morgan	15	mg kg^{-1}	
	Zn	Yes	Modified Morgan	20	mg kg^{-1}	
	Cu	Yes	Modified Morgan	15	mg kg^{-1}	
	Mn	Yes	Modified Morgan	15	mg kg^{-1}	
	B	Yes	Modified Morgan	20	mg kg^{-1}	
	Al	No	Modified Morgan	20	mg kg^{-1}	
	Cl	No	-	-	-	
Maryland	P	Yes	Mehlich-3	24	Unitless index	For P, Mehlich-1 and Bray-1 also accepted, all converted to index. For K, Ca, and Mg, Mehlich-1 and ammonium acetate also accepted, all converted to index.
	K	Yes	Mehlich-3	24	Unitless index	
	Ca	Yes	Mehlich-3	24	Unitless index	
	Mg	Yes	Mehlich-3	24	Unitless index	
	Na	No	-	-	-	
	S	No	-	-	-	
	Fe	Yes	Mehlich-3	>7	mg kg^{-1}	
	Zn	No	-	-	-	

Region & state[a]	Nutrient	Recommended?[b]	Method[c]	Years used	Reporting units[d]	Comments
	Cu	No	-	-	-	
	Mn	No	-	-	-	
	B	No	-	-	-	
	Al	Yes	Mehlich-3	>7	mg kg^{-1}	
	Cl	No	-	-	-	
Massachusetts	P	Yes	Modified $Morgan_{col}$	7	mg kg^{-1}	
	K	Yes	Modified Morgan	15	mg kg^{-1}	
	Ca	Yes	Modified Morgan	15	mg kg^{-1}	
	Mg	Yes	Modified Morgan	15	mg kg^{-1}	
	Na	No	-	-	-	
	S	Yes	Modified Morgan	15	mg kg^{-1}	
	Fe	Yes	Modified Morgan	15	mg kg^{-1}	
	Zn	Yes	Modified Morgan	15	mg kg^{-1}	
	Cu	Yes	Modified Morgan	15	mg kg^{-1}	
	Mn	Yes	Modified Morgan	15	mg kg^{-1}	
	B	Yes	Modified Morgan	15	mg kg^{-1}	
	Al	Yes	Modified Morgan	15	mg kg^{-1}	
	Cl	No	-	-	-	
New Hampshire	P	Yes	Mehlich-3	-	mg kg^{-1}	
	K	Yes	Mehlich-3	-	mg kg^{-1}	
	Ca	Yes	Mehlich-3	-	mg kg^{-1}	
	Mg	Yes	Mehlich-3	-	mg kg^{-1}	
	Na	No	Mehlich-3	-	mg kg^{-1}	
	S	No	Mehlich-3	-	mg kg^{-1}	
	Fe	No	Mehlich-3	-	mg kg^{-1}	
	Zn	No	Mehlich-3	-	mg kg^{-1}	
	Cu	No	Mehlich-3	-	mg kg^{-1}	
	Mn	No	Mehlich-3	-	mg kg^{-1}	
	B	No	Hot water	-	mg kg^{-1}	
	Al	No	Mehlich-3	-	mg kg^{-1}	
	Cl	No	Mehlich-3	-	mg kg^{-1}	
New Jersey	P	Yes	Mehlich-3	-	lbs ac^{-1}	
	K	Yes	Mehlich-3	-	lbs ac^{-1}	
	Ca	Yes	Mehlich-3	-	lbs ac^{-1}	
	Mg	Yes	Mehlich-3	-	lbs ac^{-1}	
	Na	No	-	-	-	

Region & state[a]	Nutrient	Recommended?[b]	Method[c]	Years used	Reporting units[d]	Comments
	S	No	-	-	-	
	Fe	Yes	Mehlich-3	-	Other	
	Zn	Yes	Mehlich-3	-	Other	
	Cu	Yes	Mehlich-3	-	Other	
	Mn	Yes	Mehlich-3	-	Other	
	B	Yes	Mehlich-3	-	Other	
	Al	No	-	-	-	
	Cl	No	-	-	-	
New York	P	Yes	Morgan	40	lbs ac^{-1}	
	K	Yes	Morgan	40	lbs ac^{-1}	
	Ca	Yes	Morgan	40	lbs ac^{-1}	
	Mg	Yes	Morgan	40	lbs ac^{-1}	
	Na	No	-	-	-	
	S	Yes	$SrCl_2$	10	ppm	Recommended for alfalfa only
	Fe	Yes	Morgan	40	lbs ac^{-1}	
	Zn	Yes	Morgan	40	lbs ac^{-1}	
	Cu	Yes	Morgan	40	lbs ac^{-1}	
	Mn	Yes	Morgan	40	lbs ac^{-1}	
	B	Yes	Hot water	40	lbs ac^{-1}	
	Al	Yes	Morgan	40	lbs ac^{-1}	
	Cl	No	-	-	-	
Pennsylvania	P	Yes	Mehlich-3	25	mg kg^{-1}	
	K	Yes	Mehlich-3	25	mg kg^{-1}	
	Ca	Yes	Mehlich-3	25	mg kg^{-1}	
	Mg	Yes	Mehlich-3	25	mg kg^{-1}	
	Na	-	Mehlich-3	-	-	
	S	Yes	Mehlich-3	25	mg kg^{-1}	
	Fe	-	Mehlich-3	-	-	
	Zn	Yes	Mehlich-3	25	mg kg^{-1}	
	Cu	Yes	Mehlich-3	25	mg kg^{-1}	
	Mn	-	Mehlich-3	-	-	
	B	-	Mehlich-3	-	-	
	Al	-	Mehlich-3	-	-	
Rhode Island	P	Yes	Modified $Morgan_{col}$	-	-	
	K	Yes	Modified Morgan	-	-	
	Ca	Yes	Modified Morgan	-	-	

