LAND SPREADING OF YARD WASTE

Final Report Submitted to the

Legislative Commission on Minnesota Resources

ML91, CH.254, ART. 1, SEC. 14, SUBD. 12(b)

by

Department of Soil Science
University of Minnesota

July 1993

1991-12b

LAND SPREADING OF YARD WASTE

Carl Rosen, Thomas Halbach, Jean Molina, David Birong, and Jennifer Weiszel

ABSTRACT: A field experiment at the Sand Plain Research Farm in Becker, Minn. was conducted to determine the effects of land applying yard waste (primarily tree leaves) on corn production and soil nitrate movement. The yard waste was applied in the fall of 1991. Treatments included four rates of yard waste (0, 20, 40, and 80 T/A) with either no fertilizer N applied, 200 lbs N/A during the 1992 growing season, or 66 lbs N/A applied with the yard waste plus 200 lbs N/A applied during the growing season. Yard waste application initially inhibited growth and depressed tissue nitrogen composition of developing corn plants. The inhibitory effect diminished when fertilizer N was applied. These results suggest that soil N was immobilized for 5-6 weeks after planting. By harvest, corn grain yield increased with increasing yard waste application when no fertilizer N was applied, presumably due to release of nitrogen and possibly other nutrients from the yard waste. When N was added during the growing season, with or without fall applied N, the effect of yard waste on grain yield was generally not significant. Without added N fertilizer, yard waste increased N content of corn plant by about 1 lb N/A for each ton of yard waste applied up to 40 T/A. At the 80 T/A rate, N content increased by only 0.75 lb N/A for each ton of yard waste applied. Maturity, as measured by % moisture in the grain, was delayed with yard waste application. In addition to increasing tissue N, yard waste also increased tissue levels of P, K, Mg, and Zn. Nonessential heavy metals in corn tissue were generally below detection limits or not affected by yard waste application. Application of yard waste slightly increased soil pH and soluble salts. Extractable P, K, Ca, Mn, Zn and B also increased with yard waste application. Availability of nonessential heavy metals were not affected by yard waste application. Nitrate leaching tended to decrease with increasing yard waste during the first year after application. Highest nitrate-N concentrations in soil water at the three foot depth were recorded when N was applied in the fall with or without yard waste. During the first year after yard waste application, acceptable yields were obtained at all rates of applied yard waste combined with 200 lb N/A without significant nitrate losses. This study needs to be continued to determine nitrogen release rates from yard waste in subsequent years.

---

[1]Funding for this project was provided by the Legislative Commission for Minnesota Resources

[2]Extension Soil Scientist, Extension Waste Management Specialist, Assistant Scientist, and Senior Research Plot Technician, respectively, Department of Soil Science.

Rationale and Objectives: Until recently, yard wastes (tree leaves and grass clippings) accounted for 15-20% of the bulk in landfills. In 1990 (metro counties) and in 1992 (greater Minnesota), regulations were passed that prohibited dumping of yard wastes in landfills. Because of this legislation, alternatives to landfilling yard waste need immediate attention. Some options for using or recycling the yard waste include: 1) backyard composting and application of the compost to gardens; 2) municipal composting followed by land application of the compost; and 3) direct land application of noncomposted yard waste. While backyard composting is a desirable way to handle yard waste, not all homeowners desire to compost their own yard waste. Several problems with municipal yard waste composting include finding an acceptable site, controlling nutrient runoff, and controlling odors. Direct land application of noncomposted yard waste may be more efficient than composting and does not have the same problems associated with composting. Land application of yard waste may require an adjustment of nitrogen requirements, because of its generally low available nitrogen content. In addition, the effects on nitrogen use and crop production in general need to be ascertained. Therefore, the objectives of this study were to: 1) Determine the effects of direct application and incorporation of noncomposted yard waste (primarily tree leaves), with and without fertilizer nitrogen, on productivity of irrigated field corn, and 2) Characterize nitrogen release from the leaves during the growing in terms of availability for crop needs and movement through the soil profile.

Review of Literature: Many waste materials are currently being considered for land application including sewage sludge, food wastes, paper and yard wastes (Rynk, 1992). Direct land application is often less costly than composting because it involves less handling of materials and often has lower siting and regulatory costs. Major considerations for land application of waste include nutrient content and availability of the waste, nutrient needs of the crop, timing of waste application, and environmental degradation due to high trace metal content. The composition of yard waste is dependent on the time of the year. In the fall and early spring yard waste is primarily leaves with some grass clippings. In the summer, yard waste primarily consists of grass clippings. Yard waste high in grass clippings will have higher available nitrogen than yard waste high in tree leaves. The C/N ratio of tree leaves is between 40-80, while the C/N for grass clippings is 20 (Rosen et al., 1990).

Only a few studies have been reported that critically examine the effects of yard waste applications on crop growth and the environment. Many of the early studies using noncomposted waste tested municipal refuse and sewage sludge (King et al., 1974; Volk et al., 1973; Webber, 1978). While organic matter increased with addition of these materials, problems of incorporation, odor, aesthetics (Webber, 1978), and plant toxicity (King, et al. 1974) were reported.

Direct land application of yard waste is not hampered by the problems encountered with municipal refuse. The leaves are degradable and unsitely residues would not be present. Based on cost estimates, running a yard waste land application program is less than a full scale composting operation (Hgberg et al., 1990). States that have conducted experiments with land application of yard waste include New York (Nally, 1989), Minnesota (Buchite, 1990), and Wisconsin (Peterson, 1991). Land application of grass clippings has also been reported in Pennsylvania (Biocycle, 1991). All studies reported that metal levels in crop tissue were not affected by yard waste application. Peterson (1991) reported that corn yield was not consistently affected by yard waste amendment the year of application; however, a 30-50 bushel increase due to yard waste was measured in subsequent years. The yard waste increased available phosphorus and increased soil organic matter content. In New York, yard waste applications at high rates (40 tons/A wet weight) were shown to decrease yield if insufficient nitrogen fertilizer was supplied (Nally, 1989). Increasing nitrogen application rate was necessary to maintain corn yields in a Minnesota study (Buchite, 1990). In that study, application rates greater than 20 T/A required multiple tillage operations to obtain adequate incorporation. None of the studies reported qualitatively how much nitrogen could be expected to be released from the yard waste nor did any of the studies report on potential nitrate leaching losses with high yard waste applications.

PROCEDURES

The experiment was conducted at the Sand Plain Research Farm in Becker, MN on a Hubbard loamy sand soil. Initial soil chemical characteristics include (0-6"): organic matter, 1.7%; pH (1:1 soil:water), 6.8; Bray P1, 26 ppm; K (NH_4OAc), 61 ppm. Extractable (KCl) nitrate-N and ammonium-N in the top 3 feet were 30 lbs/A and 4 lbs/A, respectively. The previous crop was rye. Yard waste was collected in October 1991 and applied to 15' x 35' plots with a front end loader on October 31, 1991. The yard waste primarily consisted of tree leaves, although some garden plants and grass clippings were also present. Subsamples of yard waste applied to each plot were collected for the following chemical analyses: moisture, pH (1:1, water), C and S (dry combustion), N (Kjeldahl) and, P, K, Ca, Mg, Na, Al, B, Cr, Cu, Fe, Pb, Mn, Ni, and Zn (dry ashed, Munter and Grande, 1981). Twelve treatments were tested: 0, 20, 40, 80 dry tons/A yard waste (no added N); these same treatments with 200 lb N/A applied during 1992; these same treatments with 66 lb N/A applied in the fall of 1991 plus 200 lb N/A applied during 1992. The fertilizer N source used in all cases was urea. An average of 30% moisture was assumed for application of all yard waste treatments. The experimental design was a randomized complete block with 4 replications. Yard waste was incorporated to a depth of 8 inches with a rototiller after application (fall 1991) and the whole field was moldboard plowed to a depth of 8-10 inches one week prior to planting in 1992. In addition, 235 lbs/A 0-0-22 and 200 lbs/A 0-0-60 were broadcast and incorporated prior to planting. Pioneer hybrid 3751 (100 day maturity) was planted on April 28, 1992 at a population of 30,700 seeds/A (2.5 ft. between rows). At planting, 185 lbs/A 0-14-42 was banded 2 inches to the side and two inches below the seed. For the N treated plots, 100 lbs N/A was sidedressed on May 27, with a hand pushed Gandy fertilizer applicator and cultivated in. Additional N at a rate of 50 lbs/A per application was applied with the Gandy applicator on June 17 and June 22 and irrigated in with 0.5 inch of water. Irrigation was used to supplement rainfall (Figure 1).

Soil samples at the 0-8 inch depth were collected from each plot before planting. After harvest, soil samples were collected from 0-6, 6-12, 12-24 and 24-36 inch depths. Soil nitrate and ammonium were determined on 2 N KCl extracts (Carlson et al., 1990). On the 0-6 inch sample additional soil chemical determinations were made: pH and soluble salts (1:1, water), P (Bray P-1); K, Ca, Mg, Na (1N ammonium acetate), Fe, Mn, Zn, Cu, Pb, Ni, Cr, and Cd (DTPA); and B (hot water). Detailed methodolgy for soil extraction procedures can be found in Rosen and Munter (1992).

Suction tubes with ceramic cups were installed at a depth of 3 feet in two replications of each treatment. Suction tubes at the 6 foot depth were installed in two reps for the control and 40 T/A yard waste plus 266 lbs of N treatments. Water samples were collected every two weeks through the growing season and analyzed for nitrate. On one set of water samples (September 11), a more extensive elemental analysis was performed using an ICP spectrophotometer (Munter and Grande, 1981).

Whole plant samples (4 per plot) were collected at the three leaf stage (May 26) before fertilizer N was applied in 1992. Whole plant samples (4 per plot) at the 8-12 leaf stage were collected on June 26 after all fertilizer N was applied. Ear leaf samples at 50% silking were collected on July 28. Two, 20 foot rows were harvested for grain and stover yield from each plot on October 10. Subsamples of stover and grain plus cob were taken for moisture determinations, shelling percentages, and nitrogen analyses. Plant tissue samples were dried and then ground through a 30 mesh screen. Dried samples were digested in concentrated sulfuric acid and Kjeldahl nitrogen was determined using conductimetric procedures (Carlson, 1978).

RESULTS

Yard Waste Elemental Composition: The yard waste had an acid pH (Table 1). The average moisture content was 30% with a range of 18.6 - 48.1%. The outer part of the pile tended to be drier than the inner part. The C/N ratio averaged 37.8:1, which is on the low side for leaves, but is in a range that should initially immobilize N. The yard waste contained 21.2 lbs N/dry ton, 3.2 lbs P/dry ton (7.4 lbs P_2O_5), and 14.4 lbs K/dry ton (17.3 lbs K_2O). The yard waste contained significant quantities of Ca, Mg and S. Trace elements were also present in the yard waste, but were not at levels considered to be detrimental to the environment.

Corn Growth and Yield: Initial growth of corn was significantly inhibited as yard waste application rate increased (Table 2). Application of N tended to minimize the negative effect of yard waste application on initial corn growth. Greatest growth at the 8-12 leaf stage occurred when N was applied in the Fall and during the growing season. Yard waste application rate up to 40 T/A tended to increase final stand count. At the 80 T/A rate, stand count declined. Stand count also increased with increasing fertilizer N rate. At harvest, increasing yard waste rates increased grain yield when no N was applied, indicating a significant release of N from the yard waste. However, when N was added during the growing season with or without fall applied N, the effect of yard waste on grain yield was generally not significant.. There was a slight decrease in grain yield at the highest yard waste rate and when fall N plus 200 lb N/A was applied. Stover yield increased with increasing yard waste application and fertilizer N rate. Yard waste and low fertilizer N tended to delay maturity as measured by higher kernel moisture percentage.

Tissue Nitrogen Concentrations and Total Nitrogen Uptake: Nitrogen concentrations in whole plants sampled at the 3 leaf stage decreased as yard waste application increased (Table 3). These results indicate that early in the season N was immobilized by the yard waste. Fall applied N significantly increased N concentrations in the plant. By the 8-12 leaf stage, yard waste application was beginning to have a positive effect on N concentrations in the plant, while the effect of fall application of N began to diminish. Ear leaf N increased with increasing yard waste application when no fertilizer N was applied, but was not affected by yard waste when fertilizer N was applied. Application of fertilizer N increased N concentrations in the ear leaf. Cob N concentrations were not affected by yard waste application and were not consistently affected by fertilizer N application (Table 4). Stover N concentrations tended to increase with increasing yard waste application, primarily when no fertilizer N was applied. Application of fertilizer N also increased N concentrations in the stover. Kernel N increased with increasing application of yard waste and increasing fertilizer N application. As with other tissues, the effect of yard waste was most pronounced when fertilizer N was not applied.

Dry matter production increased with increasing yard waste rate up to the 40 T/A rate and then decreased even when fertilizer was applied; however, without inorganic N fertilizer, dry matter increased linearly with increasing yard waste application (Table 4). Applied N nearly doubled dry matter production; however, fall applied N did not significantly increase dry matter production compared to lower rates applied during the season. Similarly, without added N fertilizer, yard waste increased N content of corn plant by about 1 lb N/A for each ton of yard waste applied up to 40 T/A. At the 80 T/A rate, N content increased by only 0.75 lb N/A for each ton of yard waste applied. With added N, N uptake was highest with the 40 T/A yard waste rate. Given the growing conditions in 1992, the nitrogen rate used could probably have been lowered to take better advantage of N mineralized from the yard waste. As expected, N uptake increased with increasing N rate.

Tissue Elemental Concentrations: Concentrations of elements (except N) in kernel, stover, and cob are presented in Tables 5, 6, and 7, respectively. Yard waste application significantly increased kernel P, K, Mg, B, Mn, and Zn, and decreased kernel Cu. Concentrations of Cd, Pb, Ni, Cr, Al, Fe, and Mo were either below detection limits or not affected by yard waste application. Increasing N rate decreased kernel K, Mg, Ca, P and Zn, and increased Fe and Mn. Increasing K concentrations in kernels were greater with yard waste than with N fertilizer, resulting in a significant interaction. Increases in kernel Mn with yard waste application were greater at low N rates compared to the higher N rates.

Yard waste application increased stover K and decreased stover Ca. Increases in stover Zn and P with yard waste were dependent on N application, with greatest increases occurring at the low N rates. Decreases in stover Al, Fe, and Mg with yard waste were also dependent on N application, with greatest decreases occurring at the low N rates. Stover Mo decreased with increasing N rate, but was not consistently affected by yard waste application. Concentrations of Cd, Ni, and Pb were below detection limits. Stover B, Na, Cr, and Cu were not affected by yard waste application and inconsistently affected by N application.

Yard waste application increased cob Mn, P, and Zn. Concentrations of Cu in cobs also increased with yard waste application, but increases were dependent on N applied. Greater increases in cob Cu with yard waste occurred at the lower N rates. Cob K decreased with yard waste application. Cob Ca and Mg also decreased with yard waste application, but decreases were more pronounced at the lower N rates. Concentrations of Al, B, and Fe were not affected by yard waste application. While cob Cd, Cr, Mo, Na, Ni, and Pb were generally below detection limits.

<u>Soil Nitrate-Nitrogen Content</u>: Soil nitrate-nitrogen increased with increasing yard waste application in the top 6 inches, but was not significantly affected by yard waste at the lower depths (Table 8). Soil nitrate-nitrogen increased with increasing fertilizer N application, with the fall applied N treatment having the highest residual N in the top 3 feet. It is interesting to note, however, that the initial soil nitrate-N content of 30 lbs/A was higher than the soil nitrate-N content following any of the fertilizer N and/or yard waste treatments.

<u>Soil Chemical Properties</u>: Effect of yard waste and nitrogen application on soil pH, Bray P1, ammonium acetate extractable cations, DTPA extractable microelements, and hot water extractable B in the top 6 inches after harvest are presented in Table 9. Soil pH slightly increased with yard waste application (6.9 to 7.2) and slightly decreased with N application. Soluble salts increased with both yard waste and N application; however, levels were not in a range that would toxicity problems. Extractable P, K, Ca, Zn and B increased with increasing yard waste application, but were not affected by N application. Extractable Mn increased with increasing yard waste and N application rates. Extractable Mg, Na, Fe, Cu, Pb, and Ni were not affected by yard waste application, extractable Na, Fe, Cu, and Ni increased with increasing N application. Extractable Cd and Cr were generally below detection limits.

<u>Soil Water Elemental Concentrations:</u> Elemental concentrations in soil water sampled on September 11 are presented in Table 10. Al, B, Cd, Cr, Cu, Fe, Mo, Ni, and Pb were generally below detection limits of the ICP. Ca, K, Na, and S tended to increase with increasing yard waste application. P concentrations tended to increase with increasing yard waste when no fertilizer N was applied, but was not consistently affected when fertilizer N was applied. Except for soil water nitrate (see below), other elements determined in soil water were not affected by yard waste application or fertilizer N.

Soil Water Nitrate Concentrations: Concentrations of nitrate-N in soil water as affected by treatments are presented in Figures 2-13. Yard waste applications tended to decrease nitrate concentrations in soil water at the three foot depth when fertilizer N was not applied. The control treatment had the highest water nitrate-N concentrations with levels slightly above 10 ppm. When yard waste was applied, nitrate-N concentrations were less than 10 ppm. When fertilizer N was applied during the season, nitrate-N concentrations in soil water at the three foot depth tended to be highest at mid-season when 80 T/A yard waste was applied. However, by the end of the season, the 0 yard waste treatment with fertilizer N had the highest nitrate concentrations. Nitrate-N concentrations in soil water were greatest when fertilizer N was applied in the fall. Highest concentrations at mid-season were recorded when 0 T/A leaves were applied. Yard waste application tended to decrease nitrate-N concentrations; however, compared to the other N treatments, fall applied N resulted in the highest losses at the end of the growing season. From these measurements, yard waste amendments appear to reduce nitrate-N losses during the first growing season after application.

