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DIRECT AND RESIDUAL EFFECTS OF LAND-APPLIED SWEET CORN PROCESSING WASTES ON NITRATE LOSS TO GROUNDWATER

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INTRODUCTION

Production of sweet corn for processing in the Midwest is concentrated in Wisconsin, Minnesota, and Illinois with these three states accounting for over 60% of the 1991 national production of about 3.3 million tons. The economic contributions of this industry benefits urban and agricultural communities throughout the region. A major problem facing the sweet corn industry is the management of waste materials in a manner consistent with sustained profitably and environmental protection. The residues generated in sweet corn processing are bulky, heavy, expensive to handle, and cause environmental problems unless they are properly managed. Approximately two-thirds of the weight of harvested corn entering a processing plant must be removed as a waste material. This material consists mainly of husks, cobs, and other plant residues generated in canned or frozen sweet corn processing. Based on 1991 Wisconsin, Minnesota, and Illinois sweet corn production, approximately 1.3 million tons of waste materials must be managed annually. Traditionally, much of this residue has been stored in silage stacks and distributed to farmers during the winter months as livestock feed. For various reasons including reduced demand for sweet corn silage, seepage of acidic high BOD effluent from the stacks, odors, and regulatory actions against processing companies regarding surface water contamination, there is increasing interest in returning the residue to agricultural land immediately after processing. Continuation of the traditional stacking process now requires increasingly complex and expensive effluent containment and monitoring facilities. Very little information is currently available to determine appropriate land application rates for sweet corn processing residues or to indicate the environmental and agronomic effects of various residue application strategies.

OBJECTIVES

Specific objectives of this research to determine agronomically and environmentally appropriate land application rates for sweet corn residues are listed below.

a. Determine the mineralization/immobilization rates of N from land application of high rates of sweet corn processing residue.
b. Determine the distribution of nitrate over time in the soil profile associated with the treatments.
c. Determine the effects of supplemental fertilizer N additions to these high rates of residue application on mineralization of the residue and nitrate in the profile.
d. Determine the effects of these high loading rate applications on growth and production of succeeding crops.
e. Determine the residual effects of sweet corn residue applications on growth and production of succeeding crops.
f. Determine the effect sweet corn residue applications have on soil water nitrate-N concentrations below the corn root zone.

METHODS

Field studies to determine the effects of land-applied sweet corn processing wastes on the amount and rate of nitrate release and use of this N by subsequent crops were conducted at the Arlington Agricultural Research Station on a Plano silt loam soil beginning in 1992. Methods used for the time frame included in this report (1994 and 1995) are discussed below.

First-Year Effect Site (1994 growing season)

Six rates (0, 25, 50, 100, 150, and 200 tons/a wet basis) of sweet corn processing residue were applied in August, 1993. Additional residue rates of 50, 100, 150, and 200 tons/a were applied to accommodate an N fertilizer (as ammonium nitrate) rate of 60 lb/a applied in spring, 1994. Nitrogen fertilizer was also applied at rates of 60, 90, 120, and 150 lb/a to the 0 tons/a residue rate to determine the optimum N rate for this site. The initial plot size was 15-ft wide by 40-ft long and trimmed to 30-ft long. A randomized complete block design with four replications was used. The effect of residue rate on corn emergence was measured at three dates in May, 1994. The effect of residue and N fertilizer rate on plant height (extended leaf) was measured approximately eight weeks after planting.

Second-Year Effect Sites (1994 and 1995 growing seasons)

Research was also conducted to determine the residual (second-year after application) effects of residue application. Residual effects of the fall, 1992 application were studied in 1994, and effects of the fall, 1993 application were studied in 1995. No additional residue or N fertilizer was applied to the existing treatments in the second-year following application except where 150 lb fertilizer N/a was applied to the initial 0 tons/a residue plus 60 lb N/a treatment in order to have a non-limiting N rate treatment.

Consecutive-Year Effect Sites (1994 and 1995 growing seasons)

Sweet corn processing residue was applied at three rates (0, 100, and 200 tons/a) for two consecutive years (fall, 1992 and 1993). The effect of these consecutive residue treatments was studied in 1994 and 1995. There was no additional N fertilizer applied to these plots.

All Sites

Field corn was grown and harvested as silage prior to the August residue applications. The residue was obtained from a local processing plant and weighed, transported, and applied using a front-end loader. Residue was uniformly distributed within each plot area and sites were disked and moldboard plowed about 1-2 weeks following application. Seedbed preparation was done the following spring using a soil finisher just prior to planting. Corn (P3578) was planted around May 1 at a density of 32,000 seeds/a and hand thinned to a uniform density of 26,000 plants/a in mid June. Conventional methods were used to control weeds and insects.

Porous ceramic cup samplers were installed according to methods used by Linden (1977) to a four-ft depth in selected treatments in the first spring following residue application and remained in the field for two growing seasons. Soil water samples were obtained on a bi-weekly basis and analyzed for nitrate.

Soil profile samples were collected monthly in selected treatments following residue application through July and at the end of the first growing season (October) in the first-year effect study. Soil profile samples were collected in April, June, and October in the second- and consecutive-year effect studies. All soil samples were analyzed for nitrate and ammonium.

Corn dry matter yields were obtained at physiological maturity from selected treatments by hand harvesting 10 plants per plot, weighing, chopping, and subsampling for dry matter percentage and total N concentration determination. Grain yield was determined by machine harvesting all the ears from a 30-ft plot length of the two center rows and a subsample was retained for moisture determination. Reported grain yields reflect a 15.5% moisture content.