Region & state[a]	Nutrient	Recommended?[b]	Method[c]	Years used	Reporting units[d]	Comments
	Mg	Yes	Modified Morgan	-	-	
	S	Yes	Modified Morgan	-	-	
	Fe	Yes	Modified Morgan	-	-	
	Zn	Yes	Modified Morgan	-	-	
	Cu	Yes	Modified Morgan	-	-	
	Mn	Yes	Modified Morgan	-	-	
	B	Yes	Modified Morgan	-	-	
Vermont	P	Yes	Modified $Morgan_{col}$	50	mg kg^{-1}	
	K	Yes	Modified Morgan	50	mg kg^{-1}	
	Ca	Yes	Modified Morgan	50	mg kg^{-1}	
	Mg	Yes	Modified Morgan	50	mg kg^{-1}	
	Na	Yes	Modified Morgan	30	mg kg^{-1}	
	S	Yes	Modified Morgan	30	mg kg^{-1}	
	Fe	Yes	Modified Morgan	30	mg kg^{-1}	
	Zn	Yes	Modified Morgan	30	mg kg^{-1}	
	Cu	Yes	Modified Morgan	30	mg kg^{-1}	
	Mn	Yes	Modified Morgan	30	mg kg^{-1}	
	B	Yes	Modified Morgan	30	mg kg^{-1}	
	Al	Yes	Modified Morgan	50	mg kg^{-1}	
West Virginia	-	-	-	-	-	
SOUTHERN						
Alabama	P	Yes	Mehlich-1	67	lbs oxide ac^{-1}	Lancaster used for P on some soils
	K	Yes	Mehlich-1	67	lbs ac^{-1}	
	Ca	Yes	Mehlich-1	67	lbs oxide ac^{-1}	
	Mg	Yes	Mehlich-1	67	lbs oxide ac^{-1}	
	Na	No	-	-		
	S	No	-	-		
	Fe	No	-	-		
	Zn	No	-	-		
	Cu	No	-	-		
	Mn	No	-	-		
	B	No	-	-		
	Al	No	-	-		
	Cl	No	-	-		
Arkansas	P	Yes	Mehlich-3	14	mg kg^{-1}	Used Mehlich-3 at a 1:7 soil:solution ratio from 1989-
	K	Yes	Mehlich-3	14	mg kg^{-1}	

Region & state[a]	Nutrient	Recommended?[b]	Method[c]	Years used	Reporting units[d]	Comments
	Ca	Yes	Mehlich-3	14	mg kg^{-1}	2005 for listed elements P
	Mg	Yes	Mehlich-3	14	mg kg^{-1}	through B
	Na	Yes	Mehlich-3	14	mg kg^{-1}	
	S	Yes	Mehlich-3	14	mg kg^{-1}	
	Fe	Yes	Mehlich-3	14	mg kg^{-1}	
	Zn	Yes	Mehlich-3	14	mg kg^{-1}	
	Cu	Yes	Mehlich-3	14	mg kg^{-1}	
	Mn	Yes	Mehlich-3	14	mg kg^{-1}	
	B	Yes	Mehlich-3	14	mg kg^{-1}	
	Al	No	Mehlich-3	14	mg kg^{-1}	
	Cl	No	Other	-	mg kg^{-1}	
Florida	P	Yes	Mehlich-3	7	mg kg^{-1}	
	K	Yes	Mehlich-3	7	mg kg^{-1}	
	Ca	Yes	Mehlich-3	-	mg kg^{-1}	
	Mg	Yes	Mehlich-3	-	mg kg^{-1}	
	S	Yes	Mehlich-3	-	mg kg^{-1}	
	Zn	Yes	Mehlich-3	-	mg kg^{-1}	
	Cu	Yes	Mehlich-3	-	mg kg^{-1}	
	Mn	Yes	Mehlich-3	-	mg kg^{-1}	
Georgia	P	Yes	Mehlich-1	50	lbs ac^{-1}	
	K	Yes	Mehlich-1	50	lbs ac^{-1}	
	Ca	Yes	Mehlich-1	50	lbs ac^{-1}	
	Mg	Yes	Mehlich-1	50	lbs ac^{-1}	
	Na	No	Mehlich-1	50	lbs ac^{-1}	
	S	No	$CaCl_2$	-	lbs ac^{-1}	
	Fe	No	Mehlich-1	50	lbs ac^{-1}	
	Zn	Yes	Mehlich-1	50	lbs ac^{-1}	
	Cu	No	Mehlich-1	50	lbs ac^{-1}	
	Mn	Yes	Mehlich-1	50	lbs ac^{-1}	
	B	No	Hot water	50	lbs ac^{-1}	
	Al	No	Mehlich-1	50	lbs ac^{-1}	
	Cl	No	NH_4OAc	-	lbs ac^{-1}	
Kentucky	P	Yes	Mehlich-3	-	Unitless index	
	K	Yes	Mehlich-3	-	Unitless index	
	Ca	Yes	Mehlich-3	-	Unitless index	
	Mg	Yes	Mehlich-3	-	Unitless index	

Region & state[a]	Nutrient	Recommended?[b]	Method[c]	Years used	Reporting units[d]	Comments
	Na	No	-	-	-	
	S	No	-	-	-	
	Fe	No	-	-	-	
	Zn	Yes	Mehlich-3	-	lbs ac^{-1}	
	Cu	No	-	-	-	
	Mn	No	-	-	-	
	B	Yes	Hot water	Unknown	Unitless index	
	Al	No	-	-	-	
	Cl	No	-	-	-	
Louisiana	P	Yes	Mehlich-3	16	mg kg^{-1}	
	K	Yes	Mehlich-3	16	mg kg^{-1}	
	Ca	Yes	Mehlich-3	16	mg kg^{-1}	
	Mg	Yes	Mehlich-3	16	mg kg^{-1}	
	Na	Yes	Mehlich-3	16	mg kg^{-1}	
	S	Yes	Mehlich-3	16	mg kg^{-1}	
	Fe	No	DTPA	30	mg kg^{-1}	
	Zn	Yes	Mehlich-3	16	mg kg^{-1}	
	Cu	Yes	Mehlich-3	16	mg kg^{-1}	
	Mn	No	DTPA	30	mg kg^{-1}	
	B	No	Hot water	30	mg kg^{-1}	
	Al	No	-	-	-	
	Cl	No	Saturated paste	-	-	
Mississippi	P	Yes	Lancaster	70	lbs ac^{-1}	
	K	Yes	Lancaster	70	lbs ac^{-1}	
	Ca	Yes	Lancaster	70	lbs ac^{-1}	
	Mg	Yes	Lancaster	70	lbs ac^{-1}	
	Na	Yes	Lancaster	70	lbs ac^{-1}	
	Zn	Yes	Lancaster	35	lbs ac^{-1}	
North Carolina	P	Yes	Mehlich-3	27	Unitless index	
	K	Yes	Mehlich-3	27	Unitless index	
	Ca	Yes	Mehlich-3	27	% of estimated CEC	
	Mg	Yes	Mehlich-3	27	% of estimated CEC	
	Na	Yes	Mehlich-3	27	meq $100cc^{-1}$	
	S	Yes	Mehlich-3	27	Unitless index	
	Zn	Yes	Mehlich-3	27	Unitless index	
	Cu	Yes	Mehlich-3	27	Unitless index	