Literature Cited

BioCycle Staff. 1991. Agricultural utilization of yard waste. BioCycle 32(8):54-57.

Buchite, H. 1990. Landspreading of yard waste. Proc. Minn. Polln. Contr. Agency 7th Solid Waste Seminar. Bloomington, MN.

Hegberg, B.A., G.R. Brenniman, W.H. Hallenberck, and R.A. Wadden. 1990. Landspreading yard waste. Biocycle 31(12):60-62.

King, L.D., L.A. Rudgers, and L.R. Webber. 1974. Application of municipal refuse and liquid sewage sludge to agricultural land: I. Field study. J. Environ. Qual. 3:361-366.

Nally, T. 1989. Leaf spreading project - town of Pittsford: project report. Cornell Univ. Coop. Ext.

Peterson, A.E. 1991. Recycling leaves and yard waste: a growing opportunity. Resource Recycling 10(4):52-55.

Rynk, R. 1992. On-farm composting handbook. Northeast Regional Agric. Eng. Serv. Ithaca, NY. 186pp.

Volk, B.G., G.H. Snyder, G.J. Gascho, and P.H. Henderson. 1973. Cropland disposal of hydropulped municpal refuse 1. A greenhouse and growth chamber evaluation. Proc. Soil and Crop Sci. Soc. Fla. 32:95-99.

Webber, L.R. 1978. Incorporation of nonsegregated, noncomposted solid waste and soil physical properties. J. Environ Qual. 7:397-400.

Methods References

Carlson, R.M. 1978. Automatic separation and conductimetric determination of ammonia and dissolved carbon dioxide. Anal. Chem. 50:1528-1532.

Carlson, R.M., R.I. Cabrera, J.L. Paul, J. Quick, and R.Y. Evans. Rapid direct determination of ammonium and nitrate in soil and plant tissue extracts. Commun. Soil Sci. Plant Anal. 21:1519-1529.

Munter, R.C. and R.A. Grande. 1981. Plant tissue and soil extract analysis by ICP-atomic emission spectrometry,, p.653-672. In: R.M. Barnes (ed.). Developments in atomic plasma spectrochemical analysis. Heyden and Sons, London.

Rosen, C.J. and R.C. Munter. 1992. Nutrient management for commercial fruit and vegetable crops in Minnesota. Minnesota Extension Sevice. AG-BU-5886-F.

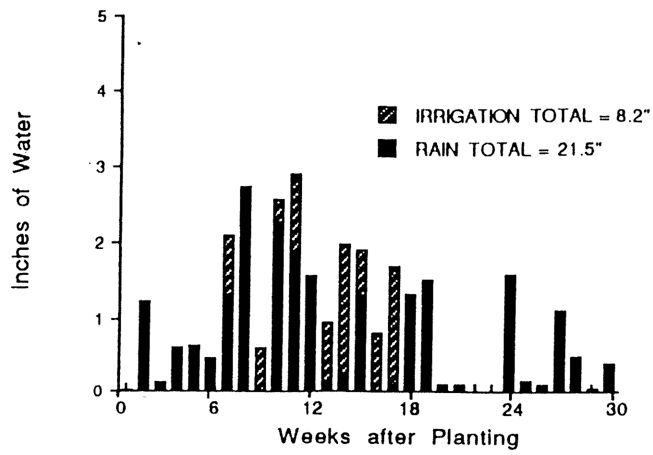


Figure 1. Rainfall and irrigation provided over the 1992 growing season.

Table 1. Elemental concentrations of original yard waste samples.

	Mean	Standard Deviation	Minimum	Maximum	lbs element/ dry ton
pH	4.9	0.2	4.4	5.5	
% moisture	29.7	7.7	18.6	48.6	
C to N ratio	37.9	3.2	29.6	42.6	
Macroelements (%)					
Carbon	39.76	3.49	33.56	45.95	795.2
Nitrogen	1.06	0.12	0.81	1.46	21.2
Phosphorus	0.16	0.02	0.12	0.20	3.2
Potassium	0.72	0.14	0.47	1.16	14.4
Calcium	2.33	0.25	1.75	2.75	46.6
Magnesium	0.37	0.04	0.27	0.49	7.4
Sulfur	0.19	0.02	0.15	0.22	3.8
Microelements (ppm)					
Aluminum	1052	464	254	1960	2.1
Boron	65	9	48	97	0.13
Cadmium	<0.52	0.35	<0.16	1.30	<0.10
Chromium	7.5	3.5	1.6	14.4	0.015
Copper	8.4	1.2	5.6	10.7	0.016
Iron	969	334	359	1755	1.9
Lead	<15.5	7.7	<2.2	39.6	<0.031
Manganese	249	40	177	399	0.50
Nickel	<6.5	3.3	<0.9	13.4	0.013
Sodium	105	23	60	163	0.21
Zinc	61	9	40	85	0.12

Table 2. Effect of yard waste and nitrogen application on whole plant dry matter at the 8-12 leaf stage, final stand count, grain yield, and kernel moisture.

Yard waste rate	Nitrogen application	Whole plant dry matter (8-12 leaf)	Final stand count	Grain yield	Kernel moisture
-tons/A-	--lbs/A--	-grams/plant-	-plants/A-	-bu/A-	- % -
0	0	16.0	26463	76	36
20	0	5.5	26789	99	39
40	0	8.8	28532	124	38
80	0	6.0	26681	130	36
0	200	21.8	27770	188	29
20	200	12.5	27334	185	34
40	200	9.3	27770	188	35
80	200	10.5	27770	182	35
0	66+200	29.3	27660	195	31
20	66+200	25.5	28859	203	30
40	66+200	15.0	28859	195	35
80	66+200	13.0	27661	176	34
Significance		**	NS	**	**
BLSD (5%)		9.3	--	20	3
Main effects					
	Yard Waste Rate				
	0	22.3	27298	153	32
	20	14.5	27661	162	34
	40	11.0	28387	169	36
	80	9.8	27370	162	35
	Significance	**	NS	NS	**
	BLSD (5%)	5.3	--	--	2
	Linear	**	NS	NS	**
	Quadratic	*	*	*	**
	Nitrogen Application				
	0	9.0	27116	107	37
	200	13.5	27661	186	33
	66+200	20.8	28260	192	32
	Significance	**	*	**	**
	BLSD (5%)	4.3	892	10	2
Interaction					
	Yard Waste x Nitrogen	NS	NS	**	*

NS = nonsignificant, * = significant at 5%, ** = significant at 1%.

Table 3. Effect of yard waste and nitrogen application on nitrogen concentrations in corn tissues at various growth stages.

Yard waste rate	Nitrogen application	Whole plant N 3 leaf stage	Whole plant N 8-12 leaf stage	Ear leaf N silking stage
-tons/A-	--lbs/A--	-----------------	% Nitrogen	----------------
0	0	4.19	1.74	1.34
20	0	3.19	2.49	1.97
40	0	3.03	2.57	2.05
80	0	2.80	3.00	2.31
0	200	4.21	3.14	2.89
20	200	3.20	3.80	2.94
40	200	3.16	3.96	2.68
80	200	3.19	3.71	3.04
0	66+200	4.32	3.08	3.00
20	66+200	4.39	3.30	2.51
40	66+200	4.10	3.57	2.95
80	66+200	3.60	3.66	2.94
Significance		**	**	**
BLSD (5%)		0.72	0.40	0.76
<u>Main effects</u>				
	<u>Yard Waste Rate</u>			
	0	4.24	2.66	2.35
	20	3.59	3.20	2.47
	40	3.43	3.36	2.56
	80	3.20	3.46	2.76
	Significance	**	**	NS
	BLSD (5%)	0.39	0.23	--
	Linear	**	**	NS
	Quadratic	*	**	NS
	<u>Nitrogen Application</u>			
	0	3.30	2.45	1.92
	200	3.44	3.65	2.89
	66+200	4.10	3.40	2.84
	Significance	**	**	**
	BLSD (5%)	0.34	0.19	0.33
<u>Interaction</u>				
	Yard Waste x Nitrogen	NS	NS	NS

NS = nonsignificant, * = significant at 5%, ** = significant at 1%.

Table 4. Effect of yard waste and nitrogen application on nitrogen concentrations, nitrogen content and dry matter accumulation in cob, stover and grain at harvest.

Yard waste rate	Nitrogen application	Nitrogen Concentration			Dry Mass				Nitrogen Content			
		Cob	Stover	Grain	Cob	Stover	Grain	Total	Cob	Stover	Grain	Total
-tons/A-	--lbs/A--	------- - % Nitrogen ---------			-------------- Ton/A -------------				------------ lb N/A -------------			
0	0	0.31	0.38	0.92	0.20	1.25	2.13	3.58	1.2	9.5	39.1	49.8
20	0	0.29	0.42	1.01	0.28	1.33	2.76	4.41	1.6	11.5	55.9	68.9
40	0	0.28	0.47	1.12	0.39	1.69	3.48	5.56	2.2	15.9	77.7	95.8
80	0	0.27	0.52	1.24	0.39	1.86	3.64	5.89	2.1	19.5	90.2	111.8
0	200	0.25	0.53	1.26	0.61	2.48	5.26	8.35	3.0	27.1	133.8	163.9
20	200	0.26	0.58	1.29	0.55	3.06	5.18	8.79	2.9	36.6	134.2	173.7
40	200	0.24	0.61	1.35	0.62	3.05	5.28	8.95	3.0	37.6	142.8	183.4
80	200	0.26	0.60	1.37	0.63	3.17	5.08	8.88	3.2	38.4	139.5	181.1
0	66+200	0.26	0.57	1.35	0.64	2.92	5.46	9.01	3.2	33.6	146.8	183.6
20	66+200	0.26	0.65	1.38	0.65	3.01	5.69	9.34	3.4	38.8	157.3	199.5
40	66+200	0.26	0.63	1.41	0.68	3.15	5.47	9.30	3.6	40.0	153.8	197.3
80	66+200	0.27	0.55	1.41	0.61	2.95	4.92	8.48	3.3	33.1	139.0	175.4
Significance		**	**	**	**	**	**	**	**	**	**	**
BLSD (5%)		0.03	0.12	0.09	0.09	0.50	0.57	1.04	0.5	9.7	17.1	24.7
Main effects												
	Yard Waste Rate											
	0	0.27	0.49	1.18	0.48	2.22	4.28	6.98	2.5	23.4	106.5	132.4
	20	0.27	0.55	1.23	0.49	2.48	4.54	7.52	2.6	28.9	115.8	147.4
	40	0.26	0.57	1.29	0.57	2.63	4.74	7.94	2.9	31.2	124.7	158.8
	80	0.26	0.56	1.34	0.54	2.66	4.55	7.75	2.9	30.3	122.9	156.1
	Significance	NS	NS	**	*	*	NS	*	*	*	**	**
	BLSD (5%)	--	--	0.05	0.06	0.34	--	0.72	0.3	6.6	11.2	16.2
	Linear	NS	NS	**	*	**	NS	*	**	*	**	**
	Quadratic	NS	NS	NS	NS	NS	*	*	NS	NS	*	*
	Nitrogen Application											
	0	0.29	0.45	1.07	0.32	1.54	3.00	4.86	1.8	14.1	65.7	81.6
	200	0.25	0.58	1.32	0.60	2.94	5.20	8.74	3.0	34.9	137.6	175.5
	66+200	0.26	0.60	1.39	0.64	3.00	5.39	9.03	3.4	36.4	149.2	188.9
	Significance	**	**	**	**	**	**	**	**	**	**	**
	BLSD (5%)	0.01	0.05	0.04	0.05	0.24	0.28	0.51	0.2	4.6	8.5	12.2
Interaction												
	Yard Waste x Nitrogen	NS	NS	*	NS	NS	**	*	NS	NS	**	*

NS = nonsignificant, * = significant at 5%, ** = significant at 1%.

Table 5. Effect of yard waste and nitrogen application on elemental composition of kernels at harvest - October 10, 1992.

Yard waste rate	Nitrogen application	Al	B	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	Zn
-tons/A-	--lbs/A--								ppm								
0	0	<6	3.2	58	<0.12	0.48	1.33	11	4464	1142	3.7	<0.41	<3.6	<0.67	3128	<1.8	17
20	0	<4	3.5	61	<0.12	0.43	1.05	10	4540	1229	4.2	<0.40	<3.7	<0.53	3409	<1.7	20
40	0	<4	3.3	51	<0.12	<0.37	1.00	10	4394	1226	4.5	<0.35	<3.6	<0.49	3442	<1.7	20
80	0	<5	3.4	50	<0.13	0.46	1.13	12	4376	1299	5.3	<0.39	<3.6	<0.52	3602	<1.8	22
0	200	<6	2.9	40	<0.13	0.39	1.29	19	3531	1057	4.3	0.43	<3.6	<0.50	2627	<1.8	14
20	200	<4	3.4	45	<0.12	<0.35	0.97	17	4114	1185	4.8	<0.30	<3.6	<0.48	3280	<1.7	18
40	200	<4	3.5	42	<0.12	0.38	0.92	16	4248	1200	4.9	<0.32	<3.6	<0.47	3464	<1.7	18
80	200	<5	3.4	44	<0.12	0.40	0.90	16	4320	1231	5.4	<0.31	<3.6	<0.44	3529	<1.7	19
0	66+200	<4	3.1	38	<0.12	0.39	1.06	19	3736	1148	4.7	<0.32	<3.6	<0.45	2895	<1.7	15
20	66+200	<5	3.5	46	<0.12	0.47	1.50	18	3822	1163	4.9	<0.39	<3.6	<0.63	3176	<1.7	17
40	66+200	<5	3.3	42	<0.12	0.50	1.06	25	4077	1215	5.0	<0.34	<3.6	<0.47	3403	<1.7	19
80	66+200	<5	3.4	41	<0.12	0.44	0.99	16	4132	1252	5.0	<0.34	<3.6	<0.47	3493	<1.7	18
Significance		--	*	**	--	--	NS	*	**	**	**	--	--	--	**	--	**
BLSD (5%)		--	0.4	10	--	--	--	10	264	76	0.4	--	--	--	248	--	2
Main effects																	
Yard Waste Rate																	
0		<5	3.1	45	<0.12	<0.42	1.23	16	3910	1116	4.2	<0.38	<3.6	<0.54	2883	<1.8	15
20		<5	3.5	51	<0.12	<0.42	1.17	15	4158	1193	4.6	<0.36	<3.6	<0.54	3288	<1.7	18
40		<4	3.4	45	<0.12	<0.42	1.00	17	4240	1213	4.8	<0.33	<3.6	<0.47	3437	<1.7	19
80		<5	3.4	45	<0.12	0.43	1.01	15	4276	1261	5.3	<0.34	<3.6	<0.48	3541	<1.7	20
Significance		--	**	NS	--	--	NS	NS	**	**	**	--	--	--	**	--	**
BLSD (5%)		--	0.2	--	--	--	--	--	155	40	0.2	--	--	--	137	--	1
Linear		--	*	NS	--	--	*	NS	**	**	**	--	--	--	**	--	**
Quadratic		--	*	NS	--	--	NS	NS	*	NS	NS	--	--	--	**	--	**
Nitrogen Application																	
	0	<5	3.4	55	<0.12	<0.44	1.13	11	4443	1224	4.4	<0.39	<3.6	<0.55	3395	<1.7	20
	200	<5	3.3	43	<0.12	<0.38	1.02	17	4053	1168	4.9	<0.34	<3.6	<0.47	3325	<1.7	17
	66+200	<5	3.3	42	<0.12	0.45	1.15	19	3942	1195	4.9	<0.35	<3.6	<0.50	3242	<1.7	17
Significance		--	NS	**	--	--	NS	**	**	*	**	--	--	--	*	--	**
BLSD (5%)		--	--	4	--	--	--	4	127	39	0.2	--	--	--	136	--	1
Interaction																	
Yard Waste x Nitrogen		--	NS	NS	--	--	NS	NS	**	NS	**	--	--	--	NS	--	NS

NS = not significant, * = significant at 5%, ** = significant at 1%.

Table 6. Effect of yard waste and nitrogen application on elemental composition of stover at harvest - October 10, 1992.