RESULTS AND DISCUSSION

Corn Growth, Yield, and Total Plant N Uptake

First-Year Effects

The effect of residue rate on corn emergence at three May, 1994 sampling dates was not significantly different (Fig. 1). Treatment effects of residue and N fertilizer rates on plant height was also not significantly different; however, a trend towards increased plant height was observed where treatments (either residue or N fertilizer) were applied compared with the control treatment (Table 1).

The effect of residue and N fertilizer rate on corn grain yield, dry matter content, and total plant N uptake was not significant in 1994 (Table 2). Grain yield was 211 bu/a in the control treatment indicating adequate N availability and ideal corn growing conditions in this year. The absence of significant yield response to added N was due to high soil N contributions from residual nitrate or high organic N mineralization rates caused by previous management practices not related to the sweet corn residue additions.

Second-Year Effects

Residual treatment effects on corn grain yield in the second year following treatment application was significant in 1994 (Table 3). Grain yields at the 25, 50, 100, and 150 tons/a rates were significantly higher than the control treatment and significantly lower than the 200 tons/a rate treatment. Corn grain yields for the 50, 100, and 150 tons/a residue rate plus 60 lb fertilizer N/a were not significantly different than the 200 tons/a residue rate. This indicates that the 200 tons/a rate supplied enough available N to obtain optimum yields for a 2-year period and lower residue rates needed supplemental N additions to meet crop demand in the second year following residue application. The latter is more desirable in terms of N management in order to avoid an increased potential for nitrate loss to groundwater. Treatment effects on plant dry matter content and total plant N uptake were not significant but a trend towards greater amounts was apparent on treatments where N availability was non-limiting.

In 1995, residual treatment effects on grain yield, plant dry matter content, and total plant N uptake were not significant (Table 4). The absence of significant yield response to added N at this site for the second year was due to high soil N contributions from residual nitrate or high organic N mineralization rates caused by previous management practices not related to the sweet corn residue additions. This site was located adjacent to a sheep facility which did not have manure applied in recent years but apparently received large additions of manure in the past resulting in high organic N mineralization rates for many years following.

Consecutive-Year Effects

The effect of sweet corn residue applied at three rates (0, 100, and 200 tons/a) in consecutive years (August, 1992 and 1993) on grain yield, plant dry matter content, and total plant N uptake in 1994 and 1995 is shown in Table 5. Consecutive residue applications of 100 and 200 tons/a resulted in significantly higher grain yields (at 95% probability level) and plant dry matter content and total plant N uptake (at 90% probability level) compared to the control treatment (0 tons/a) in 1994. In 1995, intermediate values for yield, dry matter content, and N uptake occurred at the 100 tons/a rate compared with the 0 and 200 tons/a rates. These results indicate that the 100 tons/a rate was an agronomically and environmentally desirable treatment in that it supplied all of the crop N needs in the first year and but needed some supplemental N to meet the total crop N demand in the second year.

Soil Inorganic N

First-Year Effects

Initial soil profile nitrate-N content of the experimental site on 9/3/93 was 96 lb/a in the top three feet. Soil samples obtained two months later (11/1/93) showed nitrate-N contents about two times this amount in the top two feet for all treatments regardless of residue rate due to high organic N mineralization due to past management practices not related to residue applications. Preplant (PPNT) soil nitrate samples obtained the following spring (4/4/94) indicated little change in nitrate contents occurred during the over-winter period where no residue was applied but nitrate content increased as the residue rate increased. This over-winter period increase in soil nitrate-N content due to addition of residue was 13, 25, 56, 91, and 126 lb/a in the top two feet at the 25, 50, 100, 150, and 200 tons/a rates, respectively. By 5/24/94 soil nitrate-N contents in the top two feet increased by 84 lb/a where no residue was applied to 221 lb/a where 200 tons/a was applied. By 7/28/94, the soil nitrate content in the 0 tons/a residue rate treatment decreased by 212 lb N/a in the top three feet primarily due to increasing plant N uptake during this 60-day period. Where residue was applied, soil nitrate-N contents in the top three feet decreased by 127, 125, 86, and 60 lb/a at the 25, 50, 100, and 150 tons/a rates, respectively, and increased by 74 lb/a at the 200 tons/a residue rate. This continued increase in soil nitrate content during the primary corn N uptake period for the 200 tons/a residue treatment indicates an extremely excessive residue rate for this site.

End-of-season soil nitrate-N contents (10/31/94) in the 0-3 ft depth ranged from 74 lb/a where no residue was applied to 703 lb/a where 200 tons/a was applied. Recent research indicates excessive N levels were available to corn if end-of-season soil nitrate-N contents are greater than 100 lb/a in the top two feet (Bundy and Andraski, 1996). End-of-season soil nitrate-N contents in the top two feet at this site for residue rates of 0, 25, 50, 100, 150, and 200 tons/a were 61, 44, 132, 321, 451, and 555 lb/a, respectively.

End-of-season soil nitrate-N contents at the 2- to 3-ft depth was similar at residue rates of 0 and 50 tons/a indicating little effect of land application at the 50 tons/a rate on nitrate losses out of the root zone at this site in 1994. Based on soil profile nitrate distribution comparisons between the 0 and 50 tons/a residue rates, it appears that none of the N mineralized from residue at the 50 tons/a rate was lost from the root zone within the first year of application. Therefore, an estimate of available N released from residue in the first year can be determined by the N uptake difference observed between treatments and the change in soil nitrate-N content (April to October) differences observed between treatments. Based on this method of calculation, N uptake for the 50 tons/a residue treatment was 22 lb/a greater and the change in soil nitrate content from April through October was 90 lb N/a greater compared to the 0 tons/a treatment. Therefore the total estimated available N released from 50 tons/a of residue during the first year following application was 112 lb/a or 2.24 lb/ton of sweet corn residue (wet basis) in 1994.

