



Evaluation of **R**ates
and **M**ethods of **A**pplication
of **P** and **K**
in a **C**onservation **T**illage **S**ystem

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Evaluation of Rates and Methods of P and K Application in a Conservation Tillage System

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Abstract

Farm managers face a tremendous challenge in maintaining productivity of crops while reducing soil losses by erosion. One option they can consider is conservation tillage, which leaves some plant residue on the soil surface. Surface applications of phosphorus (P) and potassium (K) under conditions where the soil is not disturbed may change soil sampling procedures and fertilizer recommendations. This study was undertaken to evaluate P and K applications in a conservation tillage system. Experiments were conducted at four Mississippi locations from 1990 to 1994. P and K were applied to the soil surface or subsurface banded in no-till (NT) and conventional-tilled (CT) systems. Yield responses from P and K applications were obtained at two of four locations. A response was obtained with no-till more often than with conventional tillage. Where yield responses were obtained, surface applications of P and K produced higher yields than in-soil placement. Yields with no-till were lower at two locations, higher at one location, and not different from conventional tillage at the fourth location. P and K applications increased foliar K concentrations more consistently than foliar P concentrations. Extractable P and K in the 0- to 6-inch layer correlated better or as well with yield as in the 0- to 2-inch layer. At present, there are insufficient data to suggest changing the traditional method of collecting soil samples (0- to 6-inch depth) in no-till systems.

Introduction

One of the major challenges faced by farm managers is that of conserving soil resources while maintaining or increasing production of crops. Soil losses from cultivatable land in Mississippi are in excess of 8 tons per acre per year. Provisions of the 1985 Food Security Act force producers to retire many acres from production unless some means of erosion control is adopted.

Conservation tillage practices, which leave some surface residue, are currently being used instead of conventional clean tillage on many acres. Schertz (5) projected that conservation tillage would be used on 63 to 83% of the planted cropland in the United States by the year 2010. Gebhardt et al. (2) predicted that more than 50% of the cropland would be in conservation tillage by 2000.

In Mississippi, there were approximately 940,000 acres in conservation tillage in 1994. Of these, approximately 580,000 acres were no-till (Larry Golden, personal communication). This practice will likely continue in the future. While these practices reduce erosion losses, little information is available on the proper method of assessing P and K placement and availability of these nutrients under conditions where the soil is not disturbed.

In conservation tillage systems, mixing of the soil and subsequent vertical mixing of surface-applied P and K are

reduced. A major proportion of applied P remains in the 0- to 2-inch zone as inorganic P (5). Hergert (3) found that surface-applied P was retained in the top 6 inches on soils that varied from clay to sand in texture. Lauer (4) reported that most P from fertilizer remained within the top 2 to 3 inches of the surface under no-tillage systems. Long-term studies on Alfisols demonstrated that nutrients remained near the surface because of the lack of physical incorporation under no-till compared to conventional-till management systems (1).

Since P does not move appreciably in soils and K moves only slightly, these nutrients, when surface-applied, could accumulate near the soil surface and become positionally unavailable, especially as the soil surface dries out (4).

Our current practice of collecting soil samples from the 0- to 6-inch depth is well-defined for conventional-tilled soils, but may not be applicable to situations where no primary tillage is used. Soil nutrient concentrations required for optimum yields and soil test calibration and recommendations should be evaluated under conservation tillage systems to promote the most judicious use of fertilizers.

The objectives of the study summarized in this bulletin were to: (1) evaluate methods of P and K application in no-tillage systems; (2) evaluate the vertical distribution of surface applied P and K as affected by time; and (3) correlate method of soil sample collection with P and K availability as measured by yield and tissue P and K concentrations.

Materials and Methods

Field studies were conducted from 1990 to 1994 at four locations in Mississippi. Locations and respective soil types were: North Mississippi Branch Station, Grenada silt loam (Glossic Fragiudalf, fine-silty, mixed, thermic); Northeast Mississippi Branch Station, Leeper silty clay loam (Vertic Haplaquept, fine, montmorillonitic, nonacid, thermic); Black Belt Branch Station, Brooksville silty clay (Aquic Chromudert, fine, montmorillonitic, thermic); and Coastal Plain Branch Station, Shubuta fine sandy loam (Typic Paleudult, clayey, mixed, thermic). Selected physical and chemical properties are shown in Table 1.

Extractable P and K were determined by the Mississippi Soil Test method. Cation exchange capacity (CEC) was determined by summation of extractable bases plus hydrogen.

The experimental design was a 2 x 9 factorial treatment arrangement in a split plot design with four replications. Main plots were no-tillage and conventional tillage. In no-tilled plots, all residue from harvesting was left on the soil surface. Soil in these plots was not disturbed except for planting. Conventional tillage was the usual tillage practice followed by the respective experiment stations (disked one or two times, do-alled, beds formed, and cultivated as needed for weed control).

Subplots were rate and placement of P and K. Individual plots were four rows wide and either 30 or 40 feet long with 10 feet between blocks. P and K were applied jointly at 0, 1/2, 1, and 1 1/2 times the soil test recommendation for the respective soils. Actual rates of P and K expressed as pounds of P₂O₅ and K₂O per acre are shown in the data tables. All treatments were dry fertilizer applied either surface broadcast or subsurface banded (4 inches deep with no-till coulters knives).

Two additional treatments, P and K surface banded at 1 and 1 1/2 times the soil test recommendation were included. Both surface band and in-soil treatments were applied approximately 2 inches to the side of the drill.

Soybeans were planted at the Black Belt and Northeast Mississippi Branch Stations, cotton was planted at the North Mississippi Branch Station, and corn was planted at the Coastal

Plain Branch Station. Recommended rates of N were applied to the cotton and corn. Recommended practices for weed, disease, and insect control were used.

At early bloom, 10 recently matured cotton leaves were collected from the inside two rows of each plot. For soybeans, 10 recently matured trifoliates were collected from each plot. For corn, 10 corn ear leaves were collected from each plot when plants were in early stages of tasseling. Samples were oven-dried at 75 °C for 24 hours, ground to pass a 20-mesh sieve, and stored for chemical analyses.

Immediately after harvest, soil samples were collected from the control and plots receiving surface applications of P and K. Samples were collected from the 0- to 2-inch and 2- to 6-inch depths. A weighted average of these data was used to determine the values for the 0- to 6-inch depth. All samples were air-dried and sieved for P and K determinations.

Foliar P concentrations were determined colorimetrically and K concentrations were determined by atomic absorption. Soil P and K concentrations were determined by Mississippi Soil Test and Mehlich-3 methods. Mehlich-3 analyses were included to compare extraction methods for different soil types. Yields were determined by machine harvesting the center two rows of each plot and converting to pounds or bushels per acre as appropriate.

All data were subjected to analysis of variance. Where a significant response was obtained from P and K application, orthogonal contrasts were used to evaluate methods of application. At locations where a yield response to P and K applications was observed, soil analyses were correlated with yield and foliar concentrations of P and K to determine the most precise method of collecting soil samples under conservation tillage practices.

At most locations, year significantly interacted with treatments. It is statistically incorrect to evaluate overall means when there is a significant interaction between factors; however, producers are more interested in long-term effects than in what happens in a given year. Therefore, discussions are based on overall averages.

Data for individual years and locations are shown in the Appendix tables. Since P and K response data have been collected in conventional tillage for many years, this discussion will focus primarily on results with no-till.

Table 1. Selected physical and chemical properties of soils involved in this study.

Branch Sta.	Soil series	Texture	pH	Organic matter	P		K		CEC
					lb/a	cmol kg ⁻¹	lb/a	cmol kg ⁻¹	
North MS	Grenada	sil	6.7	1.1	184	328	11		
Northeast MS	Leeper	sicl	8.0	2.0	158	222	36		
Black Belt	Brooksville	sic	8.0	3.1	18	172	52		
Coastal Pl	Shubuta	fsl	6.5	1.4	134	192	10		

sil - silt loam

sicl - silty clay loam

sic - silty clay

fsl - fine sandy loam

Results and Discussion

Because of adverse environmental conditions, data were not collected for all years at all locations. Since soil type and indicator crops were different for most locations, each location will be discussed separately.

North Mississippi Branch Station

Cotton yields and foliar P concentrations were higher with no-till, but were not affected by P and K applications (Table

Table 2. Average response of seed cotton to tillage and P and K rates and placement. North MS Branch, 1990, 1992-94.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a	----- lb/a -----		--- %P ---		--- %K ---	
0-0-0	1,539	1,464	0.50	0.47	1.20	1.09
0-15-15 in-soil	1,683	1,323	0.48	0.48	1.34	1.20
0-30-30 in-soil	1,796	1,385	0.51	0.47	1.16	1.18
0-45-45 in-soil	1,654	1,526	0.50	0.48	1.29	1.27
0-30-30 surf band	1,767	1,560	0.50	0.47	1.53	1.28
0-45-45 surf band	1,757	1,552	0.48	0.46	1.39	1.40
0-15-15 surf b'cast	1,658	1,568	0.49	0.47	1.15	1.18
0-30-30 surf b'cast	1,692	1,534	0.50	0.46	1.44	1.32
0-45-45 surf b'cast	1,697	1,706	0.49	0.47	1.54	1.35
Average	1,694	1,513	0.49	0.47	1.34	1.25
C.V. %	20.1		10.0		20.0	
L.S.D. _{0.05} tillage	75		0.02		ns	
L.S.D. _{0.05} fertilizer within tillage across years	ns		ns		0.18	

2). Foliar K concentrations were not affected by tillage, but were higher for both tillage systems when K was applied to the soil surface. There were no differences between surface band and surface broadcast applications. Foliar P concentrations were sufficient, but foliar K concentrations were below the sufficiency range given by Small and Ohlrogge (7).