Yard waste rate	Nitrogen application	Al	B	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	Zn
-tons/A-	--lbs/A--								ppm								
0	0	334	6.2	2653	<0.19	1.19	3.03	232	14463	2350	30.7	1.17	32.7	<1.20	1370	<3.2	14
20	0	169	5.6	2095	<0.19	1.14	3.18	134	16169	2534	20.7	1.83	27.4	<0.93	3014	<2.9	32
40	0	146	5.5	2034	<0.20	1.15	3.73	130	17506	2480	22.9	1.73	29.2	<0.98	3405	<3.1	40
80	0	119	5.4	1975	<0.19	1.01	3.46	101	18527	2073	28.7	1.24	29.6	<0.90	3320	<2.9	42
0	200	140	6.0	2382	<0.25	0.99	5.01	116	14358	2009	27.4	0.99	29.6	<1.04	469	<3.3	7
20	200	120	6.2	2266	<0.23	0.91	4.49	101	15815	1461	27.3	1.12	32.9	<1.03	784	<3.3	15
40	200	101	6.2	2077	<0.25	0.94	4.51	101	15803	1436	22.9	1.06	27.0	<1.06	1265	<3.5	14
80	200	117	6.4	2236	<0.24	1.06	4.66	119	17561	1311	30.6	1.11	29.5	<1.05	1278	<3.3	18
0	66+200	151	6.0	2527	<0.28	1.06	4.79	133	14305	2001	27.1	1.03	33.1	<1.13	485	<3.7	9
20	66+200	115	6.5	2491	<0.25	0.98	4.26	96	18723	1513	25.8	0.88	33.6	<1.05	598	<3.5	9
40	66+200	121	6.2	2347	<0.27	1.23	4.30	116	17541	1427	24.0	1.10	36.3	<1.10	951	<3.6	14
80	66+200	106	6.2	2139	<0.25	1.06	4.21	105	18727	1428	24.5	0.98	30.4	<1.02	1317	<3.4	15
Significance		**	*	**	--	NS	**	**	**	**	**	**	*	--	**	--	**
BLSD (5%)		55	0.7	334	--	--	0.69	52	2648	225	5.9	0.25	6.9	--	488	--	7
Main effects																	
Yard Waste Rate																	
0		209	6.1	2521	<0.24	1.08	4.28	161	14375	2120	28.4	1.06	31.8	<1.12	775	<3.4	10
20		135	6.1	2284	<0.23	1.01	3.98	110	16902	1836	24.6	1.28	31.3	<1.00	1465	<3.2	19
40		123	6.0	2153	<0.24	1.10	4.18	116	16950	1781	23.3	1.30	30.8	<1.04	1873	<3.4	23
80		114	6.0	2117	<0.23	1.04	4.11	108	18272	1604	27.9	1.11	29.8	<0.99	1972	<3.2	25
Significance		**	NS	**	--	NS	NS	**	**	**	**	**	NS	--	**	--	**
BLSD (5%)		31	--	174	--	--	--	29	1352	132	3.0	0.16	--	--	283	--	4
Linear		**	NS	**	--	NS	NS	**	**	**	NS	NS	NS	--	**	--	**
Quadratic		**	NS	*	--	NS	NS	*	NS	*	**	**	NS	--	**	--	**
Nitrogen Application																	
	0	192	5.7	2189	<0.20	1.12	3.35	150	16666	2359	25.8	1.49	29.7	<1.00	2777	<3.0	32
	200	120	6.2	2240	<0.25	0.97	4.67	109	15884	1554	27.0	1.07	29.7	<1.04	949	<3.4	14
	66+200	123	6.2	2376	<0.26	1.08	4.39	113	17324	1592	25.3	1.00	33.3	<1.07	838	<3.5	12
Significance		**	**	NS	--	*	**	**	NS	**	NS	**	*	--	**	--	**
BLSD (5%)		27	0.3	168	--	0.11	0.32	25	--	111	--	0.12	2.8	--	241	--	3
Interaction																	
Yard Waste x Nitrogen		**	NS	NS	--	NS	NS	*	NS	**	NS	**	NS	--	**	--	**

NS = not significant, * = significant at 5%, ** = significant at 1%.

Table 7. Effect of yard waste and nitrogen application on elemental composition of cobs at harvest - October 10, 1992.

Yard waste rate	Nitrogen application	Al	B	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	Zn
-tons/A-	--lbs/A--	ppm															
0	0	6	3.1	128	<0.12	0.49	1.85	11	16116	281	3.2	0.26	<3.8	<0.44	423	<1.7	29
20	0	5	3.4	93	<0.12	0.44	2.40	9	12921	211	3.3	0.30	<3.6	<0.45	668	<1.7	44
40	0	5	2.9	55	<0.12	0.44	2.78	11	10266	143	3.0	<0.25	<3.6	<0.44	779	<1.7	43
80	0	5	2.6	54	<0.13	0.40	2.71	8	9127	169	3.5	<0.24	<3.6	<0.45	813	<1.7	44
0	200	7	2.0	58	<0.13	0.41	2.29	10	6986	115	2.4	<0.24	<3.6	<0.69	218	<1.7	7
20	200	6	2.3	51	<0.12	<0.32	2.29	8	6482	95	2.8	<0.24	<3.6	<0.44	338	<1.7	15
40	200	5	2.1	45	<0.12	0.36	2.32	7	5781	93	2.6	<0.24	<3.6	<0.44	423	<1.7	15
80	200	6	2.2	51	<0.12	0.38	2.46	11	6154	105	3.0	<0.22	<3.6	<0.44	466	<1.7	19
0	66+200	6	2.0	41	<0.12	<0.32	2.17	10	6297	113	2.3	<0.23	<3.6	<0.48	232	<1.7	8
20	66+200	5	2.1	42	<0.12	<0.31	2.02	7	5897	108	2.5	<0.23	<3.6	<0.44	282	<1.7	12
40	66+200	5	2.1	48	<0.12	0.45	2.27	8	5225	105	2.6	<0.23	<6.1	<0.44	353	<1.7	14
80	66+200	6	2.2	51	<0.12	0.46	2.43	8	6135	122	3.0	<0.23	<3.6	<0.44	531	<1.7	20
Significance		NS	**	**	--	--	**	NS	**	**	**	--	--	--	**	--	**
BLSD (5%)		--	0.4	25	--	--	0.41	--	1574	43	0.4	--	--	--	94	--	7
Main effects																	
Yard Waste Rate																	
0		6	2.4	76	<0.12	<0.41	2.10	10	9800	170	2.6	<0.24	<3.7	<0.54	291	<1.7	15
20		6	2.6	62	<0.12	<0.36	2.24	8	8433	138	2.8	<0.26	<3.6	<0.44	429	<1.7	24
40		5	2.3	49	<0.12	<0.42	2.46	9	7091	114	2.7	<0.24	<4.4	<0.44	518	<1.7	24
80		5	2.3	52	<0.12	<0.41	2.53	9	7138	132	3.2	<0.23	<3.6	<0.44	603	<1.7	28
Significance		NS	NS	**	--	--	**	NS	**	**	**	--	--	--	**	--	**
BLSD (5%)		--	--	15	--	--	0.22	--	933	26	0.3	--	--	--	54	--	4
Linear		NS	NS	**	--	--	**	NS	**	*	**	--	--	--	**	--	**
Quadratic		NS	NS	*	--	--	NS	NS	**	**	NS	--	--	--	**	--	*
Nitrogen Application																	
	0	5	3.0	82	<0.12	0.44	2.44	10	12107	201	3.2	<0.26	<3.6	<0.44	671	<1.7	40
	200	6	2.2	51	<0.12	<0.37	2.34	9	6354	102	2.7	<0.23	<3.6	<0.50	361	<1.7	14
	66+200	6	2.1	45	<0.12	<0.39	2.22	8	5889	212	2.6	<0.23	<4.2	<0.45	350	<1.7	14
Significance		NS	**	**	--	--	NS	NS	**	**	**	--	--	--	**	--	**
BLSD (5%)		--	0.2	12	--	--	--	--	776	21	0.2	--	--	--	46	--	3
Interaction																	
Yard Waste x Nitrogen		NS	NS	**	--	--	*	NS	**	**	NS	--	--	--	*	--	NS

NS = not significant, * = significant at 5%, ** = significant at 1%.

Table 8. Effect of yard waste and nitrogen application on soil nitrate-N (lbs/A) in the top three feet at the end of the growing season.

Yard waste rate	Nitrogen application	Sample depth (inches) 0 - 6	6 - 12	12 - 24	24 - 36	Total
-tons/A-	--lbs/A--	lbs nitrate-N/A				
0	0	0.78	0.74	0.75	0.72	2.98
20	0	1.24	0.99	0.94	0.64	3.81
40	0	1.90	1.54	1.47	0.67	5.58
80	0	2.96	2.53	1.36	1.12	7.97
0	200	2.35	2.34	1.67	0.74	7.09
20	200	4.22	3.78	2.24	1.22	11.46
40	200	5.30	4.10	2.63	1.25	13.28
80	200	6.34	3.76	2.10	0.79	12.99
0	66+200	2.73	3.29	1.54	1.18	8.74
20	66+200	7.98	9.50	6.82	3.14	27.44
40	66+200	7.96	6.69	2.93	1.42	18.99
80	66+200	9.20	5.10	3.31	2.19	19.80
Significance		**	**	**	**	**
BLSD (5%)		3.41	4.62	2.96	1.24	10.80
Main effects						
Yard Waste Rate						
0		1.95	2.12	1.32	0.88	6.27
20		4.48	4.76	3.33	1.67	14.23
40		5.05	4.11	2.34	1.11	12.61
80		6.17	3.80	2.26	1.37	13.59
Significance		**	NS	NS	NS	*
BLSD (5%)		1.94	--	--	--	6.57
Linear		**	NS	NS	NS	NS
Quadratic		NS	NS	NS	NS	NS
Nitrogen Application						
	0	1.72	1.45	1.13	0.79	5.08
	200	4.55	3.49	2.16	1.00	11.20
	66+200	6.97	6.14	3.65	1.98	18.74
Significance		**	**	**	**	**
BLSD (5%)		1.57	1.93	1.28	0.54	4.78
Interaction						
Yard Waste x Nitrogen		NS	NS	NS	NS	NS

NS = nonsignificant, * = significant at 5%, ** = significant at 1%.

Table 9. Effect of yard waste and nitrogen applications on soil pH, Bray P1, ammonium acetate extractable cations, DTPA extractable microelements, and hot water extractable B, (0-6" depth) - Oct. 14, 1992.

Treatment: Yard waste rate (T/A)	Treatment: Nitrogen application (lb N/A)	pH	Soluble Salts (mmhos/cm)	Bray P	NH_4OAc Extractable K	NH_4OAc Extractable Ca	NH_4OAc Extractable Mg	NH_4OAc Extractable Na	DTPA Extractable Fe	DTPA Extractable Mn	DTPA Extractable Zn	DTPA Extractable Cu	DTPA Extractable Pb	DTPA Extractable Ni	DTPA Extractable Cr	DTPA Extractable Cd	Hot water B
				ppm													
0	0	7.1	0.10	23	61	779	170	5.2	16	4.7	0.4	0.3	0.8	0.4	<0.03	<0.02	0.4
20	0	7.1	0.15	28	96	1022	195	4.9	19	8.7	0.9	0.4	0.9	0.3	<0.05	<0.03	0.6
40	0	7.2	0.20	32	105	1080	198	4.7	18	9.6	1.1	0.4	0.6	0.4	0.05	0.04	1.1
80	0	7.2	0.23	41	156	1190	210	5.9	15	9.1	1.5	0.4	1.1	0.3	<0.03	<0.02	1.3
0	200	6.8	0.10	20	46	887	197	6.4	23	7.9	0.5	0.4	0.9	0.5	0.03	<0.05	0.4
20	200	6.9	0.17	29	104	1182	230	6.8	25	12.7	1.1	0.4	0.9	0.6	0.03	<0.06	0.8
40	200	7.0	0.17	31	117	1177	214	6.4	21	10.8	1.1	0.4	1.1	0.5	0.06	<0.04	0.9
80	200	7.0	0.25	50	188	1309	230	7.6	26	16.5	1.7	0.5	1.2	0.6	0.05	0.07	1.5
0	66+200	6.8	0.13	23	68	940	213	6.6	23	7.8	0.6	0.4	0.9	0.5	0.05	<0.05	0.4
20	66+200	6.9	0.20	30	108	1143	211	5.6	21	10.8	1.0	0.4	1.1	0.5	<0.04	<0.04	1.0
40	66+200	7.0	0.20	35	127	1181	212	6.2	22	13.7	1.2	0.5	0.9	0.7	0.05	<0.05	1.1
80	66+200	7.3	0.28	44	175	1327	235	6.5	16	10.7	1.5	0.4	1.1	0.4	0.04	<0.05	1.7
Significance		*	**	**	**	**	NS	NS	NS	**	**	NS	NS	NS	--	--	**
BLSD (0.05)		0.3	0.07	14	41	256	--	--	--	5.9	0.5	--	--	--	--	--	0.4
Main effects																	
Yard Waste Rate																	
0		6.9	0.11	22	58	868	193	6.1	21	6.8	0.5	0.4	0.9	0.5	<0.04	<0.04	0.4
20		7.0	0.18	29	102	1116	212	5.8	22	10.7	1.0	0.4	1.0	0.5	<0.04	<0.04	0.8
40		7.1	0.18	32	117	1146	208	5.8	20	10.9	1.1	0.4	0.9	0.5	0.05	<0.04	1.0
80		7.2	0.26	46	173	1275	225	6.6	20	12.5	1.6	0.4	1.1	0.4	<0.04	<0.05	1.5
Significance		*	**	**	**	**	NS	NS	NS	**	**	NS	NS	NS	--	--	**
Linear leaf		**	**	**	**	**	NS	NS	NS	**	**	NS	NS	NS	--	--	**
Quadratic leaf		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	--	--	NS
Nitrogen Application																	
	0	7.1	0.17	31	105	1017	193	5.2	17	8.0	0.9	0.3	0.8	0.4	<0.04	<0.03	0.9
	200	6.9	0.18	33	114	1139	218	6.8	24	12.0	1.1	0.4	1.1	0.6	0.04	<0.06	0.9
	66+200	7.0	0.20	33	120	1147	218	6.2	21	10.8	1.1	0.4	1.0	0.5	<0.04	<0.05	1.1
Significance		**	NS	NS	NS	NS	NS	**	*	*	NS	*	NS	*	--	--	NS
BLSD (0.05)		0.1	--	--	--	--	--	0.8	4	2.6	--	0.1	--	0.1	--	--	--
Interaction																	
Yard Waste x Nitrogen		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	--	--	NS

NS = nonsignificant, * = significant at 5%, ** = significant at 1%.

Table 10. Effect of yard waste and nitrogen application on elemental composition of soil water collected at 3' from suction tubes - Sept. 11, 1992.

Yard waste rate	Nitrogen application	Al	B	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	S	Zn
-tons/A-	--lbs/A--								ppm									
0	0	<0.18	<0.02	44	<0.006	<0.01	<0.03	<0.02	1.6	6	0.015	<0.01	6	<0.022	0.08	<0.09	33	0.11
20	0	<0.18	<0.03	55	<0.006	<0.01	0.06	<0.02	1.7	10	0.037	<0.01	38	0.028	0.08	<0.09	73	0.35
40	0	<0.18	0.17	111	<0.006	<0.01	<0.03	<0.02	1.6	13	0.052	<0.01	12	0.028	0.10	<0.09	97	0.15
80	0	<0.18	0.07	123	<0.006	<0.01	<0.03	0.03	3.8	14	0.017	<0.01	47	<0.024	0.21	<0.09	117	0.09
0	200	<0.18	<0.02	66	<0.006	<0.01	<0.03	<0.02	1.9	12	0.029	<0.01	12	<0.026	0.17	<0.09	58	0.17
20	200	<0.18	0.28	62	<0.006	<0.01	<0.03	<0.02	0.9	5	0.035	<0.01	17	<0.027	0.10	<0.09	45	0.20
40	200	<0.18	<0.02	81	<0.006	<0.01	<0.04	<0.02	1.6	8	0.027	<0.01	22	<0.023	0.08	<0.09	55	0.10
80	200	<0.18	<0.27	94	<0.006	<0.01	<0.05	<0.02	1.7	16	0.035	<0.01	27	<0.029	0.12	<0.09	83	0.13
0	66+200	<0.18	<0.15	89	<0.006	<0.01	<0.03	<0.02	2.7	10	0.036	<0.01	18	<0.029	0.07	<0.09	73	0.26
20	66+200	<0.18	<0.03	78	<0.006	<0.01	<0.03	<0.02	4.0	12	0.038	<0.01	24	<0.026	0.08	<0.09	67	0.19
40	66+200	<0.18	<0.04	67	<0.006	<0.01	<0.03	0.03	3.5	14	0.036	<0.01	22	<0.030	0.11	<0.09	65	0.19
80	66+200	<0.18	0.04	106	<0.006	<0.01	<0.03	0.04	8.3	20	0.096	<0.01	19	0.035	0.10	<0.09	86	0.25
Significance		--	--	NS	--	--	--	--	NS	NS	NS	--	NS	--	*	--	NS	NS
BLSD (5%)		--	--	--	--	--	--	--	--	--	--	--	--	--	0.08	--	--	--
Main effects																		
Yard Waste Rate																		
0		<0.18	<0.06	66	<0.006	<0.01	<0.03	<0.02	2.1	9	0.027	<0.01	12	<0.025	0.11	<0.09	55	0.18
20		<0.18	<0.13	67	<0.006	<0.01	<0.03	<0.02	2.3	9	0.036	<0.01	24	<0.027	0.09	<0.09	60	0.23
40		<0.18	<0.08	86	<0.006	<0.01	<0.03	<0.02	2.2	12	0.038	<0.01	19	<0.027	0.10	<0.09	72	0.15
80		<0.18	<0.13	108	<0.006	<0.01	<0.04	<0.03	4.6	16	0.049	<0.01	31	<0.029	0.14	<0.09	96	0.16
Significance		--	--	NS	--	--	--	--	NS	NS	NS	--	NS	--	*	--	*	NS
BLSD (5%)		--	--	--	--	--	--	--	--	--	--	--	--	--	0.04	--	28	--
Linear		--	--	*	--	--	--	--	NS	*	NS	--	*	--	*	--	**	NS
Quadratic		--	--	NS	--	--	--	--	NS	NS	NS	--	NS	--	*	--	NS	NS
Nitrogen Application																		
	0	<0.18	<0.08	87	<0.006	<0.01	<0.03	<0.02	2.2	11	0.029	<0.01	24	<0.025	0.12	<0.09	81	0.15
	200	<0.18	<0.15	76	<0.006	<0.01	<0.03	<0.02	1.5	10	0.031	<0.01	20	<0.026	0.12	<0.09	60	0.15
	66+200	<0.18	<0.06	85	<0.006	<0.01	<0.03	<0.02	4.7	14	0.051	<0.01	21	<0.030	0.09	<0.09	73	0.22
Significance		--	--	NS	--	--	--	--	NS	NS	NS	--	NS	--	NS	--	NS	NS
BLSD (5%)		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Interaction																		
Yard Waste x Nitrogen		--	--	NS	--	--	--	--	NS	NS	NS	--	NS	--	*	--	NS	NS

NS = not significant, * = significant at 5%, ** = significant at 1%.