Region & state[a]	Nutrient	Recommended?[b]	Method[c]	Years used	Reporting units[d]	Comments
	Mn	Yes	Mehlich-3	27	Unitless index	
Oklahoma	P	Yes	Mehlich-3	35	mg kg^{-1}, lbs ac^{-1}	
	K	Yes	Mehlich-3	35	mg kg^{-1}, lbs ac^{-1}	
	Fe	-	DTPA-sorbitol	-	-	
	Zn	-	DTPA-sorbitol	-	-	
	Cu	-	DTPA-sorbitol	-	-	
	Mn	-	DTPA-sorbitol	-	-	
	B	-	DTPA-sorbitol	-	-	
Puerto Rico	P	Yes	Bray-1, Olsen	>30	mg kg^{-1}	Bray-1 for acid soils and Olsen for neutral-alkaline soils for P
	K	Yes	NH_4OAc	>30	meq 100 g^{-1}	
	Ca	Yes	NH_4OAc	>30	meq 100 g^{-1}	
	Mg	Yes	NH_4OAc	>30	meq 100 g^{-1}	
	Na	Yes	NH_4OAc	>30	meq 100 g^{-1}	
	S	Yes	Ca phosphate	10	mg kg^{-1}	
	Fe	Yes	DTPA	10	mg kg^{-1}	
	Zn	Yes	DTPA	10	mg kg^{-1}	
	Cu	Yes	DTPA	10	mg kg^{-1}	
	Mn	Yes	DTPA	10	mg kg^{-1}	
	B	Yes	Hot water	10	mg kg^{-1}	
	Al	Yes	1 *M* KCl extractable	10	other	
South Carolina	P	Yes	Mehlich-1	-	lbs ac^{-1}	
	K	Yes	Mehlich-1	-	lbs ac^{-1}	
	Ca	Yes	Mehlich-1	-	lbs ac^{-1}	
	Mg	Yes	Mehlich-1	-	lbs ac^{-1}	
	Na	Yes	Mehlich-1	-	lbs ac^{-1}	
	S	No	NH_4OAc	-	lbs ac^{-1}	
	Fe	Yes	Mehlich-1	-	lbs ac^{-1}	
	Zn	Yes	Mehlich-1	-	lbs ac^{-1}	
	Cu	Yes	Mehlich-1	-	lbs ac^{-1}	
	Mn	Yes	Mehlich-1	-	lbs ac^{-1}	
	B	Yes	Mehlich-1	-	lbs ac^{-1}	
	Al	No	Mehlich-1	-	lbs ac^{-1}	
	Cl	No	-	-	-	
Tennessee	P	Yes	Mehlich-1	40	lbs ac^{-1}	
	K	Yes	Mehlich-1	40	lbs ac^{-1}	

Region & state[a]	Nutrient	Recommended?[b]	Method[c]	Years used	Reporting units[d]	Comments
	Ca	Yes	Mehlich-1	40	lbs ac^{-1}	
	Mg	Yes	Mehlich-1	40	lbs ac^{-1}	
	Na	Yes	Mehlich-1	40	lbs ac^{-1}	
	S	No	Ca phosphate	1	lbs ac^{-1}	
	Fe	Yes	Mehlich-1	40	lbs ac^{-1}	
	Zn	Yes	Mehlich-1	40	lbs ac^{-1}	
	Cu	No	-	-	lbs ac^{-1}	
	Mn	Yes	Mehlich-1	40	lbs ac^{-1}	
	B	Yes	Mehlich-1	40	lbs ac^{-1}	
	Al	No	-	-	-	
	Cl	No	-	-	-	
Texas	P	Yes	Mehlich-3	16	mg kg^{-1}	
	K	Yes	Mehlich-3	16	mg kg^{-1}	
	Ca	Yes	Mehlich-3	16	mg kg^{-1}	
	Mg	Yes	Mehlich-3	16	mg kg^{-1}	
	Na	Yes	Mehlich-3	16	mg kg^{-1}	
	S	Yes	Mehlich-3	16	mg kg^{-1}	
	Fe	-	DTPA	35	mg kg^{-1}	
	Zn	-	DTPA	35	mg kg^{-1}	
	Cu	-	DTPA	35	mg kg^{-1}	
	Mn	-	DTPA	35	mg kg^{-1}	
	B	-	Hot water	40	mg kg^{-1}	
Virginia	P	Yes	Mehlich-1	-	-	Critical levels for Zn and Mn determined by extractable Zn and Mn concentration and soil pH
	K	Yes	Mehlich-1	-	-	
	Ca	Yes	Mehlich-1	-	-	
	Mg	Yes	Mehlich-1	-	-	
	Na	No	-	-	-	
	S	No	-	-	-	
	Fe	Yes	Mehlich-1	-	-	
	Zn	Yes	Mehlich-1	-	-	
	Cu	Yes	Mehlich-1	-	-	
	Mn	Yes	Mehlich-1	-	-	
	B	Yes	Mehlich-1	-	-	
WESTERN						
Arizona	P	-	Olsen	-	-	
	K	-	NH_4OAc	-	-	

Region & state[a]	Nutrient	Recommended?[b]	Method[c]	Years used	Reporting units[d]	Comments
	Ca	-	NH_4OAc	-	-	
	Mg	-	NH_4OAc	-	-	
	Na	-	NH_4OAc	-	-	
	S	-	Hot water	-	-	
	Fe	-	DTPA	-	-	
	Zn	-	DTPA	-	-	
	Cu	-	DTPA	-	-	
	Mn	-	DTPA	-	-	
	B	-	Hot water	-	-	
California	P	Yes	Olsen	-	-	
	K	Yes	NH_4OAc	-	-	
	Ca	Yes	NH_4OAc	-	-	
	Mg	Yes	NH_4OAc	-	-	
	Na	Yes	NH_4OAc	-	-	
Colorado	P	Yes	AB-DTPA, Olsen	40	mg kg^{-1}	
	K	Yes	AB-DTPA, Olsen	40	mg kg^{-1}	
	Ca	Yes	AB-DTPA	40	mg kg^{-1}	
	Mg	Yes	AB-DTPA	40	mg kg^{-1}	
	Na	Yes	AB-DTPA	40	mg kg^{-1}	
	S	Yes	AB-DTPA	40	mg kg^{-1}	
	Fe	Yes	AB-DTPA	40	mg kg^{-1}	
	Zn	Yes	AB-DTPA	40	mg kg^{-1}	
	Cu	Yes	AB-DTPA	40	mg kg^{-1}	
	Mn	Yes	AB-DTPA	40	mg kg^{-1}	
	B	-	Hot water	40	mg kg^{-1}	
	Al	No	-	-	-	
	Cl	No	-	-	-	
Hawaii	P	Yes	Truog (dilute H_2SO_4)	50	mg kg^{-1}	
	K	Yes	NH_4OAc	50	mg kg^{-1}	
	Ca	Yes	NH_4OAc	50	mg kg^{-1}	
	Mg	Yes	NH_4OAc	50	mg kg^{-1}	
	Fe	-	Mehlich-3	-	-	
	Zn	-	Mehlich-3	-	-	
	Cu	-	Mehlich-3	-	-	
	Mn	-	Mehlich-3	-	-	
	B	-	Hot water	-	-	