Extractable P and K concentrations for no-till are shown in Tables 3 and 4 (data for conventional tillage are in Appendix Tables 5 and 6). These are presented by year and sampling depth to evaluate surface buildup and downward movement with time. It is evident that P and K did not move downward or accumulate in the 0- to 2-inch layer during the duration of this study. Extractable P and K in the 0- to 2-inch layer reflected rate of application when applied surface broadcast. The same trend is seen in the 0- to 6-inch depth because concentrations in the 0- to 2-inch layer were used in calculating the 0- to 6-inch concentrations.

An accurate measure of soil P and K effects from banded fertilizer is difficult because of sampling problems. Variability exists depending on the number of samples collected in the band as compared to outside the band. This is further confounded when the exact location of the band is not known.

At the beginning of the study, extractable P and K were high as determined by the Mississippi Soil Test. Both decreased in the check plots with time and extractable K was medium by the end of the study.

There was a high coefficient of correlation ($r = 0.99^{**}$) between the Mississippi Soil Test and Mehlich-3 extractions, and both procedures extracted similar magnitudes of P and K. When there are no yield responses to P and K application, little or no correlation would be expected between yield

Table 3. Mississippi Soil Test and Mehlich-3 extractable P, no-till. North MS Branch, 1990, 1992-1994.

Treatment and depth	1990	1992	1993	1994	avg.
N-P ₂ O ₅ -K ₂ O, lb/a	----- ppm P -----				
0 to 2 inches					
0-0-0	104 (83)	93 (79)	84 (75)	75 (78)	89 (79)
0-30-30 surf band	122 (102)	116 (106)	111 (116)	116 (124)	116 (112)
0-45-45 surf band	112 (98)	109 (97)	120 (120)	111 (123)	113 (110)
0-15-15 surf b'cast	101 (82)	100 (84)	92 (91)	89 (94)	96 (88)
0-30-30 surf b'cast	103 (75)	101 (87)	94 (100)	101 (103)	100 (91)
0-45-45 surf b'cast	105 (93)	113 (101)	120 (119)	114 (123)	113 (109)
2 to 6 inches					
0-0-0	86 (66)	65 (49)	55 (48)	43 (41)	62 (51)
0-30-30 surf band	84 (64)	73 (54)	61 (57)	57 (57)	69 (58)
0-45-45 surf band	77 (56)	63 (44)	60 (53)	53 (49)	63 (50)
0-15-15 surf b'cast	76 (59)	56 (40)	51 (44)	44 (42)	57 (46)
0-30-30 surf b'cast	75 (53)	63 (65)	50 (43)	51 (46)	60 (52)
0-45-45 surf b'cast	84 (67)	63 (52)	55 (48)	51 (49)	63 (54)
0 to 6 inches					
0-0-0	92 (72)	74 (59)	65 (57)	54 (53)	71 (60)
0-30-30 surf band	97 (77)	87 (71)	78 (77)	77 (79)	85 (76)
0-45-45 surf band	89 (70)	78 (62)	80 (75)	72 (74)	80 (70)
0-15-15 surf b'cast	84 (67)	71 (55)	65 (60)	59 (59)	70 (60)
0-30-30 surf b'cast	84 (60)	76 (72)	65 (62)	68 (65)	73 (65)
0-45-45 surf b'cast	91 (76)	80 (68)	77 (72)	72 (74)	80 (72)

Note: Numbers in parentheses are for Mehlich-3 extraction.

Table 4. Mississippi Soil Test and Mehlich-3 extractable K, no-till. North MS, 1990, 1992-1994.

Treatment and depth	1990	1992	1993	1994	avg.
N-P ₂ O ₅ -K ₂ O, lb/a ----- ppm K -----					
<i>0 to 2 inches</i>					
0-0-0	225(205)	161 (164)	149 (155)	152 (169)	172 (173)
0-30-30 surf band	282(264)	229(233)	225(227)	226(238)	240(240)
0-45-45 surf band	255(234)	198 (199)	200 (201)	215 (231)	217 (216)
0-15-15 surf b'cast	216(204)	176 (177)	170 (186)	179 (194)	185 (190)
0-30-30 surf b'cast	239 (218)	202 (198)	191 (194)	193 (212)	206(206)
0-45-45 surf b'cast	239(222)	211 (211)	206 (201)	209(226)	216 (215)
<i>2 to 6 inches</i>					
0-0-0	134 (129)	94 (93)	89 (92)	74 (88)	98 (100)
0-30-30 surf band	160 (142)	122 (119)	128 (128)	123 (137)	133 (132)
0-45-45 surf band	135 (128)	106 (105)	118 (122)	97 (113)	114 (117)
0-15-15 surf b'cast	132 (177)	99 (95)	95 (102)	91 (103)	104 (119)
0-30-30 surf b'cast	142 (130)	102 (103)	102 (106)	95 (109)	110 (112)
0-45-45 surf b'cast	143 (140)	108 (104)	110 (121)	102 (114)	116 (120)
<i>0 to 6 inches</i>					
0-0-0	164 (154)	116 (117)	109 (113)	100 (115)	122 (125)
0-30-30 surf band	201 (183)	158 (157)	160 (161)	157 (171)	169 (168)
0-45-45 surf band	175 (163)	137 (136)	145 (148)	136 (152)	148 (150)
0-15-15 surf b'cast	160 (186)	125 (122)	120 (130)	120 (133)	131 (143)
0-30-30 surf b'cast	174 (159)	135 (135)	132 (135)	128 (143)	142 (143)
0-45-45 surf b'cast	175 (167)	142 (140)	142 (148)	138 (151)	149 (152)

Note: Numbers in parentheses are for Mehlich-3 extraction.

and extractable P or K. Under these conditions, depth of soil sample collection cannot be evaluated. In this study, the coefficients of correlation between extractable P and K and yield ranged from 0.1 to 0.3.

Northeast Mississippi Branch Station

Soybean yields were higher with conventional tillage, but tillage did not affect foliar P and K concentrations (Table 5).

Table 5. Average response of soybeans to tillage and P and K rates and placement. Northeast Branch, 1991-1994.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a ----- bu/a ----- %P ----- %K -----						
0-0-0	22	29	0.50	0.48	1.41	1.53
0-15-15 in-soil	23	29	0.50	0.48	1.48	1.52
0-30-30 in-soil	24	28	0.50	0.49	1.55	1.68
0-45-45 in-soil	26	29	0.49	0.50	1.50	1.58
0-30-30 surf band	28	29	0.50	0.50	1.57	1.50
0-45-45 surf band	31	31	0.49	0.48	1.65	1.57
0-15-15 surf b'cast	22	28	0.49	0.49	1.45	1.56
0-30-30 surf b'cast	29	29	0.48	0.49	1.70	1.54
0-45-45 surf b'cast	24	28	0.49	0.48	1.48	1.48
Average	25	29	0.49	0.49	1.53	1.55
C.V. %		18.3		6.2		16.6
L.S.D. _{0.05} tillage		1		ns		ns
L.S.D. _{0.05} fertilizer within tillage across years		3		ns		0.14

There was a yield response to P and K applications with no-till but not with conventional tillage. When P and K were applied as a surface band, yields were higher than when they were applied surface broadcast or as a subsurface band.

P and K applications did not affect foliar P concentrations but increased foliar K concentrations in no-till. There were no differences in foliar concentrations attributed to P and K placement.

This soil was high in P and medium in K as determined by the Mississippi Soil Test. Foliar P concentrations were adequate but foliar K concentrations were below the sufficiency range given by Small and Ohlrogge (7).

Extractable P and K concentrations for no-till are given in Tables 6 and 7 (data for conventional tillage are in Appendix Tables 11 and 12). There was a high coefficient of correlation between the Mississippi Soil Test and Mehlich-3 extractions ($r = 0.78^{**}$ for P and 0.97^{**} for K, Tables 8 and 9); however, Mehlich-3 extracted 56% as much P and 91% as much K as the Mississippi Soil Test method. According to current calibration, Mehlich-3 extractions could result in considerably more P being recommended on this soil type. Although not an objective of this study, it was obvious that Mehlich-3 could not be used to extract P on this soil without a different calibration.