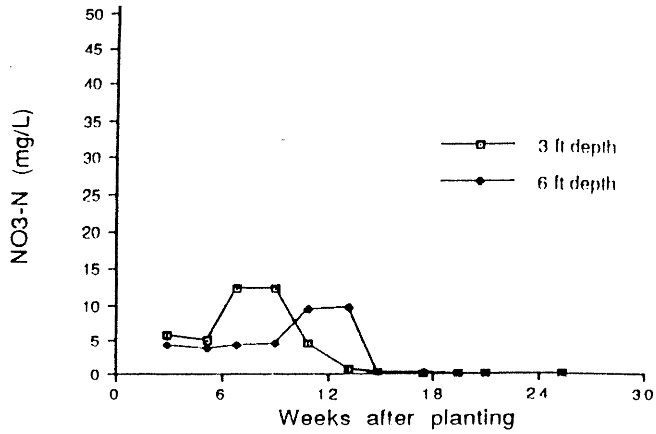


Figure 2. Nitrate-N concentration in soil water at 3 and 6 ft. depths over the 1992 growing season. Treatment 1: no leaves, no nitrogen applied.

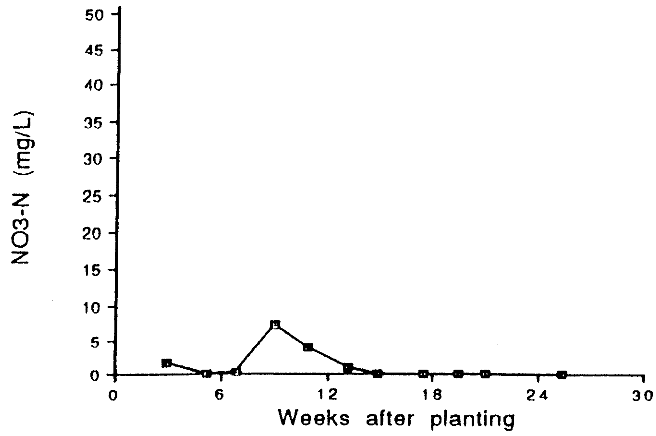


Figure 3. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 2: 20 tons/A leaves, no nitrogen applied.

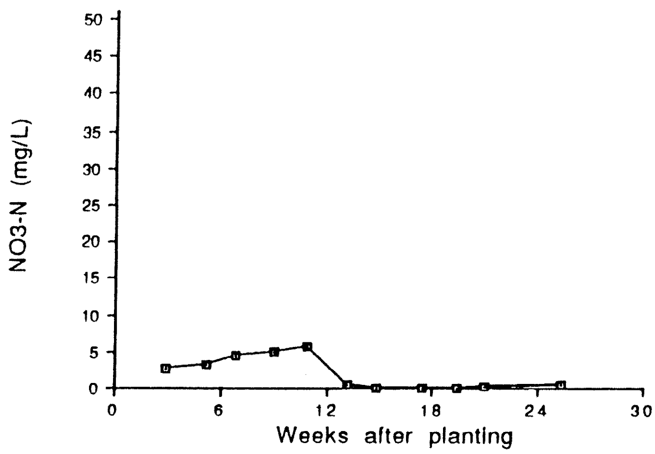


Figure 4. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 3: 40 tons/A leaves, no nitrogen applied.

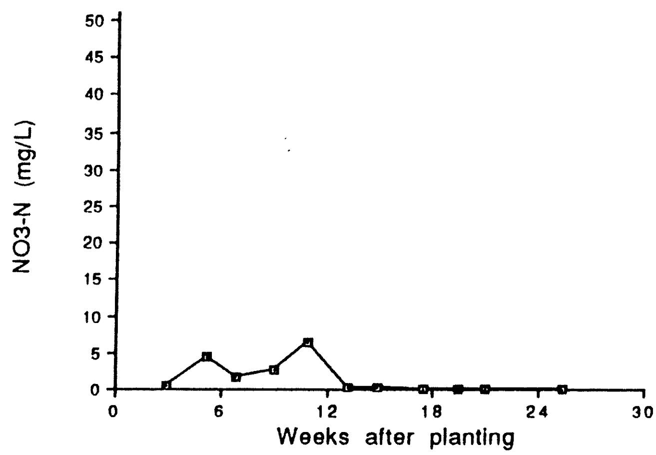


Figure 5. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 4: 80 tons/A leaves, no nitrogen applied.

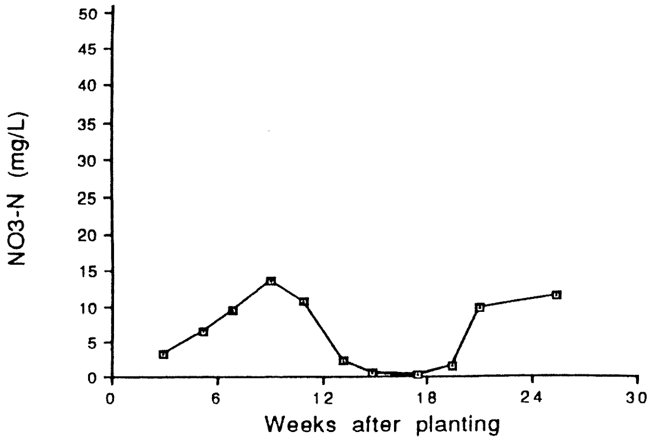


Figure 6. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 5: no leaves, 200 lbs/A nitrogen applied applied during the growing season.

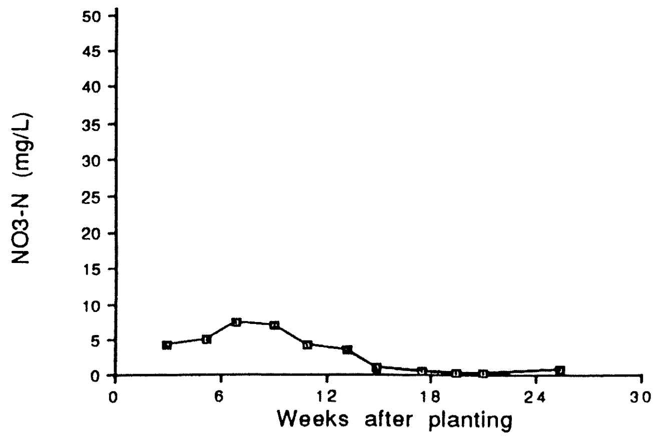


Figure 7. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 6: 20 tons/A leaves, 200 lbs/A nitrogen applied during the growing season.

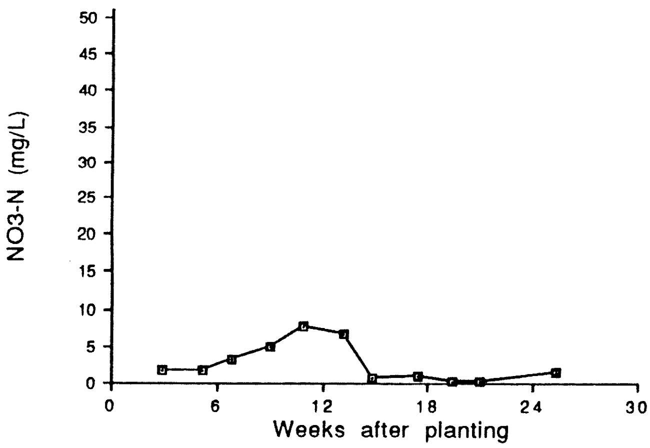


Figure 8. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 7: 40 tons/A leaves, 200 lbs/A nitrogen applied during the growing season.

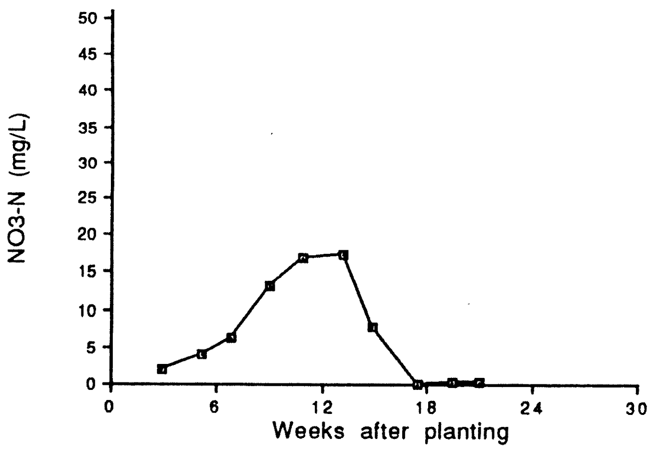


Figure 9. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 8: 80 tons/A leaves, 200 lbs/A nitrogen applied during the growing season.

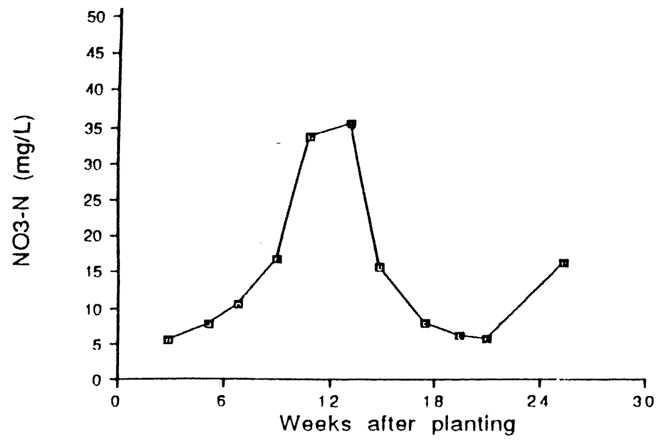


Figure 10. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 9: no leaves, 66 lbs/A nitrogen fall applied and 200 lbs/A applied during the growing season.

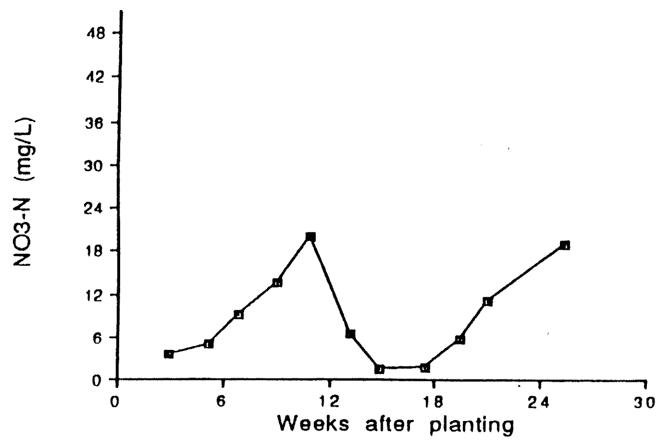


Figure 11. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 10: 20 tons/A leaves, 66 lbs/A nitrogen fall applied and 200 lbs/A applied during the growing season.

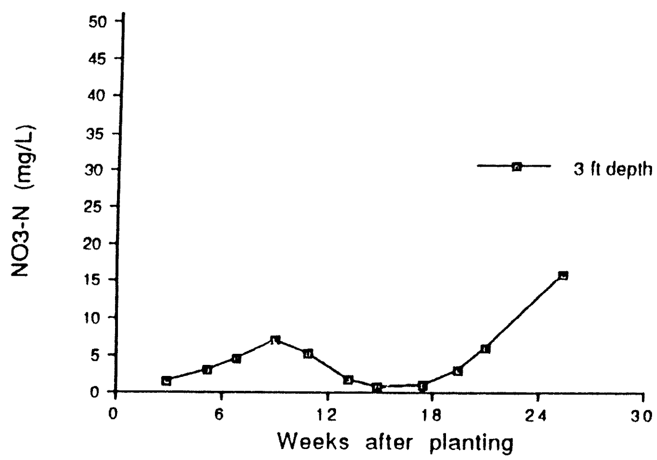


Figure 12: Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 11: 40 tons/A leaves, 66 lbs/A nitrogen fall applied and 200 lbs/A applied during the growing season.

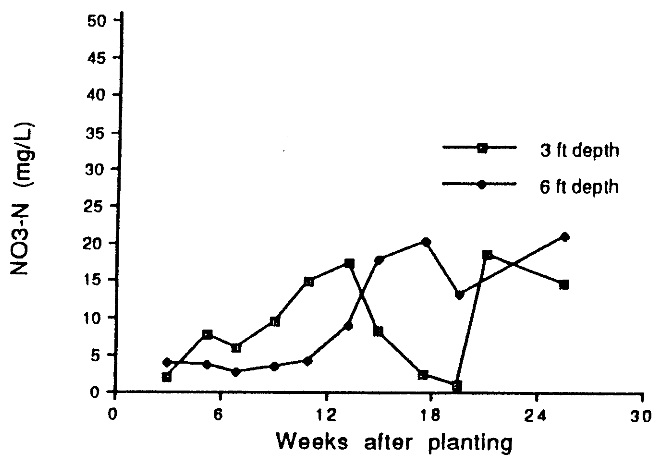


Figure 13: Nitrate-N concentration in soil water at 3 and 6 ft. depths over the 1992 growing season. Treatment 12: 80 tons/A leaves, 66 lbs/A nitrogen fall applied and 200 lbs/A applied during the growing season.

LAND SPREADING OF YARD WASTE

Final Report Submitted to the

Legislative Commission on Minnesota Resources

by

Department of Soil Science
University of Minnesota

July 1993

LAND SPREADING OF YARD WASTE

Carl Rosen, Thomas Halbach, Jean Molina, David Birong, and Jennifer Weiszel

ABSTRACT: A field experiment at the Sand Plain Research Farm in Becker, Minn. was conducted to determine the effects of land applying yard waste (primarily tree leaves) on corn production and soil nitrate movement. The yard waste was applied in the fall of 1991. Treatments included four rates of yard waste (0, 20, 40, and 80 T/A) with either no fertilizer N applied, 200 lbs N/A during the 1992 growing season, or 66 lbs N/A applied with the yard waste plus 200 lbs N/A applied during the growing season. Yard waste application initially inhibited growth and depressed tissue nitrogen composition of developing corn plants. The inhibitory effect diminished when fertilizer N was applied. These results suggest that soil N was immobilized for 5-6 weeks after planting. By harvest, corn grain yield increased with increasing yard waste application when no fertilizer N was applied, presumably due to release of nitrogen and possibly other nutrients from the yard waste. When N was added during the growing season, with or without fall applied N, the effect of yard waste on grain yield was generally not significant. Without added N fertilizer, yard waste increased N content of corn plant by about 1 lb N/A for each ton of yard waste applied up to 40 T/A. At the 80 T/A rate, N content increased by only 0.75 lb N/A for each ton of yard waste applied. Maturity, as measured by % moisture in the grain, was delayed with yard waste application. In addition to increasing tissue N, yard waste also increased tissue levels of P, K, Mg, and Zn. Nonessential heavy metals in corn tissue were generally below detection limits or not affected by yard waste application. Application of yard waste slightly increased soil pH and soluble salts. Extractable P, K, Ca, Mn, Zn and B also increased with yard waste application. Availability of nonessential heavy metals were not affected by yard waste application. Nitrate leaching tended to decrease with increasing yard waste during the first year after application. Highest nitrate-N concentrations in soil water at the three foot depth were recorded when N was applied in the fall with or without yard waste. During the first year after yard waste application, acceptable yields were obtained at all rates of applied yard waste combined with 200 lb N/A without significant nitrate losses. This study needs to be continued to determine nitrogen release rates from yard waste in subsequent years.

[1]Funding for this project was provided by the Legislative Commission for Minnesota Resources

[2]Extension Soil Scientist, Extension Waste Management Specialist, Assistant Scientist, and Se Research Plot Technician, respectively, Departmen Soil Science.

Rationale and Objectives: Until recently, yard wastes (tree leaves and grass clippings) accounted for 15-20% of the bulk in landfills. In 1990 (metro counties) and in 1992 (greater Minnesota), regulations were passed that prohibited dumping of yard wastes in landfills. Because of this legislation, alternatives to landfilling yard waste need immediate attention. Some options for using or recycling the yard waste include: 1) backyard composting and application of the compost to gardens; 2) municipal composting followed by land application of the compost; and 3) direct land application of noncomposted yard waste. While backyard composting is a desirable way to handle yard waste, not all homeowners desire to compost their own yard waste. Several problems with municipal yard waste composting include finding an acceptable site, controlling nutrient runoff, and controlling odors. Direct land application of noncomposted yard waste may be more efficient than composting and does not have the same problems associated with composting. Land application of yard waste may require an adjustment of nitrogen requirements, because of its generally low available nitrogen content. In addition, the effects on nitrogen use and crop production in general need to be ascertained. Therefore, the objectives of this study were to: 1) Determine the effects of direct application and incorporation of noncomposted yard waste (primarily tree leaves), with and without fertilizer nitrogen, on productivity of irrigated field corn, and 2) Characterize nitrogen release from the leaves during the growing in terms of availability for crop needs and movement through the soil profile.

Review of Literature: Many waste materials are currently being considered for land application including sewage sludge, food wastes, paper and yard wastes (Rynk, 1992). Direct land application is often less costly than composting because it involves less handling of materials and often has lower siting and regulatory costs. Major considerations for land application of waste include nutrient content and availability of the waste, nutrient needs of the crop, timing of waste application, and environmental degradation due to high trace metal content. The composition of yard waste is dependent on the time of the year. In the fall and early spring yard waste is primarily leaves with some grass clippings. In the summer, yard waste primarily consists of grass clippings. Yard waste high in grass clippings will have higher available nitrogen than yard waste high in tree leaves. The C/N ratio of tree leaves is between 40-80, while the C/N for grass clippings is 20 (Rosen et al., 1990).

Only a few studies have been reported that critically examine the effects of yard waste applications on crop growth and the environment. Many of the early studies using noncomposted waste tested municipal refuse and sewage sludge (King et al., 1974; Volk et al., 1973; Webber, 1978). While organic matter increased with addition of these materials, problems of incorporation, odor, aesthetics (Webber, 1978), and plant toxicity (King, et al. 1974) were reported.