Region & state[a]	Nutrient	Recommended?[b]	Method[c]	Years used	Reporting units[d]	Comments
Idaho	P	Yes	Morgan, Olsen (corn)	>25	-	For P and K, Morgan for northern Idaho, Olsen for southern Idaho
	K	Yes	Morgan, Olsen	>25	-	
	Ca	No	-	-	-	
	Mg	No	-	-	-	
	Na	No	-	-	-	
	S	Yes	Hot water	>25	-	
	Fe	No	DTPA	>25	-	
	Zn	Yes	DTPA	>25	-	
	Cu	No	DTPA	-	-	
	Mn	No	DTPA	-	-	
	B	Yes	Hot water	>25	-	
Montana	P	Yes	Olsen	>50	mg kg^{-1}	
	K	Yes	NH_4OAc	>50	mg kg^{-1}	
	Ca	No	-	-	-	
	Mg	No	-	-	-	
	Na	No	-	-	-	
	S	No	-	-	-	
	Fe	Yes	DTPA	-	mg kg^{-1}	
	Zn	Yes	DTPA	-	mg kg^{-1}	
	Cu	Yes	DTPA	-	mg kg^{-1}	
	Mn	Yes	DTPA	-	mg kg^{-1}	
	B	Yes	Hot water	-	mg kg^{-1}	
	Al	No	-	-	-	
	Cl	Yes	Saturated paste	-	lbs ac^{-1}	
New Mexico	P	Yes	Olsen	-	-	
	K	Yes	NH_4OAc	-	-	
	Ca	Yes	Saturated paste	-	-	
	Mg	Yes	Saturated paste	-	-	
	Na	Yes	Saturated paste	-	-	
	S	No	Ca phosphate	-	-	
	Fe	Yes	DTPA	-	-	
	Zn	Yes	DTPA	-	-	
	Cu	Yes	DTPA	-	-	
	Mn	Yes	DTPA	-	-	
	B	Yes	Hot water	-	-	

Region & state[a]	Nutrient	Recommended?[b]	Method[c]	Years used	Reporting units[d]	Comments
	Al	-	Other	-	-	
	Cl	-	Other	-	-	
Oregon	P	Yes	Bray-1, Olsen	-	mg kg^{-1}	For P, Bray is used in acidic soils in eastern Oregon while Olsen is used in alkaline soils in western Oregon. Almost no lab uses the S test, but the listed test is the recommended. Pondering whether DTPA-sorbitol would be good for B in Oregon.
	K	Yes	NH_4OAc, Olsen	-	mg kg^{-1}	
	Ca	Yes	NH_4OAc	-	meq 100 g^{-1}	
	Mg	Yes	NH_4OAc	-	meq 100 g^{-1}	
	Na	No	NH_4OAc	-	meq 100 g^{-1}	
	S	Yes	Ca phosphate	-	mg kg^{-1}	
	Fe	Yes	DTPA	-	mg kg^{-1}	
	Zn	Yes	DTPA	-	mg kg^{-1}	
	Cu	Yes	DTPA	-	mg kg^{-1}	
	Mn	Yes	DTPA	-	mg kg^{-1}	
	B	Yes	Hot water	-	mg kg^{-1}	
	Al	No	KCl	-	mg kg^{-1}	
	Cl	No	$Ca(NO_3)_2$	-	lbs ac^{-1}	
Utah	P	Yes	Olsen	-	mg kg^{-1}	
	K	Yes	Olsen	-	mg kg^{-1}	
	Ca	Yes	Saturated paste	-	mg kg^{-1}	
	Mg	Yes	Saturated paste	-	mg kg^{-1}	
	Na	Yes	Saturated paste	-	mg kg^{-1}	
	S	Yes	Saturated paste	-	mg kg^{-1}	
	Fe	Yes	DTPA	-	mg kg^{-1}	
	Zn	Yes	DTPA	-	mg kg^{-1}	
	Cu	Yes	DTPA	-	mg kg^{-1}	
	Mn	Yes	DTPA	-	mg kg^{-1}	
	B	Yes	Hot water	-	-	
Washington	P	-	Bray-1, Olsen	-	-	
	K	-	NH_4OAc	-	-	
Wyoming	P	Yes	Olsen	-	mg kg^{-1}	
	K	No	DTPA, Olsen	-	mg kg^{-1}	
	Ca	No	-	-	-	
	Mg	No	-	-	-	
	Na	No	-	-	-	
	S	Yes	Other	-	mg kg^{-1}	
	Fe	Yes	DTPA	-	mg kg^{-1}	
	Zn	Yes	DTPA	-	mg kg^{-1}	

Region & state[a]	Nutrient	Recommended?[b]	Method[c]	Years used	Reporting units[d]	Comments
	Cu	No	-	-	-	
	Mn	No	-	-	-	
	B	No	-	-	-	
	Al	No	-	-	-	
	Cl	No	-	-	-	

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.

[b]Nutrients recommended for routine analysis. Other nutrients can be routinely reported even if not specifically recommended. Nutrients left blank were not included in table. Nutrients in survey included P, K, Ca, Mg, Na, S, Fe, Zn, Cu, Mn, B, Al, and Cl.

[c]Method abbreviations: AB-DTPA, Ammonium bicarbonate diethylenetriaminepentaacetic acid; col, colorimetric; DTPA, diethylenetriaminepentaacetic acid; NH_4OAc, Ammonium Acetate. Assume inductively coupled plasma spectroscopy (ICP) unless otherwise noted.

[d]Elemental units unless otherwise specified (i.e., for P, mg kg^{-1} = mg P kg^{-1}). Parts per million (ppm) and mg kg^{-1} are interchangeable. See Table 18 for SI unit conversions.