Extractable P in the 0- to 2-inch depth appeared to be considerably higher in 1993 than in 1992; however, extractable P increased by approximately the same amount in the 2 to 6 inch layer. This is probably because of year-to-year variations. There was no downward movement or accumulation

Table 6. Mississippi Soil Test and Mehlich-3 extractable P, no-till. Northeast Branch, 1991-1993.

Treatment and depth	1991	1992	1993	avg.
N-P ₂ O ₅ -K ₂ O, lb/a ppm P				
<i>0 to 2 inches</i>				
0-0-0	91 (54)	86 (52)	99 (51)	92 (52)
0-30-30 surf band	98 (60)	85 (62)	113 (65)	99 (62)
0-45-45 surf band	101 (63)	102 (74)	135 (82)	113 (73)
0-15-15 surf b'cast	78 (44)	77 (50)	102 (56)	86 (50)
0-30-30 surf b'cast	108 (58)	96 (67)	116 (63)	107 (63)
0-45-45 surf b'cast	98 (56)	94 (67)	132 (73)	108 (65)
<i>2 to 6 inches</i>				
0-0-0	73 (38)	64 (38)	82 (35)	73 (37)
0-30-30 surf band	71 (40)	59 (39)	76 (37)	69 (39)
0-45-45 surf band	78 (40)	64 (42)	86 (39)	76 (40)
0-15-15 surf b'cast	57 (30)	44 (29)	64 (29)	55 (29)
0-30-30 surf b'cast	82 (40)	64 (38)	74 (31)	73 (36)
0-45-45 surf b'cast	66 (35)	62 (36)	72 (29)	67 (33)
<i>0 to 6 inches</i>				
0-0-0	79 (43)	71 (43)	88 (40)	79 (42)
0-30-30 surf band	80 (47)	68 (47)	88 (46)	79 (47)
0-45-45 surf band	86 (48)	77 (53)	102 (53)	88 (51)
0-15-15 surf b'cast	64 (35)	55 (36)	77 (38)	65 (36)
0-30-30 surf b'cast	91 (46)	75 (48)	88 (42)	85 (45)
0-45-45 surf b'cast	77 (42)	73 (46)	92 (44)	81 (44)

Note: Numbers in parenthesis are for Mehlich-3 extraction.

Table 7. Mississippi Soil Test and Mehlich-3 extractable K, no-till. Northeast Branch, 1991-1993.

Treatment and depth	1991	1992	1993	avg.
N-P ₂ O ₅ -K ₂ O, lb/a ppm K				
<i>0 to 2 inches</i>				
0-0-0	134 (109)	134 (115)	129 (132)	132 (119)
0-30-30 surf band	141 (121)	145 (125)	146 (150)	144 (132)
0-45-45 surf band	149 (124)	152 (132)	165 (162)	155 (139)
0-15-15 surf b'cast	123 (100)	127 (106)	137 (140)	129 (115)
0-30-30 surf b'cast	167 (145)	169 (141)	162 (159)	166 (148)
0-45-45 surf b'cast	136 (108)	144 (118)	148 (152)	143 (126)
<i>2 to 6 inches</i>				
0-0-0	99 (82)	104 (91)	102 (109)	101 (94)
0-30-30 surf band	99 (79)	103 (93)	94 (104)	99 (92)
0-45-45 surf band	102 (80)	111 (98)	102 (112)	105 (97)
0-15-15 surf b'cast	91 (69)	95 (81)	94 (104)	93 (85)
0-30-30 surf b'cast	121 (101)	120 (100)	108 (114)	116 (105)
0-45-45 surf b'cast	94 (76)	99 (89)	94 (104)	96 (90)
<i>0 to 6 inches</i>				
0-0-0	111 (91)	114 (99)	111 (117)	112 (102)
0-30-30 surf band	113 (93)	117 (104)	111 (119)	114 (105)
0-45-45 surf band	118 (95)	125 (109)	123 (129)	122 (111)
0-15-15 surf b'cast	102 (79)	106 (89)	108 (116)	105 (95)
0-30-30 surf b'cast	136 (116)	136 (114)	126 (129)	133 (120)
0-45-45 surf b'cast	108 (87)	114 (99)	112 (120)	111 (102)

Note: Numbers in parenthesis are for Mehlich-3 extraction.

Table 8. Coefficients of correlation (r) between extractants, depth, foliar P concentration, and yield. Northeast Branch.

	MST02 ¹	MST06 ²	M302 ³	M306 ⁴	%P	Yield
MST02		0.93**	0.77**	0.78**	-0.11	0.36
MST06			0.62**	0.79**	0.003	0.29
M302				0.89**	-0.31	0.45*
M306					-0.12	0.38
%P						-0.14
Yield						

¹Mississippi Soil Test, 0- to 2-inch depth.

² Mississippi Soil Test, 0- to 6-inch depth.

³ Mehlich-3, 0- to 2-inch depth.

⁴ Mehlich-3, 0- to 6-inch depth.

*, ** significantly different from zero at the 0.05 and 0.01 levels of probability, respectively.

of P or K with time. Extractable P and K tended to reflect rate of application.

Although Mehlich-3 extracted only 56% as much P as the Mississippi Soil Test, Mehlich-3 extractable P in the 0- to 2-inch layer was the only measurement that correlated significantly with yield ($r = 0.45^*$). There was no correlation between extractable P and foliar P concentration. Extractable K correlated well with yield and foliar K concentration (Table 9). Extractable K in the 0- to 2-inch layer correlated slightly better than the 0- to 6-inch layer. These differences are not sufficient to justify changing sampling methods.

Black Belt Branch Station

Soybean yields and foliar K concentrations were significantly higher with conventional tillage (Table 10). Tillage did not affect foliar P concentrations. Phosphorus and K applications significantly increased yields and foliar P and K concentrations in both tillage systems. Yields and foliar P concentrations were not affected by P and K placement. Foliar

Table 9. Coefficients of correlation (r) between extractants, depth, foliar K concentration, and yield. Northeast Branch.

	MST02 ¹	MST06 ²	M302 ³	M306 ⁴	%P	Yield
MST02		0.93**	0.98**	0.88**	0.81**	0.71**
MST06			0.93**	0.96**	0.74**	0.65**
M302				0.91**	0.81**	0.72**
M306					0.77**	0.65**
%K						0.58**
Yield						

¹ Mississippi Soil Test, 0- to 2-inch depth.

² Mississippi Soil Test, 0- to 6-inch depth.

³ Mehlich-3, 0- to 2-inch depth.

⁴ Mehlich-3, 0- to 6-inch depth.

** significantly different from zero at the 0.01 level of probability.

K concentrations in both tillage systems were higher when P and K were applied as a subsurface band.

Extractable P and K concentrations with no-till are given in Tables 11 and 12 (data for conventional tillage are in Appendix Tables 16 and 17). Mehlich-3 extracted 36% as much P and 113% as much K as the Mississippi Soil Test. It is evident that Mehlich-3 would not be suitable for P extraction in this soil without recalibrating response data. P and K did not accumulate in the 0- to 2-inch layer or move downward during this study.

Because of inclement weather, soil samples were not collected every year that yields and foliar P and K concentrations were measured. Data for years when all measurements were made were correlated and are presented in Tables 13 and 14. Yields and foliar P concentrations were highly correlated with extractable P in the 0- to 6-inch layer but not in the 0- to 2-inch layer, yet foliar P concentrations were as high when P and K were applied to the soil surface as when they were subsurface banded.

The close correlation between foliar P concentration and yield ($r = 0.79^{**}$) is surprising since all foliar P concentrations were within the sufficiency range given by Small and Ohrogge (7). There was a very high correlation ($r = 0.99^{**}$) between the amounts of K extracted by both methods. Extractable K from the 0- to 2-inch and 0- to 6-inch depth correlated well with foliar K concentrations; however, extractable K in the 0- to 6-inch layer correlated better with yields.

Coastal Plain Branch Station

Tillage and P and K applications did not affect corn yields or foliar P concentrations (Table 15). Foliar K concentrations were higher with no-till. P and K applications did not affect foliar K concentrations with conventional tillage and increased foliar concentration for only one treatment with no-till. Foliar

Table 10. Average response of soybeans to tillage and P and K rates and placement. Black Belt Branch, 1990, 1992, 1994.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a	bu/a		%P		%K	
0-0-0	22	29	0.36	0.35	1.34	1.46
0-45-45 in-soil	29	33	0.39	0.38	1.72	1.81
0-90-90 in-soil	30	34	0.43	0.42	1.84	2.00
0-135-135 in-soil	32	34	0.42	0.43	1.92	2.12
0-90-90 surf band	29	34	0.40	0.41	1.60	1.75
0-135-135 surf band	31	37	0.43	0.41	1.78	1.86
0-45-45 surf b'cast	28	34	0.39	0.38	1.50	1.70
0-90-90 surf b'cast	29	35	0.44	0.42	1.70	1.76
0-135-135 surf b'cast	30	36	0.41	0.44	1.91	1.89
Average	29	34	0.41	0.40	1.70	1.82
C.V. %		16.2		12.8		13.6
L.S.D. _{0.05} tillage		2		ns		0.10
L.S.D. _{0.05} fertilizer within tillage						
across years		4		0.02		0.18

Table 11. Mississippi Soil Test and Mehlich-3 extractable P, no-till. Black Belt Branch, 1990-1993.