Direct land application of yard waste is not hampered by the problems encountered with municipal refuse. The leaves are degradable and unsitely residues would not be present. Based on cost estimates, running a yard waste land application program is less than a full scale composting operation (Hgberg et al., 1990). States that have conducted ex-riments with land application of yard waste include Nev ork (Nally, 1989), Minnesota (Buchite, 1990), and Wisconsin (Peterson, 1991). Land application of grass clippings has also been reported in Pennsylvania (Biocycle, 1991). All studies reported that metal levels in crop tissue were not affected by yard waste application. Peterson (1991) reported that corn yield was not consistently affected by yard waste amendment the year of application; however, a 30-50 bushel increase due to yard waste was measured in subsequent years. The yard waste increased available phosphorus and increased soil organic matter content. In New York, yard waste applications at high rates (40 tons/A wet weight) were shown to decrease yield if insufficient nitrogen fertilizer was supplied (Nally, 1989). Increasing nitrogen application rate was necessary to maintain corn yields in a Minnesota study (Buchite, 1990). In that study, application rates greater than 20 T/A required multiple tillage operations to obtain adequate incorporation. None of the studies reported qualitatively how much nitrogen could be expected to be released from the yard waste nor did any of the studies report on potential nitrate leaching losses with high yard waste applications.

PROCEDURES

The experiment was conducted at the Sand Plain Research Farm in Becker, MN on a Hubbard loamy sand soil. Initial soil chemical characteristics include (0-6"): organic matter, 1.7%; pH (1:1 soil:water), 6.8; Bray P1, 26 ppm; K (NH_4OAc), 61 ppm. Extractable (KCl) nitrate-N and ammonium-N in the top 3 feet were 30 lbs/A and 4 lbs/A, respectively. The previous crop was rye. Yard waste was collected in October 1991 and applied to 15' x 35' plots with a front end loader on October 31, 1991. The yard waste primarily consisted of tree leaves, although some garden plants and grass clippings were also present. Subsamples of yard waste applied to each plot were collected for the following chemical analyses: moisture, pH (1:1, water), C and S (dry combustion), N (Kjeldahl) and, P, K, Ca, Mg, Na, Al, B, Cr, Cu, Fe, Pb, Mn, Ni, and Zn (dry ashed, Munter and Grande, 1981). Twelve treatments were tested: 0, 20, 40, 80 dry tons/A yard waste (no added N); these same treatments with 200 lb N/A applied during 1992; these same treatments with 66 lb N/A applied in the fall of 1991 plus 200 lb N/A applied during 1992. The fertilizer N source used in all cases was urea. An average of 30% moisture was assumed for application of all yard waste treatments. The experimental design was a randomized complete block with 4 replications. Yard waste was incorporated to a depth of 8 inches with a rototiller after application (fall 1991) and the whole field was moldboard plowed to a depth of 8-10 inches one week prior to planting in 1992. In addition, 235 lbs/A 0-0-22 and 200 lbs/A 0-0-60 were broadcast and incorporated prior to planting. Pioneer hybrid 3751 (100 day maturity) was planted on April 28, 1992 at a population of 30,700 seeds/A (2.5 ft. between rows). At planting, 185 lbs/A 0-14-42 was banded 2 inches to the side and two inches below the seed. For the N treated plots, 100 lbs N/A was sidedressed on May 27, with a hand pushed Gandy fertilizer applicator and cultivated in. Additional N at a rate of 50 lbs/A per application was applied with the Gandy applicator on June 17 and June 22 and irrigated in with 0.5 inch of water. Irrigation was used to supplement rainfall (Figure 1).

Soil samples at the 0-8 inch depth were collected from each plot before planting. After harvest, soil samples were collected from 0-6, 6-12, 12-24 and 24-36 inch depths. Soil nitrate and ammonium were determined on 2 N KCl extracts (Carlson et al., 1990). On the 0-6 inch sample additional soil chemical determinations were made: pH and soluble salts (1:1, water), P (Bray P-1); K, Ca, Mg, Na (1N ammonium acetate), Fe, Mn, Zn, Cu, Pb, Ni, Cr, and Cd (DTPA); and B (hot water). Detailed methodolgy for soil extraction procedures can be found in Rosen and Munter (1992).

Suction tubes with ceramic cups were installed at a depth of 3 feet in two replications of each treatment. Suction tubes at the 6 foot depth were installed in two reps for the control and 40 T/A yard waste plus 266 lbs of N treatments. Water samples were collected every two weeks through the growing season and analyzed for nitrate. On one set of water samples (September 11), a more extensive elemental analysis was performed using an ICP spectrophotometer (Munter and Grande, 1981).

Whole plant samples (4 per plot) were collected at the three leaf stage (May 26) before fertilizer N was applied in 1992. Whole plant samples (4 per plot) at the 8-12 leaf stage were collected on June 26 after all fertilizer N was applied. Ear leaf samples at 50% silking were collected on July 28. Two, 20 foot rows were harvested for grain and stover yield from each plot on October 10. Subsamples of stover and grain plus cob were taken for moisture determinations, shelling percentages, and nitrogen analyses. Plant tissue samples were dried and then ground through a 30 mesh screen. Dried samples were digested in concentrated sulfuric acid and Kjeldahl nitrogen was determined using conductimetric procedures (Carlson, 1978).

RESULTS

Yard Waste Elemental Composition: The yard waste had an acid pH (Table 1). The average moisture content was 30% with a range of 18.6 - 48.1%. The outer part of the pile tended to be drier than the inner part. The C/N ratio averaged 37.8:1, which is on the low side for leaves, but is in a range that should initially immobilize N. The yard waste contained 21.2 lbs N/dry ton, 3.2 lbs P/dry ton (7.4 lbs P_2O_5), and 14.4 lbs K/dry ton (17.3 lbs K_2O). The yard waste contained significant quantities of Ca, Mg and S. Trace elements were also present in the yard waste, but were not at levels considered to be detrimental to the environment.

Corn Growth and Yield: Initial growth of corn was significantly inhibited as yard waste application rate increased (Table 2). Application of N tended to minimize the negative effect of yard waste application on initial corn growth. Greatest growth at the 8-12 leaf stage occurred when N was applied in the Fall and during the growing season. Yard waste application rate up to 40 T/A tended to increase final stand count. At the 80 T/A rate, stand count declined. Stand count also increased with increasing fertilizer N rate. At harvest, increasing yard waste rates increased grain yield when no N was applied, indicating a significant release of N from the yard waste. However, when N was added during the growing season with or without fall applied N, the effect of yard waste on grain yield was generally not significant. There was a slight decrease in grain yield at the highest yard waste rate and when fall N plus 200 lb N/A was applied. Stover yield increased with increasing yard waste application and fertilizer N rate. Yard waste and low fertilizer N tended to delay maturity as measured by higher kernel moisture percentage.

Tissue Nitrogen Concentrations and Total Nitrogen Uptake: Nitrogen concentrations in whole plants sampled at the 3 leaf stage decreased as yard waste application increased (Table 3). These results indicate that early in the season N was immobilized by the yard waste. Fall applied N significantly increased N concentrations in the plant. By the 8-12 leaf stage, yard waste application was beginning to have a positive effect on N concentrations in the plant, while the effect of fall application of N began to diminish. Ear leaf N increased with increasing yard waste application when no fertilizer N was applied, but was not affected by yard waste when fertilizer N was applied. Application of fertilizer N increased N concentrations in the ear leaf. Cob N concentrations were not affected by yard waste application and were not consistently affected by fertilizer N application (Table 4). Stover N concentrations tended to increase with increasing yard waste application, primarily when no fertilizer N was applied. Application of fertilizer N also increased N concentrations in the stover. Kernel N increased with increasing application of yard waste and increasing fertilizer N application. As with other tissues, the effect of yard waste was most pronounced when fertilizer N was not applied.

Dry matter production increased with increasing yard waste rate up to the 40 T/A rate and then decreased even when fertilizer was applied; however, without inorganic N fertilizer, dry matter increased linearly with increasing yard waste application (Table 4). Applied N nearly doubled dry matter production; however, fall applied N did not significantly increase dry matter production compared to lower rates applied during the season. Similarly, without added N fertilizer, yard waste increased N content of corn plant by about 1 lb N/A for each ton of yard waste applied up to 40 T/A. At the 80 T/A rate, N content increased by only 0.75 lb N/A for each ton of yard waste applied. With added N, N uptake was highest with the 40 T/A yard waste rate. Given the growing conditions in 1992, the nitrogen rate used could probably have been lowered to take better advantage of N mineralized from the yard waste. As expected, N uptake increased with increasing N rate.

Tissue Elemental Concentrations: Concentrations of elements (except N) in kernel, stover, and cob are presented in Tables 5, 6, and 7, respectively. Yard waste application significantly increased kernel P, K, Mg, B, Mn, and Zn, and decreased kernel Cu. Concentrations of Cd, Pb, Ni, Cr, Al, Fe, and Mo were either below detection limits or not affected by yard waste application. Increasing N rate decreased kernel K, Mg, Ca, P and Zn, and increased Fe and Mn. Increasing K concentrations in kernels were greater with yard waste than with N fertilizer, resulting in a significant interaction. Increases in kernel Mn with yard waste application were greater at low N rates compared to the higher N rates.

Yard waste application increased stover K and decreased stover Ca. Increases in stover Zn and P with yard waste were dependent on N application, with greatest increases occurring at the low N rates. Decreases in stover Al, Fe, and Mg with yard waste were also dependent on N application, with greatest decreases occurring at the low N rates. Stover Mo decreased with increasing N rate, but was not consistently affected by yard waste application. Concentrations of Cd, Ni, and Pb were below detection limits. Stover B, Na, Cr, and Cu were not affected by yard waste application and inconsistently affected by N application.

Yard waste application increased cob Mn, P, and Zn. Concentrations of Cu in cobs also increased with yard waste application, but increases were dependent on N applied. Greater increases in cob Cu with yard waste occurred at the lower N rates. Cob K decreased with yard waste application. Cob Ca and Mg also decreased with yard waste application, but decreases were more pronounced at the lower N rates. Concentrations of Al, B, and Fe were not affected by yard waste application. While cob Cd, Cr, Mo, Na, Ni, and Pb were generally below detection limits.

Soil Nitrate-Nitrogen Content: Soil nitrate-nitrogen increased with increasing yard waste application in the top 6 inches but was not significantly affected by yard waste at the lower depths (Table 8). Soil nitrate-nitrogen increased with increasing fertilizer N application, with the fall applied N treatment having the highest residual N in the top 3 feet. It is interesting to note, however, that the initial soil nitrate-N content of 30 lbs/A was higher than the soil nitrate-N content following any of the fertilizer N and/or yard waste treatments.

Soil Chemical Properties: Effect of yard waste and nitrogen application on soil pH, Bray P1, ammonium acetate extractable cations, DTPA extractable microelements, and hot water extractable B in the top 6 inches after harvest are presented in Table 9. Soil pH slightly increased with yard waste application (6.9 to 7.2) and slightly decreased with N application. Soluble salts increased with both yard waste and N application; however, levels were not in a range that would toxicity problems. Extractable P, K, Ca, Zn and B increased with increasing yard waste application, but were not affected by N application. Extractable Mn increased with increasing yard waste and N application rates. Extractable Mg, Na, Fe, Cu, Pb, and Ni were not affected by yard waste application, extractable Na, Fe, Cu, and Ni increased with increasing N application. Extractable Cd and Cr were generally below detection limits.

Soil Water Elemental Concentrations: Elemental concentrations in soil water sampled on September 11 are presented in Table 10. Al, B, Cd, Cr, Cu, Fe, Mo, Ni, and Pb were generally below detection limits of the ICP. Ca, K, Na, and S tended to increase with increasing yard waste application. P concentrations tended to increase with increasing yard waste when no fertilizer N was applied, but was not consistently affected when fertilizer N was applied. Except for soil water nitrate (see below), other elements determined in soil water were not affected by yard waste application or fertilizer N.

Soil Water Nitrate Concentrations: Concentrations of nitrate-N in soil water as affected by treatments are presented in Figures 2-13. Yard waste applications tended to decrease nitrate concentrations in soil water at the three foot depth when fertilizer N was not applied. The control treatment had the highest water nitrate-N concentrations with levels slightly above 10 ppm. When yard waste was applied, nitrate-N concentrations were less than 10 ppm. When fertilizer N was applied during the season, nitrate-N concentrations in soil water at the three foot depth tended to be highest at mid-season when 80 T/A yard waste was applied. However, by the end of the season, the 0 yard waste treatment with fertilizer N had the highest nitrate concentrations. Nitrate-N concentrations in soil water were greatest when fertilizer N was applied in the fall. Highest concentrations at mid-season were recorded when 0 T/A leaves were applied. Yard waste application tended to decrease nitrate-N concentrations; however, compared to the other N treatments, fall applied N resulted in the highest losses at the end of the growing season. From these measurements, yard waste amendments appear to reduce nitrate-N losses during the first growing season after application.

Literature Cited

BioCycle Staff. 1991. Agricultural utilization of yard waste. BioCycle 32(8):54-57.

Buchite, H. 1990. Landspreading of yard waste. Proc. Minn. Polln. Contr. Agency 7th Solid Waste Seminar. Bloomington, MN.

Hegberg, B.A., G.R. Brenniman, W.H. Hallenberck, and R.A. Wadden. 1990. Landspreading yard waste. Biocycle 31(12):60-62.

King, L.D., L.A. Rudgers, and L.R. Webber. 1974. Application of municipal refuse and liquid sewage sludge to agricultural land: I. Field study. J. Environ. Qual. 3:361-366.

Nally, T. 1989. Leaf spreading project - town of Pittsford: project report. Cornell Univ. Coop. Ext.

Peterson, A.E. 1991. Recycling leaves and yard waste: a growing opportunity. Resource Recycling 10(4):52-55.

Rynk, R. 1992. On-farm composting handbook. Northeast Regional Agric. Eng. Serv. Ithaca, NY. 186pp.

Volk, B.G., G.H. Snyder, G.J. Gascho, and P.H. Henderson. 1973. Cropland disposal of hydropulped municpal refuse 1. A greenhouse and growth chamber evaluation. Proc. Soil and Crop Sci. Soc. Fla. 32:95-99.

Webber, L.R. 1978. Incorporation of nonsegregated, noncomposted solid waste and soil phys properties. J. Environ Qual. 7:397-400.

Methods References

Carlson, R.M. 1978. Automatic separation and conductimetric determination of ammonia and dissolved carbon dioxide. Anal. Chem. 50:1528-1532.

Carlson, R.M., R.I. Cabrera, J.L. Paul, J. Quick, and R.Y. Evans. Rapid direct determination of ammonium and nitrate in soil and plant tissue extracts. Commun. Soil Sci. Plant Anal. 21:1519-1529.

Munter, R.C. and R.A. Grande. 1981. Plant tissue and soil extract analysis by ICP-atomic emission spectrometry,, p.653-672. In: R.M. Barnes (ed.). Developments in atomic plasma spectrochemical analysis. Heyden and Sons, London.

Rosen, C.J. and R.C. Munter. 1992. Nutrient management for commercial fruit and vegetable crops in Minnesota. Minnesota Extension Sevice. AG-BU-5886-F.

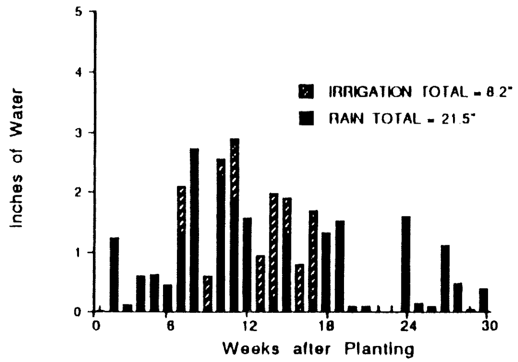


Figure 1. Rainfall and irrigation provided over the 1992 growing season.

Table 1. Elemental concentrations of original yard waste samples.

	Mean	Standard Deviation	Minimum	Maximum	
pH	4.9	0.2	4.4	5.5	
% moisture	29.7	7.7	18.6	48.6	
C to N ratio	37.9	3.2	29.6	42.6	lbs element/ dry ton
Macroelements (%)					
Carbon	39.76	3.49	33.56	45.95	795.2
Nitrogen	1.06	0.12	0.81	1.46	21.2
Phosphorus	0.16	0.02	0.12	0.20	3.2
Potassium	0.72	0.14	0.47	1.16	14.4
Calcium	2.33	0.25	1.75	2.75	46.6
Magnesium	0.37	0.04	0.27	0.49	7.4
Sulfur	0.19	0.02	0.15	0.22	3.8
Microelements (ppm)					
Aluminum	1052	464	254	1960	2.1
Boron	65	9	48	97	0.13
Cadmium	<0.52	0.35	<0.16	1.30	<0.10
Chromium	7.5	3.5	1.6	14.4	0.015
Copper	8.4	1.2	5.6	10.7	0.016
Iron	969	334	359	1755	1.9
Lead	<15.5	7.7	<2.2	39.6	<0.031
Manganese	249	40	177	399	0.50
Nickel	<6.5	3.3	<0.9	13.4	0.013
Sodium	105	23	60	163.	0.21
Zinc	61	9	40	85	0.12

Table 2. Effect of yard waste and nitrogen application on whole plant dry matter at the 8-12 leaf stage, final stand count, grain yield, and kernel moisture.