Second-Year Effects

Preplant (4/14/94) soil nitrate-N contents following fall, 1992 residue applications were highest where high residue and N fertilizer rates were applied (Table 7). Soil nitrate contents decreased as the growing season progressed. An exception to this trend was at the 200 tons/a residue rate where soil nitrate content increased slightly between the April and June sampling dates indicating N mineralization was occurring faster than plant N uptake. It is interesting to note the difference in nitrate distribution in the soil profile on 4/14/94 between the N fertilizer treatment of 150 lb/a and residue treatments. For example, 21% of the total soil nitrate in the top three feet is in the 2- to 3-ft depth for the N fertilizer treatment (33 of 160 lb/a) compared with only 6% (9 of 140 lb/a) at the 200 tons/a residue treatment. This reflects slower release of available N from residue during the previous growing season resulting in slower downward movement of nitrate through the soil profile compared with the fertilizer N treatment. Relatively little soil nitrate remained in the profile at the end of the growing season for all treatments (10/13/94)

Second-year effects of fall, 1993 residue and 1994 fertilizer N rates on 1995 soil profile nitrate contents are shown in Table 8. High soil nitrate-N contents occurred in the top three feet on 4/14/95. Soil nitrate-N contents ranged from 151 lb/a in the control treatment to 486 lb/a in the 200 tons/a residue treatment. Nitrate-N contents generally increased with soil depth. As expected, treatment effects on grain yield were not significant due to high soil nitrate contents of this site not related to residue application. Soil profile nitrate-N contents decreased from April to June by 33 lb/a in the control treatment, 109 lb/a at the 150 lb N/a fertilizer treatment, 61 lb/a at the 100 tons/a residue treatment, and 196 lb/a at the 200 tons/a residue treatment. Although soil nitrate-N contents in April were similar for the 150 lb N/a fertilizer and 100 tons/a residue treatments, June soil nitrate-N content at the 2- to 3-ft depth decreased by 76 lb/a for the fertilizer treatment compared to only 3 lb/a for the residue treatment. Change in soil nitrate-N content (0-3 ft) from June to late September decreased by 38 lb/a for the 150 lb N/a fertilizer treatment compared to 58 lb/a for the 100 tons/a residue treatment. This observation once again suggests that excessive N rates from fertilizer may exit the root zone slightly sooner than excessive N rates from sweet corn residue; however, the fate of excessive soil nitrate levels is the same regardless of the source.

Consecutive-Year Effects

The effect of fall, 1992 and 1993 sweet corn residue rates on 1994 and 1995 soil profile nitrate-N contents is shown in Table 9. Residue rate effects on soil nitrate-N contents taken in April, 1994 ranged from 107 to 183 lb/a in the top three feet. Soil nitrate contents in the residue treatments increased markedly from April to June and slightly decreased at the end of the growing season compared with the control treatment which continually decreased throughout the 1994 growing season. Soil profile nitrate-N contents in October were 33, 155, and 359 lb/a in the 0, 100, and 200 tons/a residue treatments, respectively. Downward nitrate movement in the soil profile between October, 1994 and April, 1995 was apparent for all treatments. Where residue was applied, 15% of the October, 1994 total soil profile nitrate-N content was found at the 2- to 3-ft depth compared to 38% the following spring (April 1995) indicating significant downward nitrate movement from the upper soil profile during the overwinter period.

Soil nitrate contents continually decreased throughout the 1995 growing season due to crop uptake, less N mineralization of residue, and nitrate losses from the root zone. Soil profile nitrate-N contents decreased by 61, 197, and 284 lb/a during the growing season in the 0, 100, and 200 tons/a residue treatments, respectively. Relatively little soil nitrate remained at the end of the 1995 growing season.

Soil Water Nitrate

The effect of single residue and N fertilizer treatments on soil water nitrate-N concentrations at the 4-ft depth for the first- and second-year effect studies is shown in Figures 2 and 3. The effect of consecutive residue applications on soil water nitrate-N concentrations for a period of two years is shown in Figure 4. Figures 3 and 4 show soil water nitrate-N concentrations ranging from 20 to 30 ppm at the onset of the study in the control treatment and decreasing to about 5 to 20 ppm at the end of the first growing season (1994). Nitrate concentrations in the residue and N fertilizer treatments tended to follow the same trend but were about 10 ppm higher than the control in the first year. The exception was the 200 tons/a residue treatment in which soil water nitrate-N concentrations began increasing around August, 1994 and were 60 to 70 ppm by November and increased to 120 ppm by August, 1995 indicating very excessive N availability for these sites. The second-year effect study in 1994 (Fig. 2) had much lower nitrate-N concentrations at this 200 tons/a rate and was only about 20 ppm at the end of the season. Unlike the second-year effect study in 1995 (Fig. 3), this was an N responsive site and resulted in crop uptake of available N from this high residue rate with much less nitrate loss from the root zone.

Soil water nitrate-N concentrations over a 2-year period appear to be relatively similar for the 150 lb N/a fertilizer, 50 tons/a residue plus 60 lb N/a fertilizer, and the 100 tons/a residue treatments. This suggests that land-application of sweet corn residue at rates up to 100 tons/a in the first year will not pose an increased environmental risk of nitrate loss to groundwater compared to current N fertilizer rates (160 lb/a) used for corn production. Continued land-application of residue at excessive rates would increase soil water nitrate levels and the potential for nitrate contamination of groundwater as seen in Figure 4.