Treatment and depth	1990	1992	1993	1994	avg.
N-P ₂ O ₅ -K ₂ O, lb/a ----- ppm P -----					
<i>0 to 2 inches</i>					
0-0-0	13 (2)	15 (3)	14 (3)	14 (7)	14 (4)
0-90-90 surf band	22 (7)	19 (10)	29 (12)	18 (9)	22 (10)
0-135-135 surf band	22 (8)	15 (5)	32 (12)	22 (17)	23 (10)
0-45-45 surf b'cast	22 (7)	20 (6)	21 (6)	21 (12)	21 (8)
0-90-90 surf b'cast	33 (16)	24 (10)	34 (16)	32 (19)	31 (15)
0-135-135 surf b'cast	22 (10)	24 (10)	38 (16)	26 (11)	28 (12)
<i>2 to 6 inches</i>					
0-0-0	7 (1)	5 (1)	8 (2)	3 (1)	6 (1)
0-90-90 surf band	8 (1)	6 (1)	7 (2)	6 (1)	7 (1)
0-135-135 surf band	7 (2)	4 (1)	7 (2)	5 (2)	6 (2)
0-45-45 surf b'cast	8 (2)	8 (1)	6 (3)	4 (2)	6 (2)
0-90-90 surf b'cast	7 (2)	6 (1)	8 (1)	6 (2)	7 (2)
0-135-135 surf b'cast	7 (3)	5 (0)	8 (2)	6 (4)	6 (2)
<i>0 to 6 inches</i>					
0-0-0	9 (1)	8 (2)	10 (2)	7 (3)	8 (2)
0-90-90 surf band	13 (3)	10 (4)	14 (5)	10 (4)	12 (4)
0-135-135 surf band	14 (4)	8 (2)	15 (5)	11 (7)	12 (5)
0-45-45 surf b'cast	13 (4)	10 (3)	11 (4)	10 (5)	11 (4)
0-90-90 surf b'cast	16 (7)	12 (4)	17 (6)	15 (8)	15 (6)
0-135-135 surf b'cast	12 (5)	11 (3)	18 (7)	13 (6)	14 (5)

Note: Numbers in parentheses are for Mehlich-3 extraction.

Table 12. Mississippi Soil Test and Mehlich-3 extractable K, no-till. Black Belt Branch, 1990-1993.

Treatment and depth	1990	1992	1993	1994	avg.
N-P ₂ O ₅ -K ₂ O, lb/a ----- ppm K -----					
<i>0 to 2 inches</i>					
0-0-0	105 (111)	128 (131)	131 (134)	112 (138)	119 (128)
0-90-90 surf band	124 (138)	155 (160)	152 (155)	107 (143)	134 (149)
0-135-135 surf band	153 (157)	136 (141)	168 (164)	120 (151)	144 (153)
0-45-45 surf b'cast	113 (129)	139 (143)	148 (138)	122 (151)	130 (140)
0-90-90 surf b'cast	135 (143)	144 (147)	153 (163)	137 (161)	142 (154)
0-135-135 surf b'cast	117 (127)	145 (152)	159 (169)	117 (130)	134 (144)
<i>2 to 6 inches</i>					
0-0-0	77 (95)	99 (115)	109 (117)	98 (127)	96 (114)
0-90-90 surf band	89 (103)	104 (126)	108 (112)	86 (114)	97 (114)
0-135-135 surf band	77 (92)	101 (107)	108 (111)	92 (112)	94 (108)
0-45-45 surf b'cast	80 (96)	105 (117)	109 (112)	88 (112)	96 (109)
0-90-90 surf b'cast	82 (97)	99 (107)	109 (115)	85 (114)	94 (108)
0-135-135 surf b'cast	80 (95)	100 (111)	106 (114)	85 (114)	93 (108)
<i>0 to 6 inches</i>					
0-0-0	86 (100)	109 (120)	116 (123)	103 (131)	104 (119)
0-90-90 surf band	101 (115)	121 (137)	123 (126)	93 (124)	109 (126)
0-135-135 surf band	102 (114)	113 (118)	128 (129)	101 (132)	111 (123)
0-45-45 surf b'cast	91 (107)	116 (126)	122 (121)	99 (125)	107 (120)
0-90-90 surf b'cast	100 (112)	114 (120)	124 (131)	102 (130)	110 (123)
0-135-135 surf b'cast	92 (106)	115 (125)	124 (132)	96 (119)	107 (120)

Note: Numbers in parentheses are for Mehlich-3 extraction.

Table 13. Coefficients of correlation (r) between extractants, depth, foliar P concentration, and yield. Black Belt Branch.

	MST02 ¹	MST06 ²	M302 ³	M306 ⁴	%P	Yield
MST02		0.64**	0.80**	0.68**	0.12	0.13
MST06			0.49**	0.78**	0.69**	0.67**
M302				0.80**	0.05	0.11
M306					0.47**	0.54**
%P						0.79**
Yield						

¹ Mississippi Soil Test, 0- to 2-inch depth.

² Mississippi Soil Test, 0- to 6-inch depth.

³ Mehlich-3, 0- to 2-inch depth.

⁴ Mehlich-3, 0- to 6-inch depth.

** significantly different from zero at the 0.01 level of probability.

Table 14. Coefficients of correlation (r) between extractants, depth, foliar K concentration, and yield. Black Belt Branch.

	MST02 ¹	MST06 ²	M302 ³	M306 ⁴	%K	Yield
MST02		0.67**	0.89**	0.64**	0.49**	0.61**
MST06			0.54**	0.99**	0.48**	0.87**
M302				0.57**	0.53**	0.54**
M306					0.49**	0.87**
%K						0.54**
Yield						

¹ Mississippi Soil Test, 0- to 2-inch depth.

² Mississippi Soil Test, 0- to 6-inch depth.

³ Mehlich-3, 0- to 2-inch depth.

⁴ Mehlich-3, 0- to 6-inch depth.

** significantly different from zero at the 0.01 level of probability.

Table 15. Average response of corn to tillage and P and K rates and placement. Coastal Plain Branch, 1991-1993.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a	bu/a	bu/a	%P	%P	%K	%K
0-0-0	88	100	0.31	0.31	1.86	1.79
0-20-20 in-soil	98	99	0.31	0.30	1.88	1.79
0-40-40 in-soil	96	103	0.31	0.31	1.80	1.75
0-60-60 in-soil	91	101	0.31	0.31	1.77	1.70
0-40-40 surf band	97	101	0.30	0.31	1.80	1.77
0-60-60 surf band	94	98	0.31	0.32	2.05	1.86
0-20-20 surf b'cast	99	97	0.32	0.31	1.94	1.73
0-40-40 surf b'cast	94	108	0.30	0.32	1.95	1.77
0-60-60 surf b'cast	106	91	0.31	0.32	1.90	1.89
Average	96	100	0.31	0.31	1.88	1.78
C.V. %		17.7		7.4		10.1
L.S.D. _{0.05} tillage		ns		ns		0.07
L.S.D. _{0.05} fertilizer within tillage across years		ns		ns		0.14

K concentrations for this treatment were consistently high for all years, probably because of high concentrations of extractable K in two replicates. Both foliar P and K concentrations were adequate according to Small and Ohlrogge (7).

Extractable P and K concentrations for no-till are given in Tables 16 and 17 (data for conventional tillage are in Appendix Tables 21 and 22). Mehlich-3 extracted 92% as much P and the same amount of K as the Mississippi Soil Test. P and K did not accumulate in the 0- to 2-inch layer and P did not move downward with time. It appears that a very small amount of K moved into the 2- to 6-inch layer when K was applied as surface band. Extractable P and K did not correlate with yield or foliar concentrations.

Conclusions

Results were variable from location to location and from year to year. Studies of this type should be conducted over a longer period of time to more accurately measure variables. In these studies, a response to P and K applications was obtained at two locations and no response was measured at two other locations. Where a yield response was obtained, surface applications of P and K increased yields more than in-soil applications.

Foliar K concentrations were increased by P and K applications more consistently than foliar P concentrations. At most locations, foliar concentrations were not affected by method of P and K application.

Extractable P and K did not accumulate in the 0- to 2-inch layer or move downward during the duration of this study. At most locations, extractable P and K in the 0- to 6-inch layer correlated better or as good with yields as the 0- to 2-inch layer. There are insufficient data, at present, to warrant a change in the traditional method of collecting soil samples (0- to 6-inch depth) in no-till systems.

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Table 16. Mississippi soil test and Mehlich-3 extractable P, no-till. Coastal Plain Branch, 1991-1993.