Yard waste rate	Nitrogen application	Whole plant dry matter (8-12 leaf)	Final stand count	Grain yield	Kernel moisture
-tons/A-	--lbs/A--	-grams/plant-	-plants/A-	-bu/A-	- % -
0	0	16.0	26463	76	36
20	0	5.5	26789	99	39
40	0	8.8	28532	124	38
80	0	6.0	26681	130	36
0	200	21.8	27770	188	29
20	200	12.5	27334	185	34
40	200	9.3	27770	188	35
80	200	10.5	27770	182	35
0	66+200	29.3	27660	195	31
20	66+200	25.5	28859	203	30
40	66+200	15.0	28859	195	35
80	66+200	13.0	27661	176	34
Significance		**	NS	**	**
BLSD (5%)		9.3	--	20	3
Main effects					
Yard Waste Rate					
0		22.3	27298	153	32
20		14.5	27661	162	34
40		11.0	28387	169	36
80		9.8	27370	162	35
Significance		**	NS	NS	**
BLSD (5%)		5.3	--	--	2
Linear		**	NS	NS	**
Quadratic		*	*	*	**
Nitrogen Application					
	0	9.0	27116	107	37
	200	13.5	27661	186	33
	66+200	20.8	28260	192	32
Significance		**	*	**	**
BLSD (5%)		4.3	892	10	2
Interaction					
Yard Waste x Nitrogen		NS	NS	**	*

NS = nonsignificant, * = significant at 5%, ** = significant at 1%.

Table 3. Effect of yard waste and nitrogen application on nitrogen concentrations in corn tissues at various growth stages.

Yard waste rate	Nitrogen application	Whole plant N 3 leaf stage	Whole plant N 8-12 leaf stage	Ear leaf N silking stage
-tons/A-	--lbs/A--	----------------	% Nitrogen	---------------
0	0	4.19	1.74	1.34
20	0	3.19	2.49	1.97
40	0	3.03	2.57	2.05
80	0	2.80	3.00	2.31
0	200	4.21	3.14	2.89
20	200	3.20	3.80	2.94
40	200	3.16	3.96	2.68
80	200	3.19	3.71	3.04
0	66+200	4.32	3.08	3.00
20	66+200	4.39	3.30	2.51
40	66+200	4.10	3.57	2.95
80	66+200	3.60	3.66	2.94
Significance		**	**	**
BLSD (5%)		0.72	0.40	0.76
Main effects				
Yard Waste Rate				
0		4.24	2.66	2.35
20		3.59	3.20	2.47
40		3.43	3.36	2.56
80		3.20	3.46	2.76
Significance		**	**	NS
BLSD (5%)		0.39	0.23	--
Linear		**	**	NS
Quadratic		*	**	NS
Nitrogen Application				
0		3.30	2.45	1.92
200		3.44	3.65	2.89
66+200		4.10	3.40	2.84
Significance		**	**	**
BLSD (5%)		0.34	0.19	0.33
Interaction				
Yard Waste x Nitrogen		NS	NS	NS

NS = nonsignificant, * = significant at 5%, ** = significant at 1%.

Table 4. Effect of yard waste and nitrogen application on nitrogen concentrations, nitrogen content and dry matter accumulation in cob, stove and grain at harvest.

Yard waste rate	Nitrogen application	Nitrogen Concentration Cob	Stover	Grain	Dry Mass Cob	Stover	Grain	Total	Nitrogen Content Cob	Stover	Grain	Total
-tons/A-	--lbs/A--	------- -	% Nitrogen	--------	-------------		Ton/A	-------------	------------		lb N/A -----	---
0	0	0.31	0.38	0.92	0.20	1.25	2.13	3.58	1.2	9.5	39.1	49.8
20	0	0.29	0.42	1.01	0.28	1.33	2.76	4.41	1.6	11.5	55.9	68.9
40	0	0.28	0.47	1.12	0.39	1.69	3.48	5.56	2.2	15.9	77.7	95.8
80	0	0.27	0.52	1.24	0.39	1.86	3.64	5.89	2.1	19.5	90.2	111.8
0	200	0.25	0.53	1.26	0.61	2.48	5.26	8.35	3.0	27.1	133.8	163.9
20	200	0.26	0.58	1.29	0.55	3.06	5.18	8.79	2.9	36.6	134.2	173.7
40	200	0.24	0.61	1.35	0.62	3.05	5.28	8.95	3.0	37.6	142.8	183.4
80	200	0.26	0.60	1.37	0.63	3.17	5.08	8.88	3.2	38.4	139.5	181.1
0	66+200	0.26	0.57	1.35	0.64	2.92	5.46	9.01	3.2	33.6	146.8	183.6
20	66+200	0.26	0.65	1.38	0.65	3.01	5.69	9.34	3.4	38.8	157.3	199.5
40	66+200	0.26	0.63	1.41	0.68	3.15	5.47	9.30	3.6	40.0	153.8	197.3
80	66+200	0.27	0.55	1.41	0.61	2.95	4.92	8.48	3.3	33.1	139.0	175.4
Significance		**	**	**	**	**	**	**	**	**	**	**
BLSD (5%)		0.03	0.12	0.09	0.09	0.50	0.57	1.04	0.5	9.7	17.1	24.7
Main effects												
Yard Waste Rate												
0		0.27	0.49	1.18	0.48	2.22	4.28	6.98	2.5	23.4	106.5	132.4
20		0.27	0.55	1.23	0.49	2.48	4.54	7.52	2.6	28.9	115.8	147.4
40		0.26	0.57	1.29	0.57	2.63	4.74	7.94	2.9	31.2	124.7	158.8
80		0.26	0.56	1.34	0.54	2.66	4.55	7.75	2.9	30.3	122.9	156.1
Significance		NS	NS	**	*	*	NS	*	*	*	**	**
BLSD (5%)		--	--	0.05	0.06	0.34	--	0.72	0.3	6.6	11.2	16.2
Linear		NS	NS	**	*	**	NS	*	**	*	**	**
Quadratic		NS	NS	NS	NS	NS	*	*	NS	NS	*	*
Nitrogen Application												
0		0.29	0.45	1.07	0.32	1.54	3.00	4.86	1.8	14.1	65.7	81.6
200		0.25	0.58	1.32	0.60	2.94	5.20	8.74	3.0	34.9	137.6	175.5
66+200		0.26	0.60	1.39	0.64	3.00	5.39	9.03	3.4	36.4	149.2	188.9
Significance		**	**	**	**	**	**	**	**	**	**	**
BLSD (5%)		0.01	0.05	0.04	0.05	0.24	0.28	0.51	0.2	4.6	8.5	12.2
Interaction												
Yard Waste x Nitrogen		NS	NS	*	NS	NS	**	*	NS	NS	**	*

NS = nonsignificant, * = significant at 5%, ** = significant at 1%.

Table 6. Effect of yard waste and nitrogen application on elemental composition of stover at harvest - October 10, 1992.

Yard waste rate	Nitrogen application	Al	B	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	Zn
-tons/A-	--lbs/A--								ppm								
0	0	334	6.2	2653	<0.19	1.19	3.03	232	14463	2350	30.7	1.17	32.7	<1.20	1370	<3.2	14
20	0	169	5.6	2095	<0.19	1.14	3.18	134	16169	2534	20.7	1.83	27.4	<0.93	3014	<2.9	32
40	0	146	5.5	2034	<0.20	1.15	3.73	130	17506	2480	22.9	1.73	29.2	<0.98	3405	<3.1	40
80	0	119	5.4	1975	<0.19	1.01	3.46	101	18527	2073	28.7	1.24	29.6	<0.90	3320	<2.9	42
0	200	140	6.0	2382	<0.25	0.99	5.01	116	14358	2009	27.4	0.99	29.6	<1.04	469	<3.3	7
20	200	120	6.2	2266	<0.23	0.91	4.49	101	15815	1461	27.3	1.12	32.9	<1.03	784	<3.3	15
40	200	101	6.2	2077	<0.25	0.94	4.51	101	15803	1436	22.9	1.06	27.0	<1.06	1265	<3.5	14
80	200	117	6.4	2236	<0.24	1.06	4.66	119	17561	1311	30.6	1.11	29.5	<1.05	1278	<3.3	18
0	66+200	151	6.0	2527	<0.28	1.06	4.79	133	14305	2001	27.1	1.03	33.1	<1.13	485	<3.7	9
20	66+200	115	6.5	2491	<0.25	0.98	4.26	96	18723	1513	25.8	0.88	33.6	<1.05	598	<3.5	9
40	66+200	121	6.2	2347	<0.27	1.23	4.30	116	17541	1427	24.0	1.10	36.3	<1.10	951	<3.6	14
80	66+200	106	6.2	2139	<0.25	1.06	4.21	105	18727	1428	24.5	0.98	30.4	<1.02	1317	<3.4	15
Significance		**	*	**	--	NS	**	**	**	**	**	**	*	--	**	--	**
BLSD (5%)		55	0.7	334	--	--	0.69	52	2648	225	5.9	0.25	6.9	--	488	--	7
Main effects																	
Yard Waste Rate																	
0		209	6.1	2521	<0.24	1.08	4.28	161	14375	2120	28.4	1.06	31.8	<1.12	775	<3.4	10
20		135	6.1	2284	<0.23	1.01	3.98	110	16902	1836	24.6	1.28	31.3	<1.00	1465	<3.2	19
40		123	6.0	2153	<0.24	1.10	4.18	116	16950	1781	23.3	1.30	30.8	<1.04	1873	<3.4	23
80		114	6.0	2117	<0.23	1.04	4.11	108	18272	1604	27.9	1.11	29.8	<0.99	1972	<3.2	25
Significance		**	NS	**	--	NS	NS	**	**	**	**	**	NS	--	**	--	**
BLSD (5%)		31	--	174	--	--	--	29	1352	132	3.0	0.16	--	--	283	--	4
Linear		**	NS	**	--	NS	NS	**	**	**	NS	NS	NS	--	**	--	**
Quadratic		**	NS	*	--	NS	NS	*	NS	*	**	**	NS	--	**	--	**
Nitrogen Application																	
0		192	5.7	2189	<0.20	1.12	3.35	150	16666	2359	25.8	1.49	29.7	<1.00	2777	<3.0	32
200		120	6.2	2240	<0.25	0.97	4.67	109	15884	1554	27.0	1.07	29.7	<1.04	949	<3.4	4
66+200		123	6.2	2376	<0.26	1.08	4.39	113	17324	1592	25.3	1.00	33.3	<1.07	838	<3.5	2
Significance		**	**	NS	--	*	**	**	NS	**	NS	**	*	--	**	--	**
BLSD (5%)		27	0.3	168	--	0.11	0.32	25	--	111	--	0.12	2.8	--	241	--	3
Interaction																	
Yard Waste x Nitrogen		**	NS	NS	--	NS	NS	*	NS	**	NS	**	NS	--	**	--	**

NS = not significant, * = significant at 5%, ** = significant at 1%.

Table 5. Effect of yard waste and nitrogen application on elemental composition of kernels at harvest - October 10, 1992.

Yard waste rate	Nitrogen application	Al	B	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	Zn
-tons/A-	--lbs/A--								ppm								
0	0	<6	3.2	58	<0.12	0.48	1.33	11	4464	1142	3.7	<0.41	<3.6	<0.67	3128	<1.8	17
20	0	<4	3.5	61	<0.12	0.43	1.05	10	4540	1229	4.2	<0.40	<3.7	<0.53	3409	<1.7	20
40	0	<4	3.3	51	<0.12	<0.37	1.00	10	4394	1226	4.5	<0.35	<3.6	<0.49	3442	<1.7	20
80	0	<5	3.4	50	<0.13	0.46	1.13	12	4376	1299	5.3	<0.39	<3.6	<0.52	3602	<1.8	[illegible]
0	200	<6	2.9	40	<0.13	0.39	1.29	19	3531	1057	4.3	0.43	<3.6	<0.50	2627	<1.8	[illegible]
20	200	<4	3.4	45	<0.12	<0.35	0.97	17	4114	1185	4.8	<0.30	<3.6	<0.48	3280	<1.7	[illegible]
40	200	<4	3.5	42	<0.12	0.38	0.92	16	4248	1200	4.9	<0.32	<3.6	<0.47	3464	<1.7	18
80	200	<5	3.4	44	<0.12	0.40	0.90	16	4320	1231	5.4	<0.31	<3.6	<0.44	3529	<1.7	19
0	66+200	<4	3.1	38	<0.12	0.39	1.06	19	3736	1148	4.7	<0.32	<3.6	<0.45	2895	<1.7	15
20	66+200	<5	3.5	46	<0.12	0.47	1.50	18	3822	1163	4.9	<0.39	<3.6	<0.63	3176	<1.7	17
40	66+200	<5	3.3	42	<0.12	0.50	1.06	25	4077	1215	5.0	<0.34	<3.6	<0.47	3403	<1.7	19
80	66+200	<5	3.4	41	<0.12	0.44	0.99	16	4132	1252	5.0	<0.34	<3.6	<0.47	3493	<1.7	18
Significance		--	*	**	--	--	NS	*	**	**	**	--	--	--	**	--	**
BLSD (5%)		--	0.4	10	--	--	--	10	264	76	0.4	--	--	--	248	--	2
Main effects																	
Yard Waste Rate																	
0		<5	3.1	45	<0.12	<0.42	1.23	16	3910	1116	4.2	<0.38	<3.6	<0.54	2883	<1.8	15
20		<5	3.5	51	<0.12	<0.42	1.17	15	4158	1193	4.6	<0.36	<3.6	<0.54	3288	<1.7	18
40		<4	3.4	45	<0.12	<0.42	1.00	17	4240	1213	4.8	<0.33	<3.6	<0.47	3437	<1.7	19
80		<5	3.4	45	<0.12	0.43	1.01	15	4276	1261	5.3	<0.34	<3.6	<0.48	3541	<1.7	20
Significance		--	**	NS	--	--	NS	NS	**	**	**	--	--	--	**	--	**
BLSD (5%)		--	0.2	--	--	--	--	--	155	40	0.2	--	--	--	137	--	1
Linear		--	*	NS	--	--	*	NS	**	**	**	--	--	--	**	--	**
Quadratic		--	*	NS	--	--	NS	NS	*	NS	NS	--	--	--	**	--	**
Nitrogen Application																	
0		<5	3.4	55	<0.12	<0.44	1.13	11	4443	1224	4.4	<0.39	<3.6	<0.55	3395	<1.7	20
200		<5	3.3	43	<0.12	<0.38	1.02	17	4053	1168	4.9	<0.34	<3.6	<0.47	3325	<1.7	17
66+200		<5	3.3	42	<0.12	0.45	1.15	19	3942	1195	4.9	<0.35	<3.6	<0.50	3242	<1.7	17
Significance		--	NS	**	--	--	NS	**	**	*	**	--	--	--	*	--	
BLSD (5%)		--	--	4	--	--	--	4	127	39	0.2	--	--	--	136	--	
Interaction																	
Yard Waste x Nitrogen		--	NS	NS	--	--	NS	NS	**	NS	**	--	--	--	NS	--	NS

NS = not significant, * = significant at 5%, ** = significant at 1%.

Table 7. Effect of yard waste and nitrogen application on elemental composition of cobs at harvest - October 10, 1992.

Yard waste rate	Nitrogen application	Al	B	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	Zn
-tons/A-	--lbs/A--								ppm								
0	0	6	3.1	128	<0.12	0.49	1.85	11	16116	281	3.2	0.26	<3.8	<0.44	423	<1.7	29
20	0	5	3.4	93	<0.12	0.44	2.40	9	12921	211	3.3	0.30	<3.6	<0.45	668	<1.7	44
40	0	5	2.9	55	<0.12	0.44	2.78	11	10266	143	3.0	<0.25	<3.6	<0.44	779	<1.7	43
80	0	5	2.6	54	<0.13	0.40	2.71	8	9127	169	3.5	<0.24	<3.6	<0.45	813	<1.7	44
0	200	7	2.0	58	<0.13	0.41	2.29	10	6986	115	2.4	<0.24	<3.6	<0.69	218	<1.7	[illegible]
20	200	6	2.3	51	<0.12	<0.32	2.29	8	6482	95	2.8	<0.24	<3.6	<0.44	338	<1.7	1[illegible]
40	200	5	2.1	45	<0.12	0.36	2.32	7	5781	93	2.6	<0.24	<3.6	<0.44	423	<1.7	15
80	200	6	2.2	51	<0.12	0.38	2.46	11	6154	105	3.0	<0.22	<3.6	<0.44	466	<1.7	19
0	66+200	6	2.0	41	<0.12	<0.32	2.17	10	6297	113	2.3	<0.23	<3.6	<0.48	232	<1.7	8
20	66+200	5	2.1	42	<0.12	<0.31	2.02	7	5897	108	2.5	<0.23	<3.6	<0.44	282	<1.7	12
40	66+200	5	2.1	48	<0.12	0.45	2.27	8	5225	105	2.6	<0.23	<6.1	<0.44	353	<1.7	14
80	66+200	6	2.2	51	<0.12	0.46	2.43	8	6135	122	3.0	<0.23	<3.6	<0.44	531	<1.7	20
Significance		NS	**	**	--	--	**	NS	**	**	**	--	--	--	**	--	**
BLSD (5%)		--	0.4	25	--	--	0.41	--	1574	43	0.4	--	--	--	94	--	7
Main effects																	
Yard Waste Rate																	
0		6	2.4	76	<0.12	<0.41	2.10	10	9800	170	2.6	<0.24	<3.7	<0.54	291	<1.7	15
20		6	2.6	62	<0.12	<0.36	2.24	8	8433	138	2.8	<0.26	<3.6	<0.44	429	<1.7	24
40		5	2.3	49	<0.12	<0.42	2.46	9	7091	114	2.7	<0.24	<4.4	<0.44	518	<1.7	24
80		5	2.3	52	<0.12	<0.41	2.53	9	7138	132	3.2	<0.23	<3.6	<0.44	603	<1.7	28
Significance		NS	NS	**	--	--	**	NS	**	**	**	--	--	--	**	--	**
BLSD (5%)		--	--	15	--	--	0.22	--	933	26	0.3	--	--	--	54	--	4
Linear		NS	NS	**	--	--	**	NS	**	*	**	--	--	--	**	--	**
Quadratic		NS	NS	*	--	--	NS	NS	**	**	NS	--	--	--	**	--	*
Nitrogen Application																	
0		5	3.0	82	<0.12	0.44	2.44	10	12107	201	3.2	<0.26	<3.6	<0.44	671	<1.7	40
200		6	2.2	51	<0.12	<0.37	2.34	9	6354	102	2.7	<0.23	<3.6	<0.50	361	<1.7	14
66+200		6	2.1	45	<0.12	<0.39	2.22	8	5889	212	2.6	<0.23	<4.2	<0.45	350	<1.7	14
Significance		NS	**	**	--	--	NS	NS	**	**	**	--	--	--	**	--	**
BLSD (5%)		--	0.2	12	--	--	--	--	776	21	0.2	--	--	--	46	--	3
Interaction																	
Yard Waste x Nitrogen		NS	NS	**	--	--	*	NS	**	**	NS	--	--	--	*	--	NS

NS = not significant, * = significant at 5%, ** = significant at 1%.