SUMMARY AND CONCLUSIONS

1. Sweet corn processing residue can be land-applied on N responsive sites at rates up to 100 wet tons/acre when a high nitrogen demand crop such as field corn will be grown the following year.
2. At the 100 tons/acre residue rate, addition of supplemental fertilizer N may be needed in some years to maximize field corn yields.
3. The 100 tons/acre residue rate is not expected to cause greater accumulation of nitrate in the soil profile or higher risk of nitrate leaching to groundwater than typical rates of fertilizer N applied to field corn.
4. An additional 30 to 70 lb/acre of available N usually will be provided to a crop grown in the second year after residue application. The second-year effects of residue treatments should be considered to avoid excess N applications in the second year after residues are land-applied.
5. If sweet corn residues are applied to the same land in consecutive years, the maximum rate in the second year must be reduced. A maximum application rate in the second consecutive year of application probably should not exceed 50 wet tons/acre.

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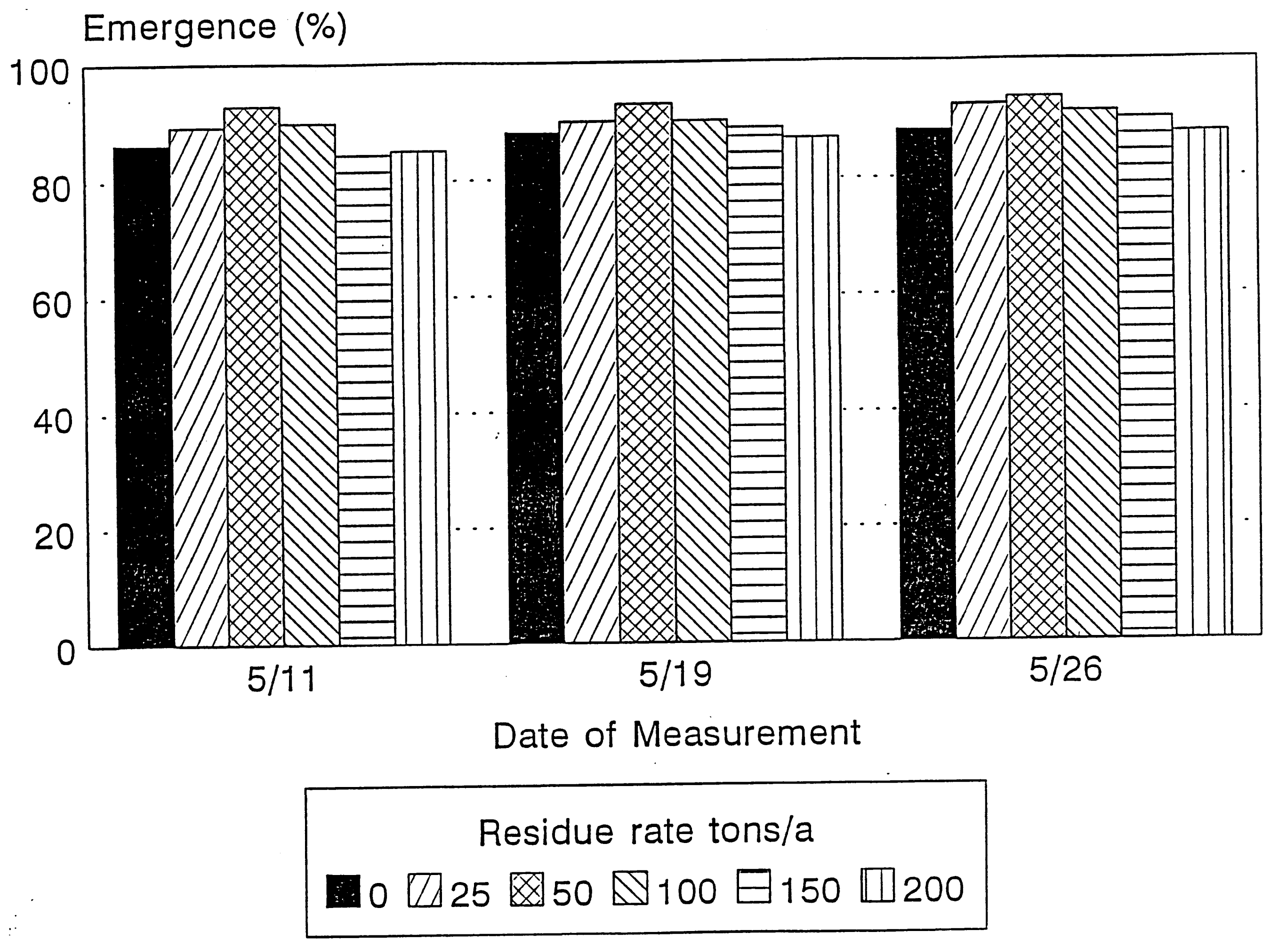

Figure 1. Effect of sweet corn residue rate (applied 8/93) on corn emergence, 1994 (First-Year Effect).

Table 1. Effect of SCPR rate (applied 8/93) and 1994 N rate on plant height taken on June 30, 1994 (First-Year Effect).

Treatment		
Residue rate	N rate	Plant height
tons/a	lb/a	inches
0	0	65.7
0	60	69.7
0	90	66.1
0	120	71.3
0	150	66.1
25	0	62.9
50	0	68.9
50	60	70.1
100	0	72.0
100	60	72.4
150	0	72.4
150	60	68.1
200	0	71.7
200	60	68.9

P > F = 0.47 (not significant).