Treatment and depth	1991	1992	1993	avg.
N-P ₂ O ₅ -K ₂ O, lb/a ----- ppm P -----				
<i>0 to 2 inches</i>				
0-0-0	98 (82)	91 (85)	81 (85)	90 (84)
0-40-40 surf band	107 (105)	101 (97)	106 (103)	105 (102)
0-60-60 surf band	99 (83)	118 (113)	113 (112)	110 (103)
0-20-20 surf b'cast	110 (101)	109 (98)	99 (91)	106 (97)
0-40-40 surf b'cast	90 (86)	97 (94)	97 (89)	95 (90)
0-60-60 surf b'cast	97 (87)	95 (92)	102 (88)	98 (89)
<i>2 to 6 inches</i>				
0-0-0	51 (41)	38 (37)	51 (46)	47 (41)
0-40-40 surf band	49 (46)	54 (50)	57 (56)	53 (51)
0-60-60 surf band	50 (40)	50 (48)	59 (54)	53 (47)
0-20-20 surf b'cast	62 (56)	60 (55)	64 (57)	62 (56)
0-40-40 surf b'cast	54 (47)	51 (47)	55 (49)	53 (48)
0-60-60 surf b'cast	42 (37)	50 (44)	50 (43)	47 (41)
<i>0 to 6 inches</i>				
0-0-0	67 (55)	56 (53)	61 (59)	61 (55)
0-40-40 surf band	68 (66)	70 (66)	73 (72)	70 (68)
0-60-60 surf band	66 (54)	73 (70)	77 (73)	72 (66)
0-20-20 surf b'cast	78 (71)	76 (69)	76 (68)	77 (69)
0-40-40 surf b'cast	66 (60)	66 (63)	69 (62)	67 (62)
0-60-60 surf b'cast	60 (54)	65 (60)	67 (58)	64 (57)

Note: Numbers in parentheses are for Mehlich-3 extraction.

Table 17. Mississippi Soil Test and Mehlich-3 Extractable K, no-till. Coastal Plain Branch, 1991-1993.

Treatment and depth	1991	1992	1993	avg.
N-P ₂ O ₅ -K ₂ O, lb/a ----- ppm P -----				
<i>0 to 2 inches</i>				
0-0-0	152 (147)	137 (134)	134 (134)	141 (138)
0-40-40 surf band	135 (136)	145 (151)	167 (168)	149 (152)
0-60-60 surf band	157 (157)	168 (174)	177 (166)	167 (166)
0-20-20 surf b'cast	161 (159)	148 (143)	151 (149)	153 (150)
0-40-40 surf b'cast	166 (164)	163 (162)	150 (146)	160 (157)
0-60-60 surf b'cast	145 (124)	165 (165)	148 (144)	153 (144)
<i>2 to 6 inches</i>				
0-0-0	68 (71)	69 (69)	67 (72)	68 (71)
0-40-40 surf band	59 (65)	74 (78)	80 (84)	71 (76)
0-60-60 surf band	68 (70)	91 (94)	94 (94)	84 (86)
0-20-20 surf b'cast	59 (67)	77 (84)	72 (78)	69 (76)
0-40-40 surf b'cast	63 (67)	81 (82)	82 (81)	75 (77)
0-60-60 surf b'cast	53 (60)	72 (73)	75 (77)	67 (70)
<i>0 to 6 inches</i>				
0-0-0	96 (96)	92 (91)	89 (93)	92 (93)
0-40-40 surf band	84 (89)	98 (102)	109 (112)	97 (101)
0-60-60 surf band	98 (99)	117 (121)	122 (118)	112 (113)
0-20-20 surf b'cast	93 (98)	101 (104)	98 (102)	97 (101)
0-40-40 surf b'cast	97 (99)	108 (109)	105 (103)	103 (104)
0-60-60 surf b'cast	84 (81)	103 (104)	99 (99)	95 (95)

Note! Numbers in parenthesis are for Mehlich-3 extraction.

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Appendix Tables

Appendix Table 1. Response of cotton to tillage and P and K rates and placement. North MS Branch, 1990.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a	lb/a		%P		%K	
0-0-0	398	690	0.46	0.42	1.18	1.11
0-15-15 in-soil	651	639	0.42	0.42	1.24	1.06
0-30-30 in-soil	548	669	0.42	0.41	1.05	1.05
0-45-45 in-soil	534	772	0.45	0.44	1.02	0.94
0-30-30 surf band	710	787	0.41	0.41	1.40	1.04
0-45-45 surf band	612	916	0.42	0.41	1.13	1.31
0-15-15 surf b'cast	643	697	0.43	0.44	1.05	1.12
0-30-30 surf b'cast	555	711	0.44	0.42	1.22	1.04
0-45-45 surf b'cast	598	870	0.42	0.43	1.17	1.14
Average	583	750	0.43	0.42	1.16	1.09
C.V. %	22.8		10.7		16.6	
L.S.D. _{0.05} tillage	84		ns		ns	
L.S.D. _{0.05} fertilizer within tillage	ns		ns		ns	

Appendix Table 2. Response of cotton to tillage and P and K rates and placement. North MS Branch, 1992.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a	lb/a		%P		%K	
0-0-0	1,618	1,570	0.43	0.45	1.35	1.14
0-15-15 in-soil	1,588	1,309	0.45	0.46	1.57	1.17
0-30-30 in-soil	1,898	1,475	0.42	0.44	1.22	1.34
0-45-45 in-soil	1,626	1,679	0.44	0.49	1.33	1.46
0-30-30 surf band	1,712	1,665	0.45	0.47	1.53	1.33
0-45-45 surf band	1,717	1,543	0.44	0.46	1.39	1.67
0-15-15 surf b'cast	1,680	1,981	0.42	0.44	1.28	1.32
0-30-30 surf b'cast	1,785	1,806	0.45	0.44	1.45	1.62
0-45-45 surf b'cast	1,627	1,800	0.44	0.46	1.44	1.47
Average	1,694	1,647	0.44	0.46	1.39	1.39
C.V. %	18.8		6.2		18.4	
L.S.D. _{0.05} tillage	ns		0.1		ns	
L.S.D. _{0.05} fertilizer within tillage	ns		ns		ns	

Appendix Table 3. Response of cotton to tillage and P and K rates and placement. North MS Branch, 1993.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a	lb/a		%P		%K	
0-0-0	1,886	1,841	0.52	0.48	0.78	0.84
0-15-15 in-soil	2,226	1,709	0.47	0.48	1.00	1.01
0-30-30 in-soil	2,306	1,807	0.51	0.47	0.77	1.03
0-45-45 in-soil	2,154	1,663	0.48	0.44	0.89	0.99
0-30-30 surf band	2,041	1,898	0.49	0.46	1.23	0.99
0-45-45 surf band	2,215	1,799	0.48	0.47	1.00	1.01
0-15-15 surf b'cast	2,019	1,716	0.50	0.46	0.70	0.91
0-30-30 surf b'cast	1,875	1,814	0.49	0.48	1.12	0.92
0-45-45 surf b'cast	1,973	1,808	0.50	0.44	1.53	1.08
Average	2,077	1,784	0.49	0.46	1.00	0.97
C.V. %	15.9		5.3		17.7	
L.S.D. _{0.05} tillage	ns		0.03		ns	
L.S.D. _{0.05} fertilizer within tillage	ns		ns		0.24	

Appendix Table 4. Response of cotton to tillage and P and K rates and placement. North MS Branch, 1994.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a	lb/a		%P		%K	
0-0-0	2,254	1,754	0.61	0.53	1.47	1.27
0-15-15 in-soil	2,268	1,634	0.58	0.54	1.57	1.55
0-30-30 in-soil	2,431	1,588	0.68	0.56	1.59	1.32
0-45-45 in-soil	2,302	1,992	0.61	0.56	1.93	1.69
0-30-30 surf band	2,605	1,890	0.63	0.55	1.97	1.78
0-45-45 surf band	2,484	1,950	0.60	0.52	2.03	1.62
0-15-15 surf b'cast	2,288	1,876	0.60	0.53	1.57	1.39
0-30-30 surf b'cast	2,552	1,807	0.61	0.52	1.98	1.68
0-45-45 surf b'cast	2,589	2,344	0.59	0.55	2.02	1.71
Average	2,419	1,871	0.61	0.54	1.79	1.56
C.V. %	21.1		8.7		21.3	
L.S.D. _{0.05} tillage	ns		ns		ns	
L.S.D. _{0.05} fertilizer within tillage	ns		ns		0.50	

Appendix Table 5. Mississippi Soil Test and Mehlich-3 extractable P, conventional tillage. North MS Branch, 1990, 1992-1994.