Table 8. Effect of yard waste and nitrogen application on soil nitrate-N (lbs/A) in the top three feet at the end of the growing season.

Yard waste rate	Nitrogen application	Sample depth (inches) 0 - 6	6 - 12	12 - 24	24 - 36	Total
-tons/A-	--lbs/A--	lbs nitrate-N/A				
0	0	0.78	0.74	0.75	0.72	2.98
20	0	1.24	0.99	0.94	0.64	3.81
40	0	1.90	1.54	1.47	0.67	5.58
80	0	2.96	2.53	1.36	1.12	7.97
0	200	2.35	2.34	1.67	0.74	7.09
20	200	4.22	3.78	2.24	1.22	11.46
40	200	5.30	4.10	2.63	1.25	13.28
80	200	6.34	3.76	2.10	0.79	12.99
0	66+200	2.73	3.29	1.54	1.18	8.74
20	66+200	7.98	9.50	6.82	3.14	27.44
40	66+200	7.96	6.69	2.93	1.42	18.99
80	66+200	9.20	5.10	[illegible]	2.19	19.80
Significance		**	**	**	**	**
BLSD (5%)		3.41	4.62	[illegible]	1.24	10.80
Main effects						
Yard Waste Rate						
0		1.95	2.12	1.32	0.88	6.27
20		4.48	4.76	3.33	1.67	14.23
40		5.05	4.11	2.34	1.11	12.61
80		6.17	3.80	2.26	1.37	13.59
Significance		**	NS	NS	NS	*
BLSD (5%)		1.94	--	--	--	6.57
Linear		**	NS	NS	NS	NS
Quadratic		NS	NS	NS	NS	NS
Nitrogen Application						
0		1.72	1.45	1.13	0.79	5.08
200		4.55	3.49	2.16	1.00	11.20
66+200		6.97	6.14	3.65	1.98	18.74
Significance		**	**	**	**	**
BLSD (5%)		1.57	1.93	1.28	0.54	4.78
Interaction						
Yard Waste x Nitrogen		NS	NS	NS	NS	NS

NS = nonsignificant, * = significant at 5%, ** = significant at 1%.

Table 10. Effect of yard waste and nitrogen application on elemental composition of soil water collected at 3' from suction tubes - Sept. 11, 1992.

Yard waste rate	Nitrogen application	Al	B	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	S	Zn
-tons/A-	--lbs/A--								ppm									
0	0	<0.18	<0.02	44	<0.006	<0.01	<0.03	<0.02	1.6	6	0.015	<0.01	6	<0.022	0.08	<0.09	33	0.11
20	0	<0.18	<0.03	55	<0.006	<0.01	0.06	<0.02	1.7	10	0.037	<0.01	38	0.028	0.08	<0.09	73	0.35
40	0	<0.18	0.17	111	<0.006	<0.01	<0.03	<0.02	1.6	13	0.052	<0.01	12	0.028	0.10	<0.09	97	0.15
80	0	<0.18	0.07	123	<0.006	<0.01	<0.03	0.03	3.8	14	0.017	<0.01	47	<0.024	0.21	<0.09	117	0.09
0	200	<0.18	<0.02	66	<0.006	<0.01	<0.03	<0.02	1.9	12	0.029	<0.01	12	<0.026	0.17	<0.09	58	0.17
20	200	<0.18	0.28	62	<0.006	<0.01	<0.03	<0.02	0.9	5	0.035	<0.01	17	<0.027	0.10	<0.09	45	0.20
40	200	<0.18	<0.02	81	<0.006	<0.01	<0.04	<0.02	1.6	8	0.027	<0.01	22	<0.023	0.08	<0.09	55	0.10
80	200	<0.18	<0.27	94	<0.006	<0.01	<0.05	<0.02	1.7	16	0.035	<0.01	27	<0.029	0.12	<0.09	83	0.13
0	66+200	<0.18	<0.15	89	<0.006	<0.01	<0.03	<0.02	2.7	10	0.036	<0.01	18	<0.029	0.07	<0.09	73	0.26
20	66+200	<0.18	<0.03	78	<0.006	<0.01	<0.03	<0.02	4.0	12	0.038	<0.01	24	<0.026	0.08	<0.09	67	0.19
40	66+200	<0.18	<0.04	67	<0.006	<0.01	<0.03	0.03	3.5	14	0.036	<0.01	22	<0.030	0.11	<0.09	65	0.19
80	66+200	<0.18	0.04	106	<0.006	<0.01	<0.03	0.04	8.3	20	0.096	<0.01	19	0.035	0.10	<0.09	86	0.25
Significance		--	--	NS	--	--	--	--	NS	NS	NS	--	NS	--	*	--	NS	NS
BLSD (5%)		--	--	--	--	--	--	--	--	--	--	--	--	--	0.08	--	--	--
Main effects																		
Yard Waste Rate																		
0		<0.18	<0.06	66	<0.006	<0.01	<0.03	<0.02	2.1	9	0.027	<0.01	12	<0.025	0.11	<0.09	55	0.18
20		<0.18	<0.13	67	<0.006	<0.01	<0.03	<0.02	2.3	9	0.036	<0.01	24	<0.027	0.09	<0.09	60	0.23
40		<0.18	<0.08	86	<0.006	<0.01	<0.03	<0.02	2.2	12	0.038	<0.01	19	<0.027	0.10	<0.09	72	0.15
80		<0.18	<0.13	108	<0.006	<0.01	<0.04	<0.03	4.6	16	0.049	<0.01	31	<0.029	0.14	<0.09	96	0.16
Significance		--	--	NS	--	--	--	--	NS	NS	NS	--	NS	--	*	--	*	NS
BLSD (5%)		--	--	--	--	--	--	--	--	--	--	--	--	--	0.04	--	28	--
Linear		--	--	*	--	--	--	--	NS	*	NS	--	*	--	*	--	**	NS
Quadratic		--	--	NS	--	--	--	--	NS	NS	NS	--	NS	--	*	--	NS	NS
Nitrogen Application																		
0		<0.18	<0.08	87	<0.006	<0.01	<0.03	<0.02	2.2	11	0.029	<0.01	24	<0.025	0.12	<0.09	81	0.15
200		<0.18	<0.15	76	<0.006	<0.01	<0.03	<0.02	1.5	10	0.031	<0.01	20	<0.026	0.12	<0.09	60	0.15
66+200		<0.18	<0.06	85	<0.006	<0.01	<0.03	<0.02	4.7	14	0.051	<0.01	21	<0.030	0.09	<0.09	73	0.22
Significance		--	--	NS	--	--	--	--	NS	NS	NS	--	NS	--	NS	--	NS	NS
BLSD (5%)		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Interaction																		
Yard Waste x Nitrogen		--	--	NS	--	--	--	--	NS	NS	NS	--	NS	--	*	--	NS	NS

NS = not significant, * = significant at 5%, ** = significant at 1%.

Table 9. Effect of yard waste and nitrogen applications on soil pH, Bray P1, ammonium acetate extractable cations, DTPA extractable microelements, and hot water extractable B, (0-6" depth) - Oct. 14, 1992.

Treatment			Soluble	Bray	NH_4OAc Extractable				DTPA Extractable								Hot water
Yard waste rate	Nitrogen application	pH	Salts	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu	Pb	Ni	Cr	Cd	B
(T/A)	(lb N/A)		(mmhos/cm)						ppm								
0	0	7.1	0.10	23	61	779	170	5.2	16	4.7	0.4	0.3	0.8	0.4	<0.03	<0.02	0.4
20	0	7.1	0.15	28	96	1022	195	4.9	19	8.7	0.9	0.4	0.9	0.3	<0.05	<0.03	0.6
40	0	7.2	0.20	32	105	1080	198	4.7	18	9.6	1.1	0.4	0.6	0.4	0.05	0.04	1.1
80	0	7.2	0.23	41	156	1190	210	5.9	15	9.1	1.5	0.4	1.1	0.3	<0.03	<0.02	1.3
0	200	6.8	0.10	20	46	887	197	6.4	23	7.9	0.5	0.4	0.9	0.5	0.03	<0.05	0.4
20	200	6.9	0.17	29	104	1182	230	6.8	25	12.7	1.1	0.4	0.9	0.6	0.03	<0.06	0.8
40	200	7.0	0.17	31	117	1177	214	6.4	21	10.8	1.1	0.4	1.1	0.5	0.06	<0.04	0.9
80	200	7.0	0.25	50	188	1309	230	7.6	26	16.5	1.7	0.5	1.2	0.6	0.05	0.07	1.5
0	66+200	6.8	0.13	23	68	940	213	6.6	23	7.8	0.6	0.4	0.9	0.5	0.05	<0.05	0.4
20	66+200	6.9	0.20	30	108	1143	211	5.6	21	10.8	1.0	0.4	1.1	0.5	<0.04	<0.04	1.0
40	66+200	7.0	0.20	35	127	1181	212	6.2	22	13.7	1.2	0.5	0.9	0.7	0.05	<0.05	1.1
80	66+200	7.3	0.28	44	175	1327	235	6.5	16	10.7	1.5	0.4	1.1	0.4	0.04	<0.05	1.7
Significance		*	**	**	**	**	NS	NS	NS	**	**	NS	NS	NS	--	--	**
BLSD (0.05)		0.3	0.07	14	41	256	--	--	--	5.9	0.5	--	--	--	--	--	0.4
Main effects																	
Yard Waste Rate																	
0		6.9	0.11	22	58	868	193	6.1	21	6.8	0.5	0.4	0.9	0.5	<0.04	<0.04	0.4
20		7.0	0.18	29	102	1116	212	5.8	22	10.7	1.0	0.4	1.0	0.5	<0.04	<0.04	0.8
40		7.1	0.18	32	117	1146	208	5.8	20	10.9	1.1	0.4	0.9	0.5	0.05	<0.04	1.0
80		7.2	0.26	46	173	1275	225	6.6	20	12.5	1.6	0.4	1.1	0.4	<0.04	<0.05	1.5
Significance		*	**	**	**	**	NS	NS	NS	**	**	NS	NS	NS	--	--	**
Linear leaf		**	**	**	**	**	NS	NS	NS	**	**	NS	NS	NS	--	--	**
Quadratic leaf		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	--	--	NS
Nitrogen Application																	
0		7.1	0.17	31	105	1017	193	5.2	17	8.0	0.9	0.3	0.8	0.4	<0.04	<0.03	0.9
200		6.9	0.18	33	114	1139	213	6.8	24	12.0	1.1	0.4	1.1	0.6	0.04	<0.06	0.9
66+200		7.0	0.20	33	120	1147	218	6.2	21	10.8	1.1	0.4	1.0	0.5	<0.04	<0.05	1.1
Significance		**	NS	NS	NS	NS	NS	**	*	*	NS	*	NS	*	--	--	NS
BLSD (0.05)		0.1	--	--	--	--	--	0.8	4	2.6	--	0.1	--	0.1	--	--	--
Interaction																	
Yard Waste x Nitrogen		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	--	--	NS

NS = nonsignificant, * = significant at 5%, ** = significant at 1%.

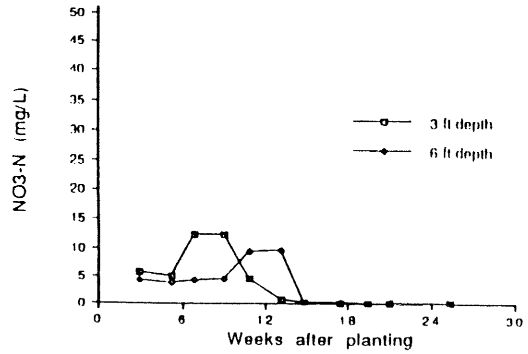


Figure 2. Nitrate-N concentration in soil water at 3 and 6 ft. depths over the 1992 growing season. Treatment 1: no leaves, no nitrogen applied.

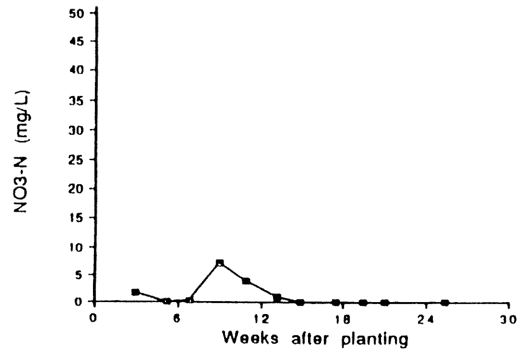


Figure 3. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 2: 20 tons/A leaves, no nitrogen applied.

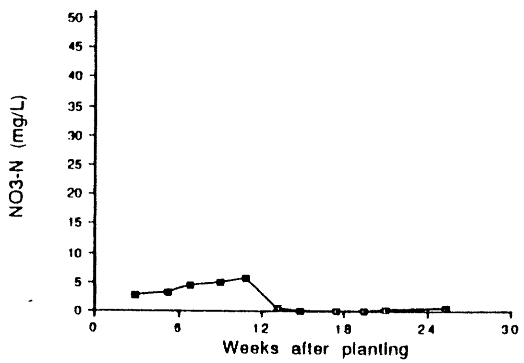


Figure 4. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 3: 40 tons/A leaves, no nitrogen applied.

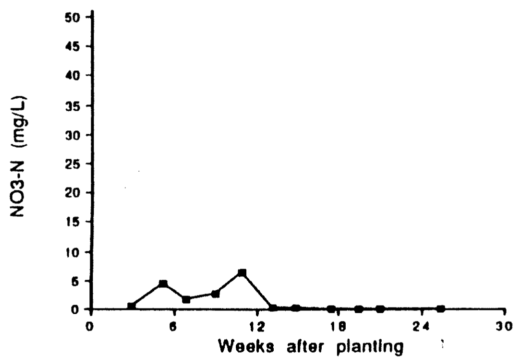


Figure 5. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 4: 80 tons/A leaves, no nitrogen applied.

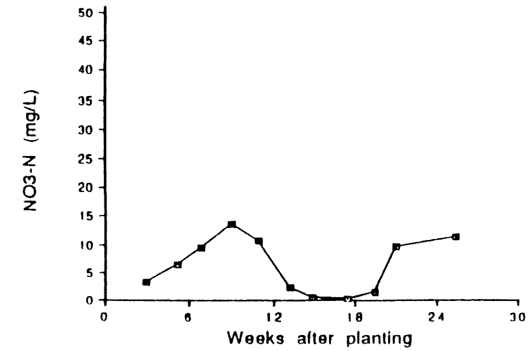


Figure 6. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 5: no leaves, 200 lbs/A nitrogen applied applied during the growing season.

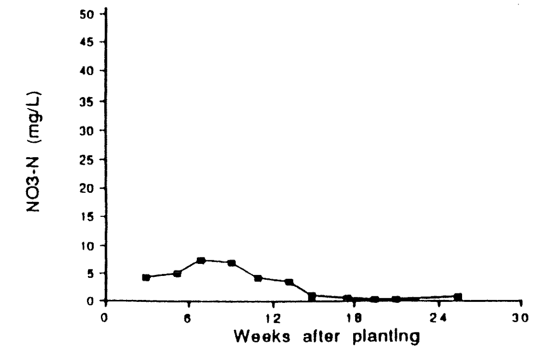


Figure 7. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 6: 20 tons/A leaves, 200 lbs/A nitrogen applied during the growing season.

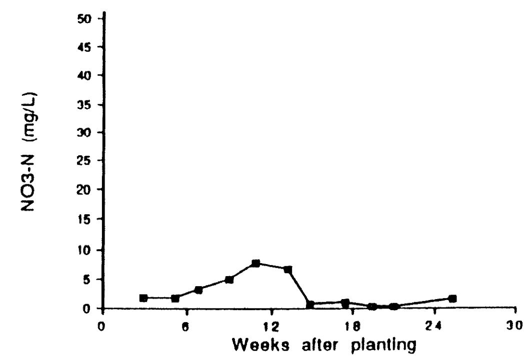


Figure 8. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 7: 40 tons/A leaves, 200 lbs/A nitrogen applied during the growing season.

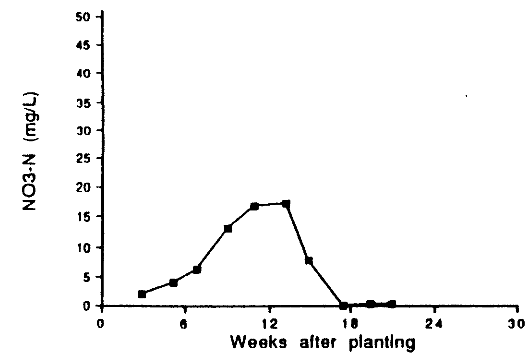


Figure 9. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 8: 80 tons/A leaves, 200 lbs/A nitrogen applied during the growing season.