Table 2. Effect of SCPR rate (applied 8/93) and 1994 N rate on corn grain yield, total dry matter content, and total plant N uptake, 1994 (First-Year Effect).

Treatment				
Residue rate	N rate	Grain yield	Dry matter	Plant N uptake
tons/a	lb/a	bu/a	tons/a	lb/a
0	0	211	9.1	262
0	60	222	9.8	287
0	90	220	9.4	298
0	120	220	9.1	277
0	150	218	9.4	275
25	0	227	9.2	264
50	0	221	9.7	284
50	60	224	8.7	246
100	0	227	9.7	288
100	60	217	9.7	274
150	0	223	9.8	281
150	60	215	9.0	259
200	0	224	10.0	294
200	60	216	10.1	301
P > F		0.91(NS)	0.81(NS)	0.87(NS)

NS = not significant.

Table 3. Effect of SCPR rate (applied 8/92) and 1993 N rate on corn grain yield, total dry matter content, and total plant N uptake, 1994 (Second-Year Effect).

Treatment: Residue rate	Treatment: 1993 N rate	Grain yield	Dry matter	Plant N uptake
tons/a	lb/a	bu/a	tons/a	lb/a
0	0	139 e *	7.6	188
0	90	158 de		
0	120	198 ab		
0	150	181 abcd	8.7	223
0	60(150 in 1994)	186 abc	8.9	226
25	0	172 bcd	7.4	177
50	0	156 de	7.6	148
50	60	178 abcd		
100	0	159 cde	7.6	177
100	60	175 bcd		
150	0	162 cde	8.5	213
150	60	203 a		
200	0	192 ab	8.5	207
200	60	200 ab		
P > F		0.0007	0.58(NS)	0.58(NS)

* Values followed by the same letter are not significantly different using Fisher's LSD (0.05) test.

NS = not significant.

Table 4. Effect of SCPR rate (applied 8/93) and 1994 N rate on corn grain yield, total dry matter content, and total plant N uptake, 1995 (Second-Year Effect).

Treatment				
Residue rate	1994 N rate	Grain yield	Dry matter	Plant N uptake
tons/a	lb/a	bu/a	tons/a	lb/a
0	0	162	7.8	192
0	90	169		
0	120	173		
0	150	177	7.9	191
0	60(150 in 1995)	173	8.3	234
25	0	173	8.0	198
50	0	169	8.4	209
50	60	175		
100	0	170	8.6	213
100	60	167		
150	0	166	8.7	235
150	60	173		
200	0	173	9.4	249
200	60	168		
P > F		0.92(NS)	0.19(NS)	0.09(NS)

NS = not significant.

Table 5. Effect of SCPR rate (applied 8/92 and 8/93) and N rate on corn grain yield, total dry matter content, and total plant N uptake in 1994 and 1995 (Consecutive-Year Effect).

Treatment: Residue rate	Treatment: N rate		Grain yield	Dry matter	Plant N uptake
tons/a	lb/a		bu/a	tons/a	lb/a
			Year 1994		
0	0		180 b *	7.8	194
100	0		214 a	9.9	300
200	0		200 a	9.2	268
		(P > F)	0.01	0.10(NS)	0.08(NS)
			Year 1995		
0	0		113 b	5.9 b	100 c
100	0		145 ab	7.7 a	161 b
200	0		166 a	9.2 a	229 a
		(P > F)	0.03	0.006	0.006

* Values followed by the same letter are not significantly different using Fisher's LSD (0.05) test.

NS = not significant.

Table 6. Effect of SCPR rate (applied 8/93) and 1994 N rate on soil NO_3-N content at several depths from 9/93 through 10/94 (First-Year Effect).

Date	Residue rate	1994 N rate	Soil depth, ft 0-1	1-2	2-3	(0-2)	(0-3)
	tons/a	lb/a	soil NO_3-N, lb/a				
9/3/93	0	0	25	27	44	(52)	(96)
11/1/93	0	0	58	52		(110)	
	25	0	33	36		(69)	
	50	0	33	38		(71)	
	100	0	45	44		(89)	
	150	0	62	48		(110)	
	200	0	63	42		(105)	
4/4/94	0	0	60	55	48	(115)	(163)
	25	0	44	43	51	(87)	(138)
	50	0	53	56	45	(109)	(154)
	100	0	83	67	46	(150)	(196)
	150	0	117	89	52	(206)	(258)
	200	0	134	102	74	(236)	(310)
5/24/94	0	0	126	73	63	(199)	(262)
	25	0	127	40	33	(167)	(200)
	50	0	117	56	39	(173)	(212)
	100	0	149	72	47	(221)	(268)
	150	0	313	96	55	(409)	(464)
	200	0	316	141	75	(457)	(532)
6/29/94	0	0	75	35	42	(110)	(152)
	25	0	97	47	32	(144)	(176)
	50	0	91	40	32	(131)	(163)
	100	0	183	59	34	(242)	(276)
	150	0	227	110	53	(337)	(390)
	200	0	322	157	69	(479)	(548)
7/28/94	0	0	15	14	21	(29)	(50)
	25	0	26	20	27	(46)	(73)
	50	0	47	18	22	(65)	(87)
	100	0	94	55	33	(149)	(182)
	150	0	229	129	46	(358)	(404)
	200	0	292	222	92	(514)	(606)
10/31/94	0	0	44	17	13	(61)	(74)
	0	60	70	44	23	(114)	(137)
	0	90	70	73	34	(143)	(177)
	0	120	83	134	40	(217)	(257)
	0	150	97	108	67	(205)	(272)
	25	0	28	16	16	(44)	(60)
	50	0	82	50	23	(132)	(155)
	50	60	119	100	42	(219)	(261)
	100	0	163	158	57	(321)	(378)
	100	60	130	133	54	(263)	(317)
	150	0	198	253	57	(451)	(508)
	150	60	171	186	72	(357)	(429)
	200	0	276	279	117	(555)	(672)
	200	60	272	297	134	(569)	(703)

Table 7. Effect of SCPR rate (applied 8/92) and 1993 N rate on soil NO_3-N content at several depths during the 1994 growing season (Second-Year Effect).