Table 14a. Goals and objectives of soil health research for each state institution. Responses given in 2020 and 2021 (Question 5.2)

	Goals and objectives of on-going soil health research at each institution						
Region & State[a]	To inform management decisions (e.g., cover cropping, crop rotation, tillage)	To augment routine soil test results to make fertilizer recommendations	Correlation with soil productivity in the absence of fertilization	To identify site-specific limitations	To compare with routine soil test methods for making nutrient management reccommendations	No soil health research being conducted	Other/Notes
NORTH CENTRAL							
Illinois	-	-	-	-	-	-	Assessing how values of soil health indicators change over time and space
Indiana	X	-	-	-	-	-	
Iowa	X	X	X	X	X	-	Field calibration of the weak organic acid test of the Haney Soil Health Tool (offered by many labs in the NC region) for crop production and P loss with surface runoff
Kansas	-	X	-	-	X	-	
Michigan	X	X	-	-	X	-	
Minnesota	X	X	X	X	X	-	To determine if soil health measurements have any validity in crop production
Missouri	X	-	-	-	-	-	
Nebraska	X	-	-	-	-	-	
North Dakota	X	-	-	-	-	-	To evaluate the interaction of soil fertility and soil health. We have an N credit for long-term no-till as a result of N calibration work in corn, spring wheat and sunflower
Ohio	X	X	X	X	-	-	
South Dakota	X	X	-	-	X	-	
Wisconsin	X	X	-	-	X	-	Beginning to evaluate H3A correlation with Bray (lab correlations) and corn/soybean yield response. Other research ongoing to evaluate the ability

Region & State[a]	Goals and objectives of on-going soil health research at each institution: To inform management decisions (e.g., cover cropping, crop rotation, tillage)	To augment routine soil test results to make fertilizer recommendations	Correlation with soil productivity in the absence of fertilization	To identify site-specific limitations	To compare with routine soil test methods for making nutrient management reccommendations	No soil health research being conducted	Other/Notes
							of soil health tests alone or in conjunction with other test and soil properties to improve N recommendations for corn.
NORTHEAST							
Connecticut	-	-	-	-	-	X	
Delaware	X	X	-	X	-	-	
Maine	X	X	-	X	-	-	
Maryland	-	-	-	-	-	X	Some ongoing efforts in the state to look at soil health
Massachusetts	-	-	-	-	-	-	Unknown
New Hampshire	-	-	-	-	-	-	Maintaining or improving organic matter
New Jersey	X	X	X	X	X	-	Government policy impacts farming systems which may impact soil health
New York	X	X	X	X	X	-	
Pennsylvania	X	X	-	-	-	-	
Rhode Island	-	-	-	-	-	X	
Vermont	X	X	-	-	-	-	
West Virginia	X	-	X	X	X	-	Best method to evaluate soil health in the field and in the lab
SOUTHEAST							
Alabama	X	X	X	X	X	-	
Arkansas	-	-	X	-	X	-	
Florida	X	X	-	X	-	-	Identify the parameters that can be indexed to assess soil health for Florida soils, predominantly sands
Georgia	-	-	X	-	-	-	
Kentucky	X	-	-	-	-	-	
Louisiana	X	-	-	-	-	-	

	Goals and objectives of on-going soil health research at each institution						
Region & State[a]	To inform management decisions (e.g., cover cropping, crop rotation, tillage)	To augment routine soil test results to make fertilizer recommendations	Correlation with soil productivity in the absence of fertilization	To identify site-specific limitations	To compare with routine soil test methods for making nutrient management reccommendations	No soil health research being conducted	Other/Notes
Mississippi	X	-	X	X	-	-	
North Carolina	-	-	-	-	-	-	We've done a number of studies that have been published and soil health metrics are variable and are not correlated to yield, soil physical properties, tillage, management, or fertility.
Oklahoma	X	X	-	-	-	-	
Puerto Rico	-	-	-	-	-	-	Soil health research is done on an ad-hoc basis dependent on extramural funds
South Carolina	X	-	X	-	-	-	
Tennessee	X	-	X	-	X	-	
Texas	X	-	-	-	X	-	Methods to determine physical soil health relationships that can be scaled to production soil testing.
Virginia	-	-	-	-	-	-	Soil health research conducted by individual researchers as grant funds obtained
WESTERN							
Arizona	X	-	X	-	-	-	
California	X	-	-	-	-	-	
Colorado	X	X	X	-	-	-	
Hawaii	X	X	X	-	-	-	
Idaho	X	-	-	-	-	-	
Montana	X	-	-	X	-	-	
New Mexico	X	-	-	X	-	-	
Oregon	X	-	-	X	-	-	Most of the soil health work going on now is not directly connected to soil fertility.

	Goals and objectives of on-going soil health research at each institution						
Region & State[a]	To inform management decisions (e.g., cover cropping, crop rotation, tillage)	To augment routine soil test results to make fertilizer recommendations	Correlation with soil productivity in the absence of fertilization	To identify site-specific limitations	To compare with routine soil test methods for making nutrient management reccommendations	No soil health research being conducted	Other/Notes
Utah	X	-	-	-	-	-	Development of proficiency testing samples for soil health analyses
Washington	-	-	-	-	-	-	
Wyoming	X	-	X	X	-	-	To use soil health measurement so assess sustainability of management or restoration practices

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.

Table 14b. Soil health testing availability and recommendations. Responses given in 2020 and 2021 (Questions 5.3 through 5.6)

Region & state[a]	Soil health test offered	Soil health testing recommended	Comments/notes[b]
NORTH CENTRAL			
Illinois	No	No	
Indiana	No	No	
Iowa	No	No	
Kansas	No	No	
Michigan	No	No	
Minnesota	No	No	
Missouri	Yes	Unknown	Soil Health Assessment Center (a separate lab) offers soil health tests
Nebraska	No	No	
North Dakota	No	No	
Ohio	Yes	No	We offer limited soil health testing for research purposes, not to the general public. We are expanding services in 2020.
South Dakota	No	No	
Wisconsin	No	No	
NORTHEASTERN			
Connecticut	No	No	
Delaware	No	No	
Maine	Yes	Yes	Respiration, N-min, SOM/POM, WSA, H_2O capacity. Cover cropping, cover crop species, minimizing tillage, addressing tillage pans.
Maryland	No	No	
Massachusetts	No	No	
New Hampshire	No	Unknown	
New Jersey	Yes	Yes	Solvita as well as field observations by dig, look, and feel. Organic farmers like to document improvements in soil health because it is encouraged by the writing of the organic farm plan. This is a requirement for USDA Organic Certification.
New York	Yes	Yes	http://soilhealth.cals.cornell.edu/
Pennsylvania	No	No	
Rhode Island	No	No	
Vermont	No	No	
West Virginia	No	No	
SOUTHERN			
Alabama	Yes	Yes	Alabama Soil Health Analysis. Mostly a combination of routine and USDA-ARS soil management recommendations
Arkansas	No	No	
Florida	No	No	
Georgia	No	No	
Kentucky	No	No	

Region & state[a]	Soil health test offered	Soil health testing recommended	Comments/notes[b]
Louisiana	No	No	
Mississippi	No	No	
North Carolina	No	No	
Oklahoma	No	No	
Puerto Rico	No	No	
South Carolina	No	No	
Tennessee	No	No	
Texas	No	No	
Virginia	No	No	
WESTERN			
Arizona	No	No	
California	No	No	
Colorado	Yes	Yes	Haney Test, Soil Respiration, Enzymes, POX-C, Wet Aggregate Stability, Available Water Holding Capacity, Total digest for Nutrients and heavy metals. They are currently not being used for management recommendations
Hawaii	No	No	
Idaho	No	No	
Montana	No	Yes	If SOM is low, we recommend replacing fallow with a crop or cover crop. If pH is low, we recommend liming or preventing further acidification by controlling N rates and using more legumes and perennials in rotation. These are examples, we have documents on this topic.
New Mexico	No	Yes	Aggregate stability, water infiltration, and soil compaction are three soil health measures used to make management recommendations.
Oregon	Yes	Unknown	
Utah	No	Yes	Nothing has been formalized [for recommendation].
Washington	-	-	
Wyoming	No	Yes	Labile SOM fractions are used to detect effects of changes in management; total SOM is used to recommend conservation ag practices.