Treatment and depth	1990	1992	1993	1994	avg.
N-P ₂ O ₅ -K ₂ O, lb/a	----- ppm P -----				
<i>0 to 2 inches</i>					
0-0-0	91 (73)	72 (56)	63 (53)	56 (52)	70 (58)
0-30-30 surf band	103 (83)	82 (64)	77 (69)	74 (68)	84 (71)
0-45-45 surf band	106 (89)	94 (78)	85 (83)	80 (80)	91 (82)
0-15-15 surf b'cast	95 (68)	78 (63)	66 (59)	62 (58)	75 (62)
0-30-30 surf b'cast	99 (80)	85 (68)	73 (75)	71 (65)	82 (72)
0-45-45 surf b'cast	106 (82)	83 (66)	75 (71)	74 (72)	84 (73)
<i>2 to 6 inches</i>					
0-0-0	73 (56)	60 (43)	50 (38)	46 (39)	57 (44)
0-30-30 surf band	76 (56)	61 (42)	58 (48)	50 (40)	61 (46)
0-45-45 surf band	79 (59)	71 (54)	55 (47)	58 (52)	66 (53)
0-15-15 surf b'cast	70 (50)	50 (37)	51 (43)	43 (37)	54 (42)
0-30-30 surf b'cast	74 (54)	65 (45)	49 (50)	59 (58)	62 (52)
0-45-45 surf b'cast	87 (56)	68 (49)	60 (48)	56 (49)	68 (50)
<i>0 to 6 inches</i>					
0-0-0	79 (62)	64 (47)	54 (43)	49 (43)	62 (49)
0-30-30 surf band	85 (65)	68 (49)	64 (55)	58 (49)	69 (54)
0-45-45 surf band	88 (69)	79 (62)	65 (59)	65 (61)	74 (63)
0-15-15 surf b'cast	78 (56)	59 (46)	56 (48)	49 (44)	60 (48)
0-30-30 surf b'cast	82 (63)	72 (53)	57 (58)	63 (60)	68 (58)
0-45-45 surf b'cast	93 (65)	73 (55)	65 (56)	62 (57)	73 (58)

Note: Numbers in parentheses are for Mehlich-3 extraction.

Appendix Table 6. Mississippi Soil Test and Mehlich-3 extractable K, conventional tillage. North MS Branch, 1990, 1992-1994.

Treatment and depth	1990	1992	1993	1994	avg.
N-P ₂ O ₅ -K ₂ O, lb/a	----- ppm P -----				
<i>0 to 2 inches</i>					
0-0-0	161 (158)	137 (136)	135 (132)	121 (138)	138 (141)
0-30-30 surf band	201 (197)	159 (183)	165 (164)	163 (180)	172 (181)
0-45-45 surf band	202 (192)	184 (188)	181 (186)	199 (187)	192 (188)
0-15-15 surf b'cast	189 (175)	159 (159)	151 (157)	146 (158)	161 (162)
0-30-30 surf b'cast	185 (178)	161 (160)	161 (166)	152 (167)	165 (168)
0-45-45 surf b'cast	200 (182)	164 (166)	159 (168)	160 (174)	171 (172)
<i>2 to 6 inches</i>					
0-0-0	117 (121)	95 (95)	92 (95)	86 (101)	98 (103)
0-30-30 surf band	132 (130)	109 (114)	111 (110)	99 (120)	113 (118)
0-45-45 surf band	149 (140)	119 (118)	114 (122)	125 (135)	127 (129)
0-15-15 surf b'cast	127 (119)	102 (103)	98 (106)	91 (103)	104 (108)
0-30-30 surf b'cast	129 (125)	103 (105)	105 (113)	103 (120)	110 (116)
0-45-45 surf b'cast	139 (128)	111 (112)	107 (114)	102 (117)	115 (118)
<i>0 to 6 inches</i>					
0-0-0	132 (133)	109 (109)	106 (107)	98 (113)	111 (116)
0-30-30 surf band	155 (152)	126 (137)	129 (128)	120 (140)	132 (139)
0-45-45 surf band	167 (157)	141 (141)	136 (143)	150 (152)	148 (148)
0-15-15 surf b'cast	148 (138)	121 (122)	116 (123)	109 (121)	124 (126)
0-30-30 surf b'cast	148 (143)	122 (123)	124 (131)	119 (136)	128 (133)
0-45-45 surf b'cast	159 (146)	129 (130)	124 (132)	121 (136)	133 (136)

Note: Numbers in parentheses are for Mehlich-3 extraction.

Appendix Table 7. Response of soybeans to tillage and P and K rates and placement. Northeast Branch, 1991.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a	lb/a		%P		%K	
0-0-0	20	32	0.57	0.52	1.32	1.56
0-15-15 in-soil	21	30	0.58	0.55	1.42	1.57
0-30-30 in-soil	20	28	0.58	0.55	1.48	1.66
0-45-45 in-soil	22	29	0.54	0.57	1.21	1.34
0-30-30 surf band	23	30	0.56	0.55	1.31	1.55
0-45-45 surf band	26	33	0.56	0.55	1.40	1.49
0-15-15 surf b'cast	19	32	0.56	0.56	1.15	1.49
0-30-30 surf b'cast	24	31	0.54	0.56	1.44	1.64
0-45-45 surf b'cast	16	28	0.56	0.52	1.14	1.39
Average	21	30	0.56	0.55	1.32	1.52
C.V. %	18.7		4.8		15.6	
L.S.D. _{0.05} tillage	2		ns		ns	
L.S.D. _{0.05} fertilizer within tillage	ns		ns		0.30	

Appendix Table 8. Response of soybeans to tillage and P and K rates and placement. Northeast Branch, 1992.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a	lb/a		%P		%K	
0-0-0	29	34	0.50	0.51	1.45	1.38
0-15-15 in-soil	29	33	0.52	0.50	1.47	1.62
0-30-30 in-soil	27	34	0.54	0.53	1.58	1.46
0-45-45 in-soil	32	34	0.53	0.54	1.46	1.56
0-30-30 surf band	34	34	0.52	0.53	1.46	1.46
0-45-45 surf band	33	34	0.50	0.51	1.52	1.48
0-15-15 surf b'cast	27	30	0.50	0.52	1.42	1.39
0-30-30 surf b'cast	31	32	0.51	0.54	1.73	1.36
0-45-45 surf b'cast	29	34	0.50	0.50	1.46	1.45
Average	30	33	0.51	0.52	1.51	1.46
C.V. %	10.5		5.0		9.2	
L.S.D. _{0.05} tillage	2		ns		ns	
L.S.D. _{0.05} fertilizer within tillage	5		0.04		ns	

Appendix Table 9. Response of soybeans to tillage and P and K rates and placement. Northeast Branch, 1993.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a	lb/a		%P		%K	
0-0-0	18	19	0.48	0.44	1.08	1.36
0-15-15 in-soil	18	21	0.44	0.43	1.14	1.39
0-30-30 in-soil	27	18	0.43	0.45	1.28	1.56
0-45-45 in-soil	21	25	0.45	0.45	1.28	1.59
0-30-30 surf band	27	19	0.47	0.47	1.38	1.35
0-45-45 surf band	30	23	0.46	0.45	1.41	1.51
0-15-15 surf b'cast	21	19	0.45	0.44	1.15	1.43
0-30-30 surf b'cast	31	18	0.44	0.46	1.43	1.57
0-45-45 surf b'cast	23	18	0.44	0.44	1.16	1.33
Average	24	20	0.45	0.45	1.24	1.44
C.V. %	19.5		8.6		17.2	
L.S.D. _{0.05} tillage	3		ns		ns	
L.S.D. _{0.05} fertilizer within tillage	6		ns		ns	

Appendix Table 10. Response of soybeans to tillage and P and K rates and placement. Northeast MS, 1994.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a	lb/a		%P		%K	
0-0-0	21	30	0.45	0.44	1.80	1.82
0-15-15 in-soil	26	33	0.45	0.44	1.88	1.52
0-30-30 in-soil	22	30	0.45	0.44	1.86	2.05
0-45-45 in-soil	28	30	0.45	0.44	2.05	1.82
0-30-30 surf band	29	33	0.46	0.44	1.94	1.63
0-45-45 surf band	29	33	0.43	0.43	2.12	1.81
0-15-15 surf b'cast	21	32	0.45	0.43	2.07	2.00
0-30-30 surf b'cast	30	34	0.45	0.41	2.19	1.57
0-45-45 surf b'cast	30	33	0.45	0.42	2.15	1.86
Average	27	32	0.45	0.43	2.00	1.79
C.V. %	19.0		6.0		12.6	
L.S.D. _{0.05} tillage	ns		ns		0.11	
L.S.D. _{0.05} fertilizer within tillage	8		ns		ns	

Appendix Table 11. Mississippi Soil Test and Mehlich-3 extractable P, conventional tillage. Northeast Branch, 1991-1993.