Date	Residue rate	1993 N rate	Soil depth, ft				
			0-1	1-2	2-3	(0-2)	(0-3)
	tons/a	lb/a	soil NO_3-N, lb/a				
4/14/94	0	0	51	14	23	(65)	(88)
	0	150	73	54	33	(127)	(160)
	50	0	47	14	6	(61)	(67)
	100	0	79	23	8	(102)	(110)
	100	60	67	40	19	(107)	(126)
	200	0	100	31	9	(131)	(140)
6/27/94	0	0	46	22	10	(68)	(78)
	0	150	42	28	32	(70)	(102)
	50	0	40	13	8	(53)	(61)
	100	0	41	22	11	(63)	(74)
	100	60	56	31	18	(87)	(105)
	200	0	90	57	21	(147)	(168)
10/13/94	0	0	35	6	3	(41)	(44)
	0	150	45	9	4	(54)	(58)
	50	0	32	7	2	(39)	(41)
	100	0	32	10	3	(42)	(45)
	100	60	50	17	9	(67)	(76)
	200	0	53	15	9	(68)	(77)

Table 8. Effect of SCPR rate (applied 8/93) and 1994 N rate on soil NO_3-N content at several depths during the 1995 growing season (Second-Year Effect).

Date	Residue rate	1994 N rate	Soil depth, ft 0-1	1-2	2-3	(0-2)	(0-3)
	tons/a	lb/a	soil NO_3-N, lb/a				
4/14/95	0	0	45	57	49	(102)	(151)
	0	150	32	73	105	(105)	(210)
	50	0	36	65	77	(101)	(178)
	100	0	53	99	80	(152)	(232)
	100	60	52	115	116	(167)	(283)
	200	0	84	191	211	(275)	(486)
6/28/95	0	0	50	26	42	(76)	(118)
	0	150	47	25	29	(72)	(101)
	50	0	47	28	44	(75)	(119)
	100	0	55	39	77	(94)	(171)
	100	60	58	34	86	(92)	(178)
	200	0	80	64	146	(144)	(290)
9/28/95	0	0	25	8	4	(33)	(33)
	0	150	40	13	10	(53)	(63)
	50	0	40	13	13	(53)	(66)
	100	0	63	18	32	(81)	(113)
	100	60	53	17	49	(70)	(119)
	200	0	98	45	94	(143)	(237)

Table 9. Effect of SCPR rate (applied 8/92 and 8/93) on soil NO_3-N content at several depths during the 1994 and 1995 growing seasons (Consecutive-Year Effect).

Date	Residue rate	N rate	Soil depth, ft 0-1	1-2	2-3	(0-2)	(0-3)
	tons/a	lb/a	soil NO_3-N, lb/a				
4/14/94	0	0	57	24	26	(81)	(107)
	100	0	73	24	25	(97)	(122)
	200	0	118	33	32	(151)	(183)
6/28/94	0	0	51	13	18	(64)	(82)
	100	0	142	47	26	(189)	(215)
	200	0	218	108	48	(326)	(374)
10/13/94	0	0	25	5	3	(30)	(33)
	100	0	86	47	22	(133)	(155)
	200	0	160	142	57	(302)	(359)
4/14/95	0	0	23	29	24	(52)	(76)
	100	0	59	89	77	(148)	(225)
	200	0	85	137	152	(222)	(374)
6/29/95	0	0	32	12	17	(44)	(61)
	100	0	50	29	45	(79)	(124)
	200	0	65	50	90	(115)	(205)
9/28/95	0	0	12	2	1	(14)	(15)
	100	0	21	4	3	(25)	(28)
	200	0	51	11	28	(62)	(90)