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.

[b]POX-C, permanganate oxidizable carbon; POM, particulate organic matter; SOM, soil organic matter; USDA-ARS, United States Department of Agriculture Agricultural Research Service; WSA, water stable aggregate stability

Table 15. Soil organic matter (SOM) testing as part of routine soil fertility testing, how it is measured, and if and how SOM results are used to modify fertilizer recommendations (rec.). Responses given in 2020 and 2021 (Questions 5.7 through 5.10)

		Method used for SOM determination					
Region & state[a]	Routine SOM test[b]	Loss on ignition	Total C by combustion	Walkley-Black	Other	SOM used to modify fertilizer rec.?	Description of how SOM is used in fertilizer recommendations[c]
NORTH CENTRAL							
Illinois	N/A	-	-	-	-	Yes	N rates adjusted based on SOM content.
Indiana	N/A	-	-	-	-	No	
Iowa	Yes	-	X	-	-	No	
Kansas	Yes	X	-	-	-	Yes	To estimate N and S supply from organic matter mineralization (N and S credits).
Michigan	Yes	X	-	-	-	Yes	Productivity potential is a component within certain nutrient recommendations.
Minnesota	Yes	X	-	-	-	Yes	Sulfur guidelines are adjusted based on SOM, some N guidelines for minor crops SOM is also used.
Missouri	Yes	X	-	-	-	Yes	N credit is calculated based on SOM and soil texture.
Nebraska	Yes	X	-	-	-	Yes	It is used in determining N and S rates for some crops.
North Dakota	Yes	X	-	-	-	Yes	Only if SOM is >6%. 50 lbs N credit for SOM 6-6.9%, 100 lbs N credit for 7-7.9% No soils in ND have greater than 7.9% SOM.
Ohio	N/A	X	-	-	-	No	
South Dakota	Yes	X	-	-	-	No	
Wisconsin	Yes	X	-	-	-	Yes	SOM is used to adjust N recommendations for crops other than corn and wheat. If SOM is greater than 6.0%, then Mn soil test is ineffective and soil pH is used as the basis of Mn recommendations.
NORTHEASTERN							
Connecticut	No	X	-	-	-	No	
Delaware	Yes	X	-	-	-	Yes	Used to adjust lime rates and target pH.
Maine	Yes	X	-	-	-	Yes	Generalized N credit.
Maryland	N/A	-	-	-	-	No	
Massachusetts	No	X	-	-	-	No	
New Hampshire	Yes	X	-	-	-	Yes	Nitrogen credits are calculated based on the %SOM and the crop being grown.

Region & state[a]	Routine SOM test[b]	Method used for SOM determination				SOM used to modify fertilizer rec.?	Description of how SOM is used in fertilizer recommendations[c]
		Loss on ignition	Total C by combustion	Walkley-Black	Other		
New Jersey	No	-	X	-	-	Yes	SOM content is a consideration when making sulfur recommendations.
New York	Yes	X	-	-	-	Yes	Book values of soil N supply are used for corn N recommendations (not the soil test results but soil type specific N supply values). For adjustments, ISNT-N is recommended for corn
Pennsylvania	No	X	-	-	-	No	
Rhode Island	N/A	-	-	-	-	No	
Vermont	Yes	X	-	-	-	No	
West Virginia	No	X	-	-	-	No	
SOUTHERN							
Alabama	Yes	X	-	-	-	No	
Arkansas	No	X	-	-	-	No	
Florida	No	-	X	X	-	No	
Georgia	No	X	-	-	-	No	
Kentucky	No	X	X	-	-	No	Princeton lab uses LOI and Lexington lab uses combustion.
Louisiana	No	-	X	-	-	No	
Mississippi	No	-	X	-	-	No	
North Carolina	Yes	-	-	-	Humic matter by NaOH extraction	Yes	Class soils (mineral, mineral-organic and organic) based on humic matter content. Target pH is based on class. P recommendations are lower for organic-classed soils. Copper recommendations are higher for organic-classed soils.
Oklahoma	No	X	X	-	-	No	Loss on ignition used on calcareous soils.
Puerto Rico	Yes	X	X	-	-	No	
South Carolina	No	X	-	-	-	No	
Tennessee	No	-	X	-	-	No	
Texas	No	-	-	-	Organic C by reduced temp. combustion analyses	No	
Virginia	No	X	-	X	-	No	Loss on ignition or Walkley-Black, depending on the county.

Region & state[a]	Routine SOM test[b]	Method used for SOM determination				SOM used to modify fertilizer rec.?	Description of how SOM is used in fertilizer recommendations[c]
		Loss on ignition	Total C by combustion	Walkley-Black	Other		
WESTERN							
Arizona	N/A	-	X	-	-	No	
California	Unknown	-	-	-	-	-	
Colorado	Yes	-	-	X	-	Yes	Nitrogen Recommendations
Hawaii	No	-	X	-	-	No	
Idaho	Yes	X	-	-	-	Yes	To calculate N mineralization rates in soils.
Montana		-	-	-	-	Yes	Add 15 to 20 lbs N ac^{-1} if 1% SOM or less. Decrease N by 15 to 20 lbs N ac^{-1} if SOM > 3
New Mexico	Yes	-	-	X	-	Yes	Reduces amount of N fertilizer.
Oregon	N/A	-	-	-	-	No	
Utah	No	-	-	X	-	No	
Washington	-	-	-	-	-	-	
Wyoming	-	-	-	-	Organic C	Yes	20 lbs N credited for each 1% SOM.

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.

[b]Is soil organic matter (SOM) a standard measurement included with the routine soil fertility test package? N/A listed for those states without public service laboratories.

[c]ISNT, Illinois soil nitrogen test; See Table 18 for SI unit conversions.