Treatment and depth	1991	1992	1993	avg.
N-P₂O₅-K₂O, lb/a ----- ppm P -----				
<i>0 to 2 inches</i>				
0-0-0	81 (46)	73 (46)	84 (42)	79 (45)
0-30-30 surf band	97 (57)	85 (58)	106 (58)	96 (58)
0-45-45 surf band	98 (59)	87 (58)	96 (51)	94 (56)
0-15-15 surf b'cast	92 (57)	82 (53)	97 (51)	90 (54)
0-30-30 surf b'cast	90 (54)	81 (56)	99 (55)	90 (55)
0-45-45 surf b'cast	99 (62)	88 (62)	109 (64)	99 (63)
<i>2 to 6 inches</i>				
0-0-0	66 (36)	58 (35)	56 (24)	60 (32)
0-30-30 surf band	75 (42)	57 (38)	65 (29)	66 (36)
0-45-45 surf band	64 (31)	62 (34)	58 (24)	61 (30)
0-15-15 surf b'cast	80 (34)	56 (34)	57 (25)	64 (31)
0-30-30 surf b'cast	63 (34)	55 (36)	59 (27)	59 (32)
0-45-45 surf b'cast	68 (35)	57 (35)	56 (25)	60 (32)
<i>0 to 6 inches</i>				
0-0-0	71 (35)	63 (39)	65 (30)	66 (36)
0-30-30 surf band	82 (47)	66 (45)	79 (39)	76 (44)
0-45-45 surf band	75 (40)	70 (42)	71 (33)	72 (38)
0-15-15 surf b'cast	84 (42)	65 (40)	70 (34)	73 (39)
0-30-30 surf b'cast	72 (41)	64 (43)	72 (36)	69 (40)
0-45-45 surf b'cast	78 (44)	67 (44)	74 (38)	73 (42)

Note: Numbers in parentheses are for Mehlich-3 extraction.

Appendix Table 12. Mississippi Soil Test and Mehlich-3 extractable K, conventional tillage. Northeast Branch, 1991-1993.

Treatment and depth	1991	1992	1993	avg.
N-P₂O₅-K₂O, lb/a ----- ppm K -----				
<i>0 to 2 inches</i>				
0-0-0	135 (109)	131 (105)	129 (133)	132 (116)
0-30-30 surf band	137 (116)	130 (112)	126 (137)	131 (122)
0-45-45 surf band	152 (131)	143 (116)	135 (140)	143 (129)
0-15-15 surf b'cast	153 (126)	144 (115)	139 (139)	145 (127)
0-30-30 surf b'cast	140 (113)	135 (116)	133 (140)	136 (123)
0-45-45 surf b'cast	130 (108)	131 (115)	132 (138)	131 (120)
<i>2 to 6 inches</i>				
0-0-0	105 (86)	107 (93)	96 (110)	103 (96)
0-30-30 surf band	97 (78)	100 (87)	92 (104)	96 (90)
0-45-45 surf band	108 (86)	100 (85)	97 (108)	102 (93)
0-15-15 surf b'cast	109 (95)	105 (93)	96 (103)	103 (97)
0-30-30 surf b'cast	98 (73)	103 (87)	93 (103)	98 (88)
0-45-45 surf b'cast	98 (76)	98 (85)	89 (101)	95 (87)
<i>0 to 6 inches</i>				
0-0-0	115 (94)	115 (97)	107 (118)	112 (103)
0-30-30 surf band	110 (91)	110 (95)	103 (115)	108 (100)
0-45-45 surf band	123 (101)	114 (95)	110 (119)	116 (105)
0-15-15 surf b'cast	124 (105)	118 (100)	110 (115)	117 (107)
0-30-30 surf b'cast	112 (86)	114 (97)	106 (115)	111 (99)
0-45-45 surf b'cast	109 (87)	109 (95)	103 (113)	107 (98)

Note: Numbers in parentheses are for Mehlich-3 extraction.

Appendix Table 13. Response of soybeans to tillage and P and K rates and placement. Black Belt Branch, 1990.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a	bu/a		%P		%K	
0-0-0	12	14	0.31	0.35	1.29	1.26
0-45-45 in-soil	13	15	0.32	0.36	1.59	1.53
0-90-90 in-soil	14	15	0.37	0.38	1.69	1.61
0-135-135 in-soil	14	14	0.38	0.37	1.66	1.71
0-90-90 surf band	10	13	0.30	0.34	1.35	1.35
0-135-135 surf band	14	13	0.34	0.32	1.34	1.42
0-45-45 surf b'cast	12	14	0.33	0.34	1.22	1.24
0-90-90 surf b'cast	11	14	0.31	0.39	1.32	1.51
0-135-135 surf b'cast	12	14	0.33	0.35	1.39	1.43
Average	12	14	0.33	0.36	1.43	1.45
C.V. %	17.7		14.0		14.8	
L.S.D. _{0.05} tillage	ns		ns		ns	
L.S.D. _{0.05} fertilizer within tillage	ns		ns		0.29	

Table 14. Response of soybeans to tillage and P and K rates and placement. Black Belt Branch, 1992.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a	bu/a		%P		%K	
0-0-0	20	36	0.45	0.37	1.24	1.61
0-45-45 in-soil	30	41	0.46	0.42	1.70	1.88
0-90-90 in-soil	33	43	0.51	0.45	1.82	1.99
0-135-135 in-soil	37	44	0.48	0.45	1.93	2.24
0-90-90 surf band	36	45	0.49	0.43	1.42	1.79
0-135-135 surf band	33	50	0.51	0.43	1.56	1.99
0-45-45 surf b'cast	31	44	0.47	0.39	1.32	1.87
0-90-90 surf b'cast	31	47	0.51	0.44	1.56	1.88
0-135-135 surf b'cast	34	47	0.47	0.47	1.76	1.87
Average	32	44	0.48	0.43	1.59	1.90
C.V. %	16.5		8.1		10.7	
L.S.D. _{0.05} tillage	6		0.02		0.26	
L.S.D. _{0.05} fertilizer within tillage	9		0.05		0.24	

Appendix Table 15. Response of soybeans to tillage and P and K rates and placement. Black Belt Branch, 1994.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a	lb/a		%P		%K	
0-0-0	35	36	0.33	0.34	1.48	1.50
0-45-45 in-soil	45	43	0.39	0.36	1.86	2.03
0-90-90 in-soil	42	45	0.40	0.44	2.01	2.40
0-135-135 in-soil	45	43	0.41	0.47	2.16	2.40
0-90-90 surf band	41	44	0.42	0.47	2.03	2.12
0-135-135 surf band	46	47	0.45	0.47	2.45	2.16
0-45-45 surf b'cast	40	44	0.36	0.41	1.97	1.99
0-90-90 surf b'cast	46	45	0.47	0.43	2.21	1.90
0-135-135 surf b'cast	44	47	0.44	0.51	2.57	2.37
Average	43	45	0.41	0.43	2.08	2.10
C.V. %	10.8		11.5		13.3	
L.S.D. _{0.05} tillage	ns		ns		ns	
L.S.D. _{0.05} fertilizer within tillage	7		0.06		0.40	

Appendix Table 16. Mississippi Soil Test and Mehlich-3 extractable P, conventional tillage. Black Belt Branch, 1990-1993.

Treatment and depth	1990	1992	1993	1994	avg.
N-P₂O₅-K₂O, lb/a					
----- ppm P -----					
0 to 2 inches					
0-0-0	16 (3)	14 (4)	19 (6)	13 (8)	16 (5)
0-90-90 surf band	16 (4)	16 (3)	31 (12)	21 (13)	21 (8)
0-135-135 surf band	26 (10)	24 (7)	28 (9)	28 (18)	26 (11)
0-45-45 surf b'cast	16 (6)	13 (3)	26 (9)	19 (13)	18 (8)
0-90-90 surf b'cast	18 (6)	17 (5)	27 (12)	17 (14)	20 (9)
0-135-135 surf b'cast	24 (10)	18 (8)	39 (16)	30 (20)	28 (14)
2 to 6 inches					
0-0-0	10 (2)	6 (1)	7 (2)	5 (4)	7 (2)
0-90-90 surf band	4 (2)	4 (0)	8 (3)	5 (5)	5 (2)
0-135-135 surf band	9 (2)	7 (0)	7 (0)	6 (5)	7 (2)
0-45-45 surf b'cast	5 (2)	2 (0)	9 (1)	5 (4)	5 (2)
0-90-90 surf b'cast	6 (1)	5 (1)	6 (2)	5 (4)	6 (2)
0-135-135 surf b'cast	7 (1)	5 (1)	9 (2)	5 (5)	6 (2)
0 to 6 inches					
0-0-0	12 (2)	9 (2)	11 (3)	8 (5)	10 (3)
0-90-90 surf band	8 (3)	8 (1)	16 (6)	10 (8)	10 (4)
0-135-135 surf band	15 (5)	13 (2)	14 (3)	13 (9)	14 (5)
0-45-45 surf b'cast	9 (3)	6 (1)	15 (4)	10 (7)	10 (4)
0-90-90 surf b'cast	10 (3)	9 (2)	13 (5)	9 (6)	10 (4)
0-135-135 surf b'cast	13 (4)	9 (3)	19 (7)	13 (10)	14 (6)

Note: Numbers in parentheses are for Mehlich-3 extraction.

Appendix Table 17. Mississippi Soil Test and Mehlich-3 extractable K, conventional tillage. Black Belt Branch, 1990-1993.