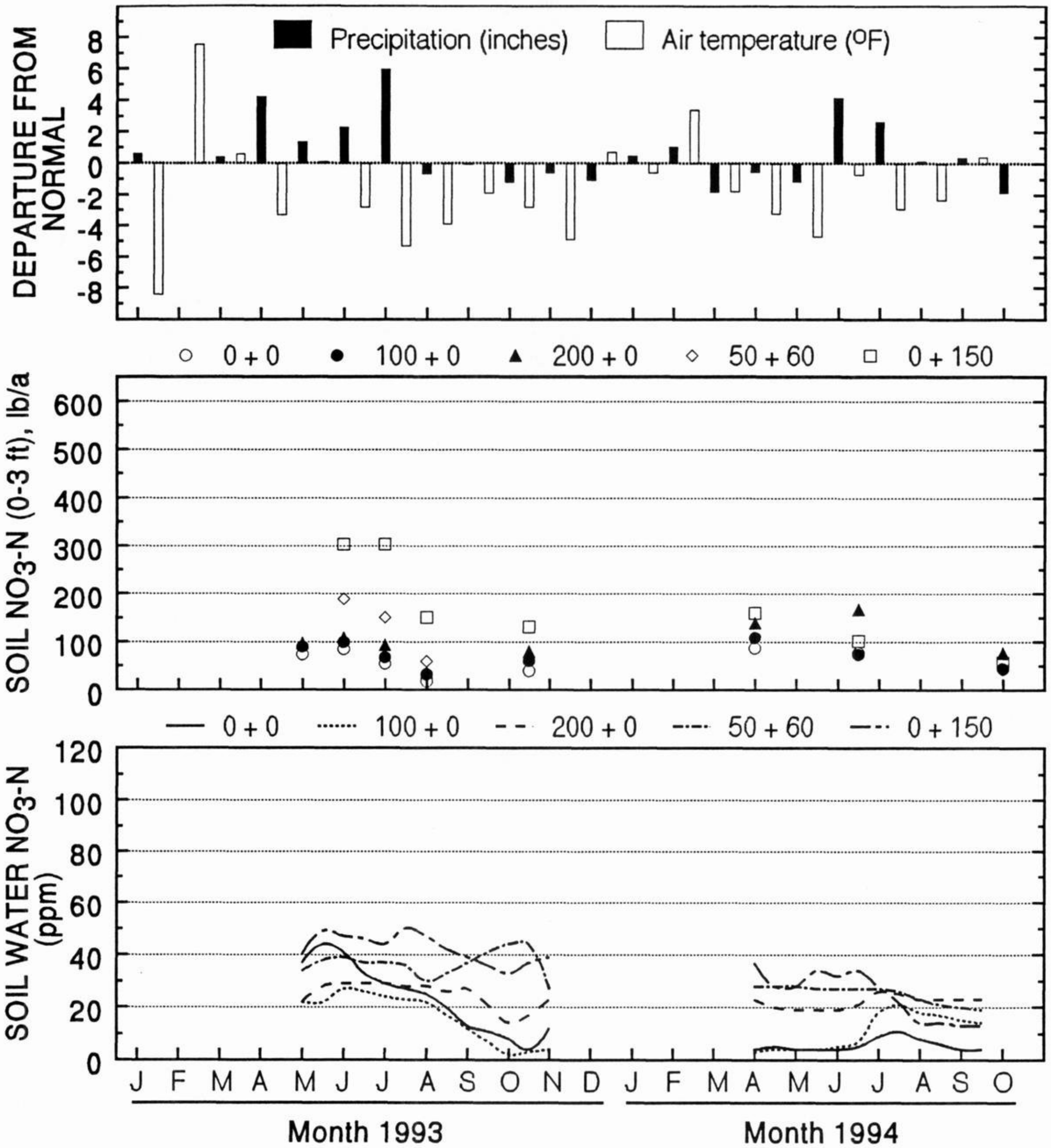

Figure 2. Effect of sweet corn residue (applied 8/92) and N fertilizer rate on soil water nitrate-N content (4-ft depth), soil nitrate content (0-3 ft), and precipitation and air temperature at various times in 1993 and 1994.