Table 16. Soil sampling procedures for P and K recommendations (rec.) including soil sampling frequency and depth under different management scenarios and crops. Also noted is whether precision sampling recommendations are provided for operations using variable rate fertilizer (VRF) technology. Responses given in 2020 and 2021 (Questions 6.2 through 6.7)

		Tillage-specific sampling depths		Crop-specific sampling depths[b]		
Region & state[a]	Recommended sampling frequency (every *n* years)	Tillage	Lower sampling depth (cm)[c]	Crop	Lower sampling depth (cm)[c]	VRF sampling recommendation
NORTH CENTRAL						
Illinois	2	Unknown	-	Unknown	-	No
Indiana	4	None	-	None	-	Yes
Iowa	2	All	15	None	-	Yes
Kansas	1	All	15	None	-	Unknown
Michigan	3	Conventional-till No-till	20 10	Unknown	-	Unknown
Minnesota	4	All	15	Unknown	-	No
Missouri	4	Conventional-till No-till	18-20 15-18	None	-	Yes
Nebraska	4	All	20	None	-	Yes
North Dakota	1	All	15	None	-	Yes
Ohio	3-4	Conventional-till No-till	20 10, 20[d]	None	-	No
South Dakota	3	All	15	Turfgrass	7.5	No
Wisconsin	4	All	15	None	-	Yes
NORTHEASTERN						
Connecticut	3-5	All	15	None	-	No
Delaware	3	All	15-20	Established alfalfa Turfgrass Established pasture/hay	5-10 5-10 5-10	Yes
Maine	3	Conventional-till No-till	15-20 10-15	Tree fruit Turfgrass Pasture/hay	20-30 7.5-10 6.5-10	No
Maryland	3	All	20	None	-	No
Massachusetts	2	-	-	-	-	No
New Hampshire	2	Conventional-till No-till	20 5	Turfgrass	10	No
New Jersey	2	All	15	None	-	No

Region & state[a]	Recommended sampling frequency (every *n* years)	Tillage-specific sampling depths		Crop-specific sampling depths[b]		VRF sampling recommendation
		Tillage	Lower sampling depth (cm)[c]	Crop	Lower sampling depth (cm)[c]	
New York	3	Conventional-till No-till	20 15	Pasture	15	Yes
Pennsylvania	3	All	20	Turfgrass Pasture/hay	10 10	No
Rhode Island	No specific rec.	-	-	-	-	No
Vermont	1-3 depending on when crop rotation occurs	All	15 or depth of tillage	Pasture/hay	10-15	No
West Virginia	No specific rec.	Conventional-till No-till	15 10	Pasture/hay	5	No
SOUTHERN						
Alabama	2	Conventional-till No-till	15 10	Turfgrass Pasture/hay	7.5 7.5	Yes
Arkansas	No specific rec.	All	10 or 15	Corn Cotton Grain sorghum Vegetables Tree fruit Small fruit Soybean Wheat Rice Alfalfa Turfgrass Pasture/hay	15 15 15 15 15 15 10 10 10 10 10 10	No
Florida	1	Raised beds under plastic	15	None	-	No
Georgia	1	Conventional-till No-till	20 10	Vegetables Tree fruit Small fruit Turfgrass Pasture/hay	15 20 25 10 10	No
Kentucky	1-2 depending on crop/situation	Conventional-till No-till	18 10	Alfalfa Turfgrass	10 10	Yes

Region & state[a]	Recommended sampling frequency (every *n* years)	Tillage-specific sampling depths		Crop-specific sampling depths[b]		VRF sampling recommendation
		Tillage	Lower sampling depth (cm)[c]	Crop	Lower sampling depth (cm)[c]	
				Pasture/hay	10	
Louisiana	2	All	15	Alfalfa	7.5	No
				Turfgrass	7.5	
				Pasture/hay	7.5	
Mississippi	3	Unknown	-	Unknown	-	Yes
North Carolina	3, 2 (sandy soil)	Conventional-till	15	Alfalfa	10	Yes
		No-till	10	Tree fruit	20, 20-40*	
				Established small fruit, turfgrass, pasture/hay	10	
				Small fruit, turfgrass, pasture/hay at establishement	15	
Oklahoma	1	All	15	None	-	No
Puerto Rico	4	All	-	None	-	No
South Carolina	1	All	15-20	Turgrass	5-10	No
				Pasture/hay	5-10	
Tennessee	3	All	15	None	-	No
Texas	1	All	15	None	-	No
Virginia	3-5	Conventional-till	5-10	None	-	No
		No-till	15-20			
WESTERN						
Arizona	No specific rec.	All	-	Unknown	-	Unknown
California	Varies by crop	All	-	Corn	30	No
				Wheat	30	
				Vegetables	15-30	
				Tre fruit	up to 60	
Colorado	No specific rec.	Conventional-till	10	None	-	No
Hawaii	1	Conventional-till	15	Corn	15	Unknown
		No-till	10	Vegetables	10	
				Tree fruit	50	
Idaho	Once every crop rotation	Conventional-till	30	None	-	Yes
		No-till	2.5-30*			
Montana	1	All	15	None	-	Yes

Region & state[a]	Recommended sampling frequency (every *n* years)	Tillage-specific sampling depths: Tillage	Tillage-specific sampling depths: Lower sampling depth (cm)[c]	Crop-specific sampling depths[b]: Crop	Crop-specific sampling depths[b]: Lower sampling depth (cm)[c]	VRF sampling recommendation
New Mexico	1	Conventional-till No-till	30 20	Unknown	-	No
Oregon	Crop-specific	Conventional-till No-till[e]	15-20 5, 5-15 or 5-20*	Corn grain Corn silage Wheat, eastern Oregon Alfalfa Vegetables, no-till Vegetables, tilled Pasture/hay	30 30-60* 30 30 20 30 15-20	No
Utah	2	All	30	Vegetables Turfgrass	20 15	No
Washington	-	-	-	-	-	-
Wyoming	No specific rec.	All	-	None	-	Unknown

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.

[b]Refer to tillage-specific sampling depths for crops not listed.

[c]Upper sampling depths are from the surface (0 cm) unless noted by *. Originally reported in inches, converted to centimeters.

[d]Ohio: Both 0-10 cm and 0-20 cm depths recommended to assess stratification

[e]Oregon: If fertilized within 2-3 years, recommend split samples 0- to 5-cm and 5- to 15 or 20-cm. If a no-till field has not been fertilized for 2-3 years, stratified sampling not recommended.