Treatment and depth	1990	1992	1993	1994	avg.
N-P₂O₅-K₂O, lb/a					
----- ppm P -----					
0 to 2 inches					
0-0-0	103 (113)	128 (141)	132 (131)	106 (129)	117 (128)
0-90-90 surf band	112 (124)	119 (127)	142 (138)	116 (145)	122 (134)
0-135-135 surf band	116 (132)	129 (130)	144 (150)	122 (151)	128 (141)
0-45-45 surf b'cast	106 (121)	125 (129)	139 (143)	115 (137)	121 (132)
0-90-90 surf b'cast	110 (129)	131 (140)	142 (140)	113 (139)	124 (137)
0-135-135 surf b'cast	116 (120)	132 (138)	160 (163)	135 (161)	136 (146)
2 to 6 inches					
0-0-0	80 (96)	109 (120)	107 (114)	84 (111)	95 (110)
0-90-90 surf band	78 (96)	97 (112)	106 (112)	88 (122)	92 (110)
0-135-135 surf band	82 (98)	102 (104)	108 (122)	90 (123)	96 (112)
0-45-45 surf b'cast	82 (96)	101 (113)	107 (115)	88 (115)	94 (110)
0-90-90 surf b'cast	79 (99)	99 (114)	101 (116)	85 (118)	91 (112)
0-135-135 surf b'cast	84 (96)	101 (119)	109 (113)	90 (120)	96 (112)
0 to 6 inches					
0-0-0	88 (102)	115 (127)	115 (120)	91 (117)	102 (116)
0-90-90 surf band	89 (105)	104 (117)	118 (121)	97 (130)	102 (118)
0-135-135 surf band	93 (109)	111 (113)	120 (131)	101 (132)	106 (121)
0-45-45 surf b'cast	90 (104)	109 (117)	118 (124)	97 (122)	104 (117)
0-90-90 surf b'cast	89 (109)	110 (123)	115 (124)	94 (125)	102 (120)
0-135-135 surf b'cast	95 (104)	111 (125)	126 (130)	105 (134)	109 (123)

Note: Numbers in parentheses are for Mehlich-3 extraction.

Appendix Table 18. Response of corn to tillage and P and K rates and placement. Coastal Plain Branch, 1991.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a	bu/a		%P		%K	
0-0-0	125	146	0.31	0.33	2.44	2.40
0-20-20 in-soil	129	148	0.31	0.32	2.36	2.39
0-40-40 in-soil	126	148	0.32	0.32	2.40	2.24
0-60-60 in-soil	121	145	0.31	0.33	2.23	2.17
0-40-40 surf band	132	140	0.30	0.33	2.19	2.49
0-60-60 surf band	124	136	0.31	0.34	2.54	2.34
0-20-20 surf b'cast	124	126	0.35	0.34	2.40	2.32
0-40-40 surf b'cast	119	136	0.27	0.34	2.27	2.38
0-60-60 surf b'cast	139	131	0.32	0.34	2.40	2.44
Average	127	140	0.31	0.33	2.36	2.35
C.V. %	9.4		8.0		8.4	
L.S.D. _{0.05} tillage	5.9		0.01		ns	
L.S.D. _{0.05} fertilizer	ns		ns		ns	

Appendix Table 19. Response of corn to tillage and P and K rates and placement. Coastal Plain Branch, 1992.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a	bu/a		%P		%K	
0-0-0	86	102	0.30	0.30	1.68	1.60
0-20-20 in-soil	95	102	0.30	0.29	1.83	1.61
0-40-40 in-soil	102	106	0.30	0.30	1.58	1.72
0-60-60 in-soil	94	106	0.30	0.31	1.67	1.61
0-40-40 surf band	102	106	0.29	0.30	1.69	1.42
0-60-60 surf band	96	106	0.30	0.30	1.92	1.72
0-20-20 surf b'cast	109	116	0.31	0.29	1.82	1.52
0-40-40 surf b'cast	89	121	0.30	0.31	1.97	1.61
0-60-60 surf b'cast	95	110	0.30	0.30	1.68	1.71
Average	96	108	0.31	0.30	1.76	1.61
C.V. %	16.4		4.6		11.3	
L.S.D. _{0.05} tillage	ns		ns		0.09	
L.S.D. _{0.05} fertilizer	ns		ns		ns	

Appendix Table 20. Response of corn to tillage and P and K rates and placement. Coastal Plain Branch, 1993.

Treatment	NT	CT	NT	CT	NT	CT
N-P ₂ O ₅ -K ₂ O, lb/a	lb/a		%P		%K	
0-0-0	54	52	0.32	0.30	1.69	1.66
0-20-20 in-soil	70	46	0.31	0.30	1.76	1.66
0-40-40 in-soil	61	54	0.31	0.31	1.68	1.56
0-60-60 in-soil	58	51	0.31	0.29	1.64	1.62
0-40-40 surf band	57	57	0.31	0.31	1.61	1.65
0-60-60 surf band	61	53	0.31	0.32	1.88	1.74
0-20-20 surf b'cast	64	48	0.31	0.29	1.73	1.66
0-40-40 surf b'cast	73	67	0.32	0.32	1.76	1.70
0-60-60 surf b'cast	84	33	0.32	0.32	1.72	1.80
Average	65	51	0.31	0.31	1.72	1.67
C.V. %	29.7		4.5		9.7	
L.S.D. _{0.05} tillage	ns		ns		ns	
L.S.D. _{0.05} fertilizer within tillage	ns		0.02		0.19	

Appendix Table 21. Mississippi Soil Test and Mehlich-3 extractable P, conventional tillage. Coastal Plain Branch, 1991-1993.

Treatment and depth	1991	1992	1993	avg.
N-P ₂ O ₅ -K ₂ O,	ppm P			lb/a
<i>0 to 2 inches</i>				
0-0-0	74 (68)	68 (62)	57 (48)	66 (59)
0-40-40 surf band	83 (75)	72 (67)	86 (81)	80 (74)
0-60-60 surf band	105 (99)	85 (86)	92 (89)	94 (91)
0-20-20 surf b'cast	86 (74)	82 (77)	65 (58)	78 (70)
0-40-40 surf b'cast	93 (94)	96 (89)	76 (72)	88 (85)
0-60-60 surf b'cast	97 (86)	94 (89)	87 (84)	93 (86)
<i>2 to 6 inches</i>				
0-0-0	50 (45)	39 (35)	43 (34)	44 (38)
0-40-40 surf band	50 (39)	45 (40)	51 (46)	49 (42)
0-60-60 surf band	68 (65)	58 (56)	56 (53)	61 (58)
0-20-20 surf b'cast	61 (52)	45 (42)	47 (38)	51 (44)
0-40-40 surf b'cast	67 (61)	55 (44)	56 (49)	59 (51)
0-60-60 surf b'cast	53 (46)	48 (46)	49 (45)	50 (46)
<i>0 to 6 inches</i>				
0-0-0	58 (53)	49 (44)	48 (39)	52 (45)
0-40-40 surf band	61 (51)	54 (49)	63 (58)	59 (53)
0-60-60 surf band	80 (76)	67 (66)	68 (65)	72 (69)
0-20-20 surf b'cast	69 (59)	57 (54)	53 (45)	60 (53)
0-40-40 surf b'cast	76 (72)	69 (59)	63 (57)	69 (63)
0-60-60 surf b'cast	68 (59)	63 (60)	62 (58)	64 (59)

Note: Numbers in parentheses are for Mehlich-3 extraction.

Appendix Table 22. Mississippi Soil Test and Mehlich-3 extractable K, conventional tillage. Coastal Plain Branch, 1991-1993.

Treatment and depth	1991	1992	1993	avg.
N-P ₂ O ₅ -K ₂ O,	ppm P			lb/a
<i>0 to 2 inches</i>				
0-0-0	133 (129)	143 (143)	133 (127)	136 (133)
0-40-40 surf band	147 (147)	148 (132)	135 (135)	143 (138)
0-60-60 surf band	148 (144)	155 (151)	167 (161)	157 (152)
0-20-20 surf b'cast	125 (124)	135 (134)	114 (112)	125 (123)
0-40-40 surf b'cast	141 (142)	122 (133)	120 (125)	128 (133)
0-60-60 surf b'cast	165 (164)	179 (183)	150 (147)	165 (165)
<i>2 to 6 inches</i>				
0-0-0	77 (83)	75 (77)	69 (71)	74 (77)
0-40-40 surf band	66 (73)	64 (68)	67 (67)	66 (69)
0-60-60 surf band	79 (83)	77 (79)	82 (85)	79 (82)
0-20-20 surf b'cast	71 (72)	69 (72)	58 (60)	66 (68)
0-40-40 surf b'cast	64 (66)	67 (70)	63 (70)	65 (69)
0-60-60 surf b'cast	90 (96)	79 (82)	71 (73)	80 (84)
<i>0 to 6 inches</i>				
0-0-0	96 (98)	98 (99)	90 (90)	95 (96)
0-40-40 surf band	93 (98)	92 (89)	90 (90)	92 (92)
0-60-60 surf band	102 (103)	103 (103)	110 (110)	105 (105)
0-20-20 surf b'cast	89 (89)	91 (93)	77 (77)	86 (86)
0-40-40 surf b'cast	90 (91)	85 (91)	82 (88)	86 (90)
0-60-60 surf b'cast	115 (119)	112 (116)	97 (98)	108 (111)

Note: Numbers in parentheses are for Mehlich-3 extraction.

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