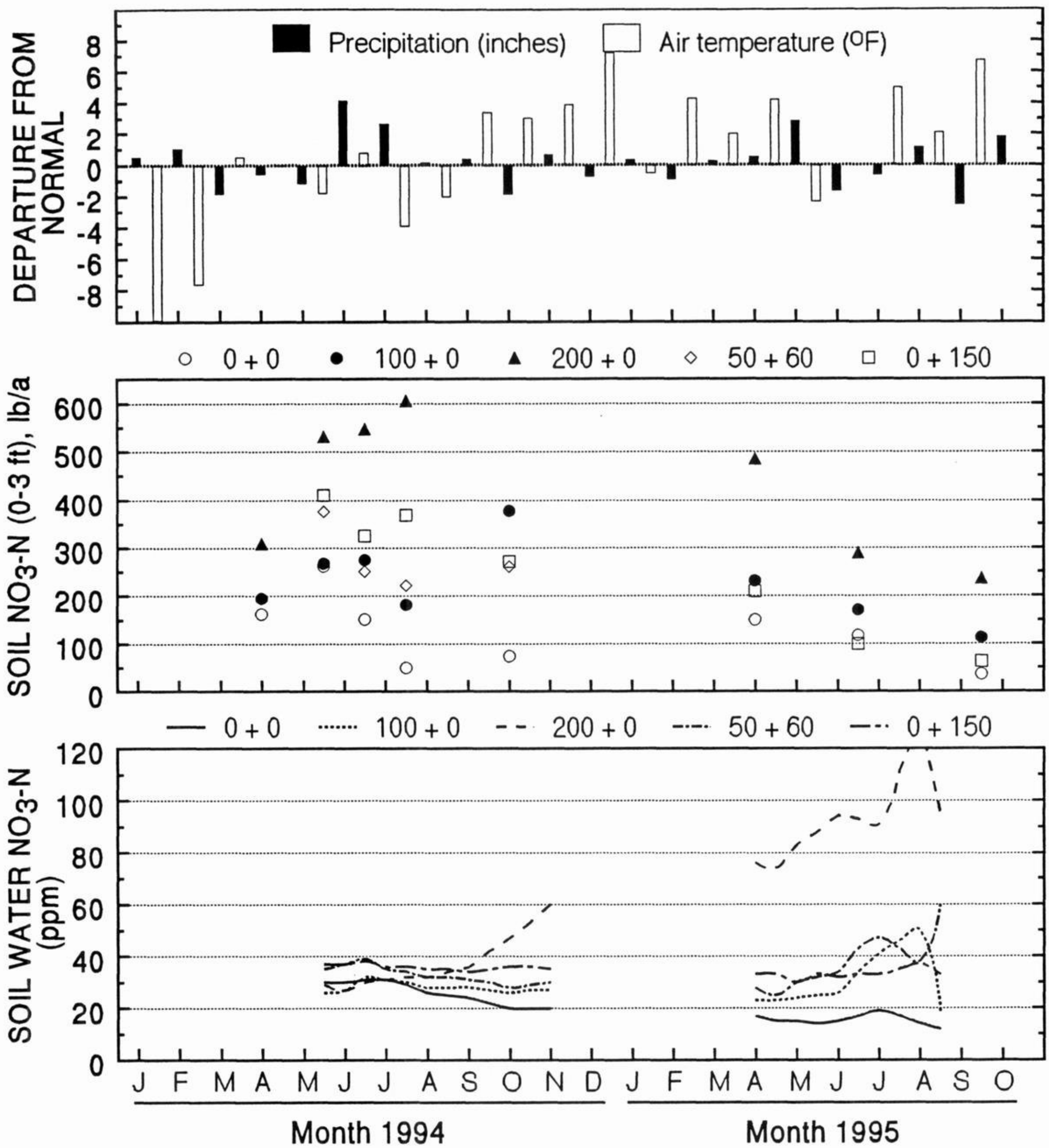

Figure 3. Effect of sweet corn residue (applied 8/93) and N fertilizer rate on soil water nitrate-N content (4-ft depth), soil nitrate content (0-3 ft), and precipitation and air temperature at various times in 1994 and 1995.

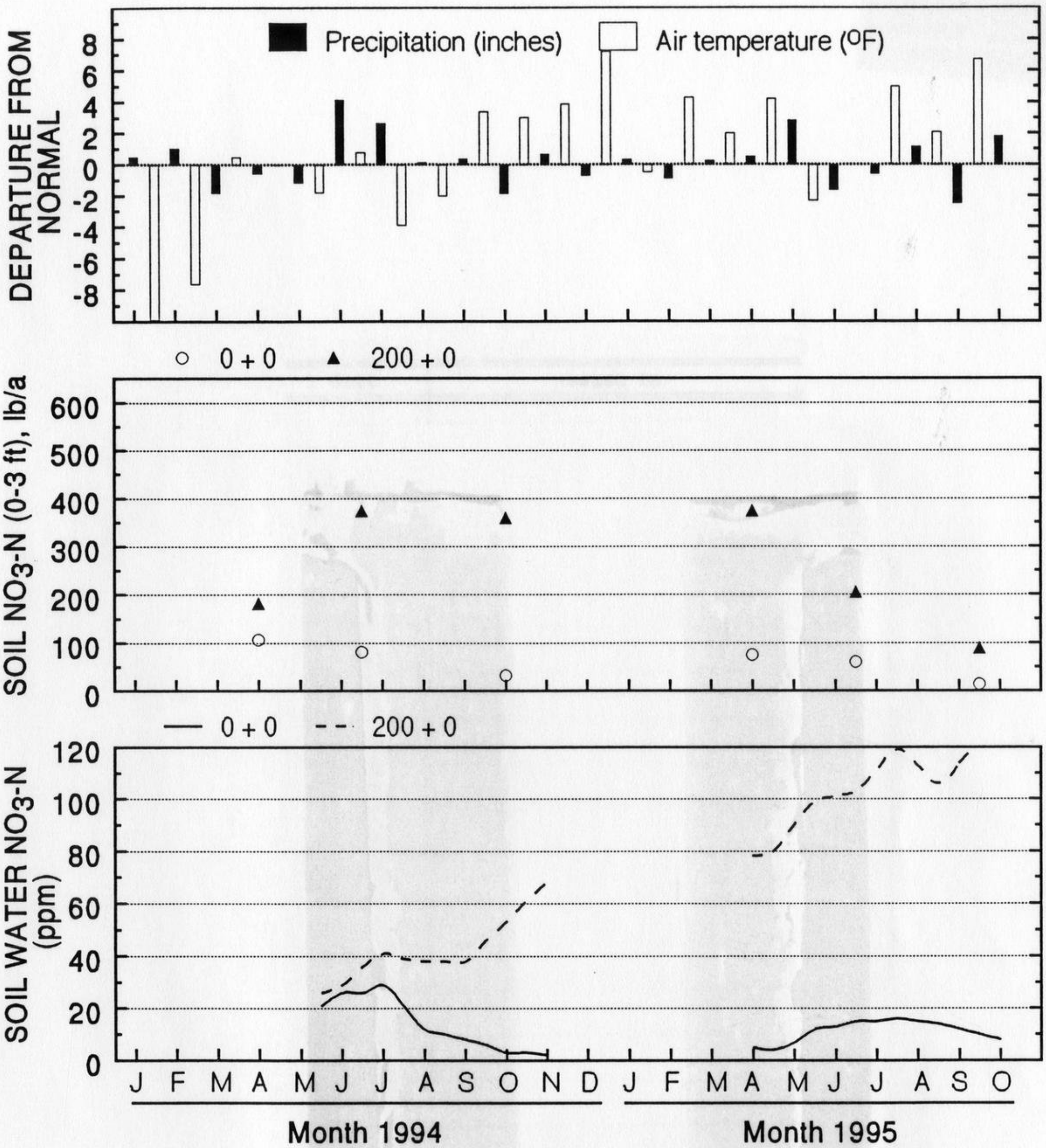

Figure 4. Effect of sweet corn residue rate (applied 8/92 and 8/93) on soil water nitrate-N content (4-ft depth), soil nitrate content (0-3 ft), and precipitation and air temperature at various times in 1994 and 1995.

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