Table 17. Laboratory soil sub-sample preparation for routine P and K extraction. Separate rows for P and K denote differences in method. Responses given in 2020 and 2021 (Questions 8.3 through 8.15)

Region & state[a]	Nutrient	Scoop volume (cm^3)[b]	Sub-sample weight (g)	Scoop density	Assumed scoop density (g/cm^3)	Density reported to clients?	Extractant volume (mL)	Same extraction for P and K?	Notes
NORTH CENTRAL									
Illinois	-	-	-	-	-	-	-	-	
Indiana	P K	Unknown	-	Unknown	-	-	Unknown	Yes	No public lab.
Iowa	P K	1.70	-	Assumed	Other	-	Other	Yes	Recommend NCERA-13 methods
Kansas	P	Unknown	-	Assumed	Unknown	-	Unknown	Unknown	
Michigan	P	1.70	-	Unknown	-	-	Unknown	Unknown	
Minnesota	P K	1.70	-	Assumed	1.18	-	10	Yes	
Missouri	P K	1.70	-	Assumed	1.18	No	20	No	
Nebraska	P	1.70	-	Assumed	1.18	-	Other	No	
	K	Other	-	Unknown	-	-	Other		
North Dakota	P	1.70	-	Assumed	1.18	-	25	No	
	K	1.70	-	Assumed	1.18	No	20		
Ohio	P K	1.70	-	Assumed	1.18	-	20	Yes	
South Dakota	P	1.70	-	Unknown	1.18	No	20	No	
	K	1.70	-	Assumed	1.18	No	10	No	
Wisconsin	P K	Unknown	-	Weighed	-	No	15	Yes	Scoops are calibrated to measure 1.5 grams of a silt loam soil
NORTHEASTERN									
Connecticut	P	4.00	-	Assumed	1.00	-	20	Yes	
Delaware	P	1.00	-	Assumed	Unknown	-	10	Yes	
Maine	P	4.00	-	Weighed	-	No	20	Yes	
Maryland	P	Unknown	-	Unknown	-	-	Unknown	Yes	.
Massachusetts	P K	5.00	-	Weighed	-	Yes	25	Yes	
New Hampshire	P K	1.70	-	Assumed	1.18	-	20	Yes	
New Jersey	P	2.50	-	Unknown	-	-	25	Yes	
New York	P K	4.00	-	Weighed	-	No	20	Yes	
Pennsylvania	P K	1.70	-	Assumed	1.18	-	20	Yes	
Rhode Island	P	Unknown	-	Unknown	-	-	Unknown	-	
Vermont	P K	4.00	-	Assumed	Other	-	20	Yes	
West Virginia	P K	2.50	-	Assumed	1.10	-	25	Yes	
SOUTHERN									
Alabama	P K	NS	5	Weighed	-	No	20	Yes	

Region & state[a]	Nutrient	Scoop volume (cm^3)[b]	Sub-sample weight (g)	Scoop density	Assumed scoop density (g/cm^3)	Density reported to clients?	Extractant volume (mL)	Same extraction for P and K?	Notes
Arkansas	P K	1.70	-	Assumed	1.18	-	20	Yes	
Florida	P K	2.50	-	Assumed	1.30	-	25	Yes	
Georgia	P K	4.00	-	Assumed	1.25	-	20	Yes	
Kentucky	P K	2.00	-	Assumed	1.00	-	20	Yes	
Louisiana	P K	2.00	-	Weighed	-	No	20	Yes	
Mississippi	P K	NS	5	Weighed	-	No	25	Yes	
North Carolina	P K	2.50	-	Vol basis	-	Yes	25	Yes	Scoop density expressed on a volume basis (e.g., mg cm^{-3}). Index can be converted to mg dm^{-3} or mg kg^{-1} based on density
Oklahoma	P K	1.70	-	Assumed	1.18	-	20	Yes	
Puerto Rico	-	Unknown	-	Unknown	-	-	Unknown	Unknown	
South Carolina	P K	4.00	-	Assumed	1.25	-	20	Yes	
Tennessee	P K	4.25	-	Assumed	1.18	-	20	Yes	
Texas	P K	1.70	-	Assumed	1.18	-	20	Yes	
Virginia	P K	4.00	-	Assumed	1.25	-	20	Yes	
WESTERN									
Arizona	-	Unknown	-	Unknown	-	-	Unknown	Unknown	
California	P K	Unknown	-	Unknown	-	-	Unknown	No	
Colorado	P K	NS	10	Weighed	-	No	20	Yes	
Hawaii	P	NS	5	Assumed	1.10	-	50	No	
	K	NS	5	Assumed	1.10	No	25		
Idaho	P K	NS	Unknown	Unknown	-	-	Unknown	Yes	
Montana	P	NS	5	Weighed	-	-	Unknown	No	
	K	NS	Unknown	-	-	-	Unknown		
New Mexico	P K	Unknown	-	Unknown	-	-	Unknown	No	
Oregon	-	Unknown	-	Unknown	-	-	Unknown	Unknown	
Utah	P K	NS	2	Weighed	-	No	40	Yes	
Washington	-	-	-	-	-	-	-	-	
Wyoming	P	NS	10	Weighed	-	Unknown	Unknown	Unknown	

[a]Regions defined by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). No representatives from Alaska or Nevada were available to complete the survey.

[b]NS: Samples are not scooped, only weighed

Table 18. International System of Units (SI) conversion factors

Convert		*To*		*Multiply by*	
Unit	Symbol	Unit	Symbol		Notes
feet	ft	meters	m	0.3048	
inches	in	centimeters	cm	2.54	
percent	%	grams per kilogram	g kg^{-1}	10	
hundredweight	cwt	kilograms	kg	50.8023	
tons	tons	kilograms	kg		
pounds	lbs	kilograms	kg		
acres	ac	hectares	ha		
parts per million	ppm	miligrams per kilogram	mg kg^{-1}	1	
milliequivalents per 100 grams	meq 100 g^{-1}	centimole per kilogram	cmol kg^{-1}	1	
pounds per acre	lbs ac^{-1}	miligrams per kilogram	mg kg^{-1}	0.5	
pounds per acre	lbs ac^{-1}	kilograms per hectare	kg ha^{-1}	1.12085	
pounds P_2O_5 per acre	lbs P_2O_5 ac^{-1}	kilograms P per hectare	kg P ha^{-1}	0.48925	
pounds K_2O per acre	lbs K_2O ac^{-1}	kilograms K per hectare	kg K ha^{-1}	0.9304	
tons per acre	tons ac^{-1}	kilograms per hectare	kg ha^{-1}	2241.7	
Barley: bushels per acre	bu ac^{-1}	kilograms per hectare	kg ha^{-1}	53.8	Assume 1 bu barley = 48 lbs
Corn grain: bushels per acre	bu ac^{-1}	kilograms per hectare	kg ha^{-1}	62.7676	Assume 1 bu corn = 56 lbs
Millet: bushels per acre	bu ac^{-1}	kilograms per hectare	kg ha^{-1}	56.0425	Assume 1 bu millet = 50 lbs
Oats: bushels per acre	bu ac^{-1}	kilograms per hectare	kg ha^{-1}	35.8672	Assume 1 bu oats = 32 lbs
Soybean: bushels per acre	bu ac^{-1}	kilograms per hectare	kg ha^{-1}	67.251	Assume 1 bu soybean = 60 lbs
Wheat: bushels per acre	bu ac^{-1}	kilograms per hectare	kg ha^{-1}	67.251	Assume 1 bu wheat = 60 lbs