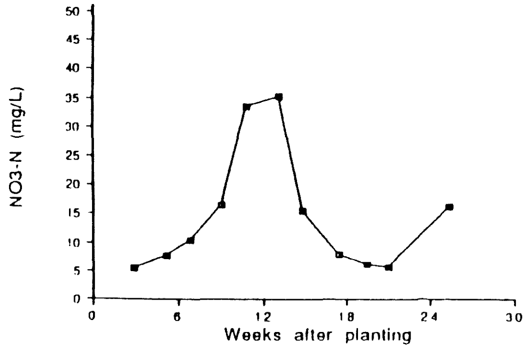


Figure 10. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 9: no leaves, 66 lbs/A nitrogen fall applied and 200 lbs/A applied during the growing season.

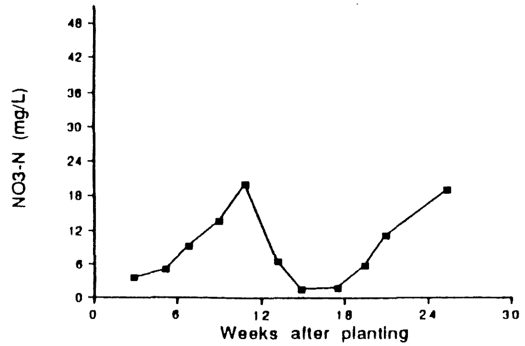


Figure 11. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 10: 20 tons/A leaves, 66 lbs/A nitrogen fall applied and 200 lbs/A applied during the growing season.

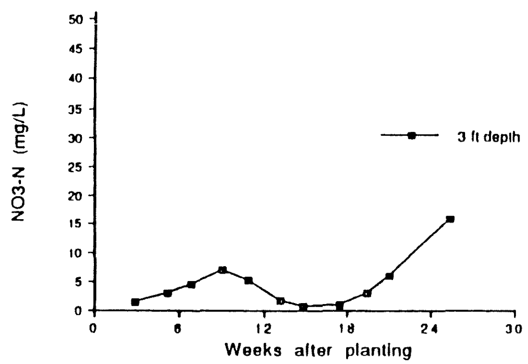


Figure 12: Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 11: 40 tons/A leaves, 66 lbs/A nitrogen fall applied and 200 lbs/A applied during the growing season.

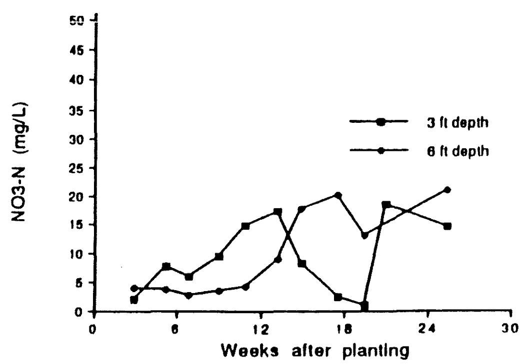


Figure 13: Nitrate-N concentration in soil water at 3 and 6 ft. depths over the 1992 growing season. Treatment 12: 80 tons/A leaves, 66 lbs/A nitrogen fall applied and 200 lbs/A applied during the growing season.

June 30, 1993 LCMR Final Report

I. Title: Land Spreading of Yard Waste - Waste 12(b)

Program Manager: Thomas R. Halbach
439 Borlaug Hall
Soil Science Department
University of Minnesota
St. Paul, MN 55108
(612) 625-3135

A.M.L. 1991. Ch.254, Art.1 Sec.14 Subd.12(b)
Appropriation: $100,000 Balance: $0.00
Land Spreading Yard Wastes: This appropriation is to the Office of Waste Management for a grant to the University of Minnesota, Soil Science Department, to determine the maximum and optimum rates that yard wastes can be applied to Minnesota soils without reducing yields or endangering the environment.

B. Compatible Data: In addition to satisfying the needs under Objective A the data collected under the program must satisfy the needs of Objective B: Developing a computer model.

C. Match Requirement: N.A. Funds Raised to Date: N.A.

II. Narrative

After January 1, 1990 in the metro counties, and January 1, 1992 in greater Minnesota, yard wastes may no longer be put in landfills. These yard wastes account for up to 18% of the bulk in landfills. Land spreading would extend the life of landfills and recycle a valuable natural resource. Research has shown that by direct land spreading more effective utilization of the plant nutrients in wastes is achieved than with composting and spreading compost. The yard wastes are typically deficient in nitrogen, but the rates of nitrogen needed to correct this imbalance so as not to reduce crop yields or to endanger the environment is not precisely known.

III. Objectives

A. To evaluate different application rates of yard waste applied and directly incorporated into agricultural soils, and to identify rates of nitrogen required to accelerate the decay of yard wastes that can be actively decomposed without reducing agricultural crop yields or presenting an unacceptable environmental threat to the soil.

A.1.Narrative: Tree leaf and wood wastes have high carbon to nitrogen ratios. Microbes decaying these wastes compete effectively for the nitrogen that is present, leaving little for the current crop. Supplemental nitrogen may have to be added to grow a crop. Appropriate rates of yard wastes and supplemental nitrogen applied to the land to maximize nutrient utilization and minimize potential environmental problems are not precisely known for Minnesota conditions.

A.2.Procedures: This study includes a review of the scientific literature available on this topic. Small research plots were established at the Becker Experiment Station. The soil types of the site are loamy sand soils. A chemical analysis of the fall leaves were conducted. The leaves were spread in the fall of the year and incorporated with a roto-tiller. A broadcast application of phosphorus and potassium were applied according to needs indicated by soil tests and U of M recommendations in the spring at planting. No additional N was applied to 16 of the plots, and 32 of the plots will receive the same amount of N,

based on U of M recommendations. Tree leaves (4 rates) were applied at 0, 20, 40, and 80 tons/acre (dry weight basis). Supplemental nitrogen (2 rates) were applied at 0, and 66 lb/acre in the fall at the time of incorporation of the tree leaves. Each treatment was replicated four times for a total of 48 treatments. Plots were six corn rows wide (30 inches each) and 30 feet long. The middle two rows were used for analyses. Corn was planted at the rate of 30,000 kernels per acre. The following soil tests were made on each plot prior to establishment of treatments and at the end of each cropping season: regular soil test(s), nitrate nitrogen, Kjeldahl nitrogen and total organic carbon. Diagnostic leaf samples were taken at the 7 leaf stage. At harvest the following including whole plant analyses were made: Kjeldahl-nitrogen, nitrate-nitrogen and ICP analyses for macro- and micro-nutrients. Suction cup samplers were installed in two plots (check vs. high nitrogen/high leaf treatment) at 3 and 6 foot depths. During the time when the soil is not frozen, soil water samples will be taken to monitor nitrate movement in the soil. All data will be statistically analyzed for significant differences.

A.3.Budget:

	LCMR Funds	Matching Funds
a. Amount Budgeted	$70,000.00	N.A.
b. Balance	$ 0.00	N.A.

A.4.Time-line for products/tasks:

	July 91	Jan 92	June 92	Jan 93	June 93
Literature Review	....	....		......	
Establish field plots	....		....		
Analyze soil chemistry		.....		.....	
Analyze tree leaf chemistry		....			
Analyze whole plant chemistry				....	
Analyze water samples		....		....	

A.5.Status: This is the final report.

The first year of the field study at Becker, MN to determine the effect of yard waste on corn productivity has been completed. Yard waste application rate had no effect on final plant population. Initial growth of corn was significantly inhibited as leaf application rate increased. Fall application of N and N applied two weeks after emergence tended to minimize the negative effect of yard waste application on initial corn growth. Without added fertilizer nitrogen final grain and stover yield increased with increasing yard waste rate, suggesting release on nitrogen from the yardwaste over the season. With added fertilizer nitrogen, the influence of yard waste rate diminished. The 80 T/A yard waste rate tended to reduce yields compared to the lower application rates and the control. Fall application of nitrogen did not significantly affect final yields. Soil water samples have been collected at the 3-ft depth from two of the 4 replications and nitrate determinations have been completed. Nitrogen uptake by the crop and leaching of nitrate during the season has been completed. See Attachment A for additional details.

A.6.Benefits: Land spreading appears to offer a cost effective alternative for yard waste disposal. Yard wastes are a major component of the solid waste stream often accounting for 15% to 20% of the total Municipal Solid Waste stream. However, previous research has not established acceptable rates of these wastes plus supplemental nitrogen to optimize the needs of the crop and minimize potential environmental impacts. This research helps to establish rates of application of fall tree leaves and supplemental nitrogen. Substantial savings in landfill volume should be saved. In some cases direct incorporation of fall tree leaves into agricultural soils can be done at a lower total cost as compared to large scale composting of yard wastes and then applying the compost to agricultural soils.

B. To develop a prediction model so others can forecast the rate of yard waste decomposition under varying soil, climatic and tillage conditions.

B.1.Narrative: Field experiments can consider only a few combinations of yard waste and nitrogen application rates. Managerial scenarios not experimentally tried will be simulated by a computer predictive model. Computer simulation will also be used to analyze the long term effect of yard waste application. A computer model was developed by modifying an existing research computer model of carbon and nitrogen flows in the soil plant system.

B.2.Procedures: A user friendly interface was developed to make the research model NCSWAP accessible to non-experts. This software addresses some managerial options which are relevant to land spreading of yard wastes. This front end to the research model was tested with extension agents for ease of information accessibility. Validation of the model was performed with the field data collected.

B.3.Budget:

	LCMR Funds	Matching Funds
a. Amount	$30,000.00	N.A.
b. Balance	$ 0.00	N.A.

B.4.Time-line for products/tasks:

	July 91	Jan 92	June 92	Jan 93	June 93
First version of interface	....				
Validation of first year data				....	
Final version			....		

B.5.Status: This is the final report.

The application program of NCSWAP is complete. Two of the three objectives for a phase 1 simulation model have been achieved. The first objective was to modify, then run the research version of NCSWAP on a microcomputer. Select variables were fixed or eliminated, and program code modified to reduce program size and improve run time. The second objective was to test the new application version for errors, and correct them. The third objective is to create a user-friendly program interface. This section allows the user to choose among various yard waste disposal scenario; cropping and weather conditions, application rates, etc. An output screen then tells the user the simulated results of the scenario and offers recommendations where appropriate. Scenario outcomes include crop yields, residue balance, nitrogen balance, and nitrates leached from the system. This third objective was not achieved. Validation of the first year's field data showed that Models's "useability" was not good enough to use with farmers. The model could not accurately predict the outcomes with only input data. It could come fairly close to real world outcomes when the outcomes were known. Additional real world numbers will be required with different crops, soils and weather if the third objective is to be achieved. See Attachment B for more detailed information.

B.6.Benefits: A user friendly version of the simulation model will be made available to managers of yard waste spreading sites. Managers will use the model to adjust rates and timing of waste and nitrogen application to variations in the climate and yard waste composition for optimum crop yield and minimum nitrate leaching.

IV. Evaluation: The success of the project may have several measures: 1) if no adverse effects of utilizing yard wastes are found this fact would greatly increase possible flexibility in utilizing these wastes as soil amendments or mulches; 2) if the research shows that there are limits to amounts that should be spread the data should provide guidelines that the regulatory agencies could use to develop limits in effectively regulating the use of

yard wastes; and 3) general acceptance by the farming community and general public permitting recycling of this resource would confirm its usefulness and credibility.

V. Context:

A. Research with yard waste has focused on demonstration type experiments with little quantitative potential. Land spreading of yard wastes has been shown to be feasible both here and in Wisconsin. High rates of leaves have also been shown to generate severe nitrogen deficiency for some types of agricultural crops. Yet these same leaves may contain large amounts of nitrogen which may be released as decomposition becomes nearly complete. When fully decayed, excess nitrogen from these yard wastes has the potential to pollute ground water. Thus, the process of management of yard wastes, particularly in terms of nitrogen management, must be better understood. Appropriate application rates of yard wastes and supplemental nitrogen under varying soil and meteorological conditions in Minnesota have not been precisely determined.

B. Determining the mineral nutrient balance of tree leaves from a variety of species and soil types and different stages of weathering should make a significant contribution to the scientific literature.

C. One of the cooperators worked with the OLEO group in their grant for 1987-1988. Their work was more qualitative than quantitative. Controls were inadequate to be scientifically acceptable. The original plot design was excellent but tillage, leaf rates, and supplemental nitrogen was not precisely replicated by the farmers. Data gathered here will yield valuable conclusions about rates of yard wastes and supplementary nitrogen that are acceptable.

D. Not applicable

E. Biennial Budget System Program Title and Budget see page 1.

VI. Qualification:

1. Program Manager Thomas R. Halbach, Assistant State Specialist - Waste Management and Water Quality Minnesota Extension Service, Dept. of Soil Science, University of Minnesota.

VII. Reporting Requirements:

Semi-annual status reports will be submitted no later than January 1, 1992; July 1, 1992; January 1, 1993 and a final status report by July 1, 1993.

1991 RESEARCH PROJECT ABSTRACT
For the period ending June 30, 1993

Title:	Land Spreading of Yard Waste - Waste 12(b)
Program Manager:	Thomas R. Halbach
Organization:	Soil Science Department, University of Minnesota
Legal Citation:	A.M.L. 1991. Ch.254, Art.1 Sec.14 Subd.12(b)
Approp. Amount:	$100,000

Statement of Objectives

To evaluate different application rates of yard waste applied and directly incorporated into agricultural soils, and to identify rates of nitrogen required to accelerate the decay of yard wastes that can be actively decomposed without reducing agricultural crop yields or presenting an unacceptable environmental threat to the soil. To develop a prediction model so others can forecast the rate of yard waste decomposition under varying soil, climatic and tillage conditions.

Results

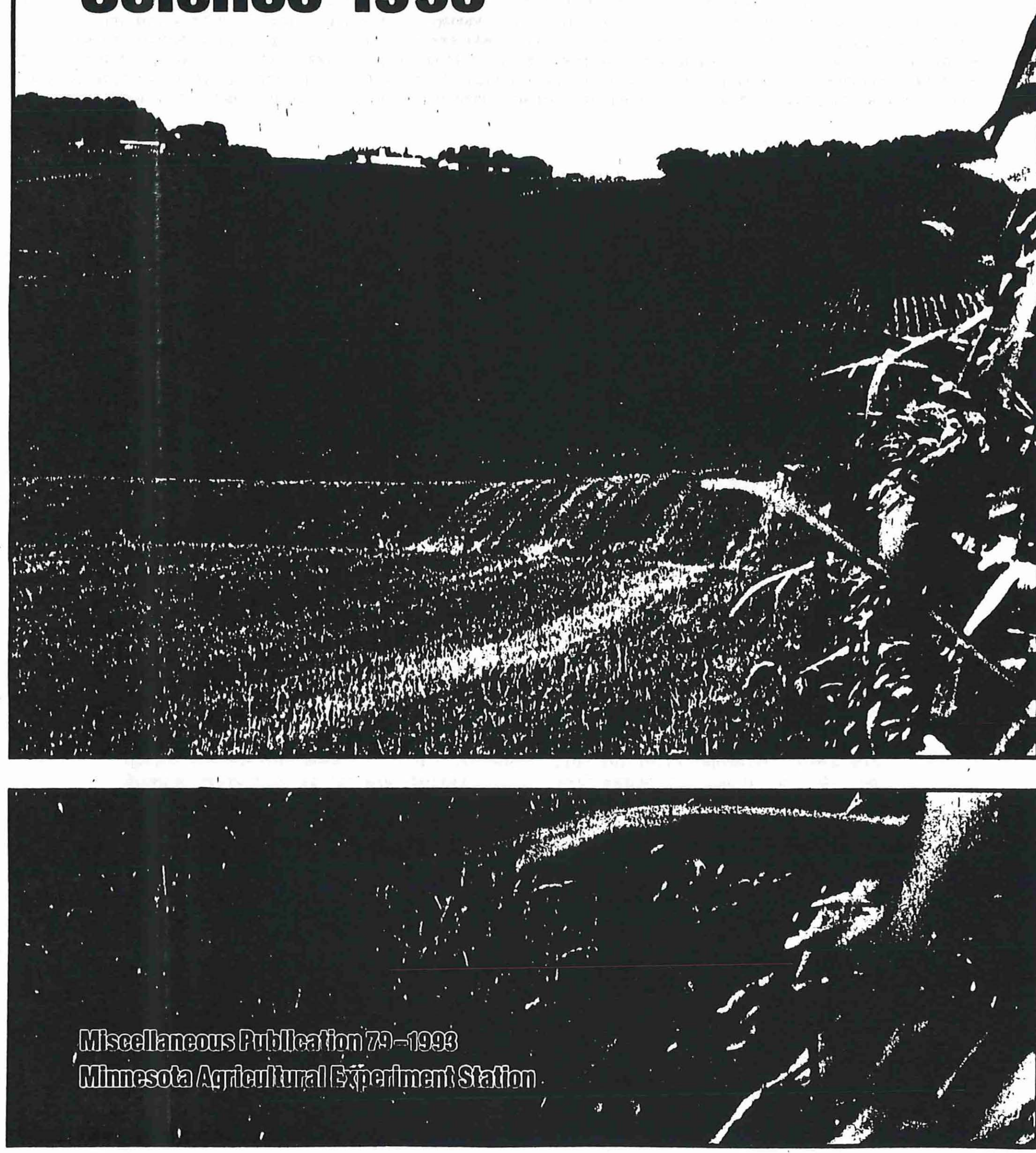
The first year of the field study at Becker, MN to determine the effect of yard waste on corn productivity has been completed. Yard waste application rate had no effect on final plant population. Initial growth of corn was significantly inhibited as leaf application rate increased. Fall application of N and N applied two weeks after emergence tended to minimize the negative effect of yard waste application on initial corn growth. Without added fertilizer nitrogen final grain and stover yield increased with increasing yard waste rate, suggesting release on nitrogen from the yardwaste over the season. With added fertilizer nitrogen, the influence of yard waste rate diminished. The 80 T/A yard waste rate tended to reduce yields compared to the lower application rates and the control. Fall application of nitrogen did not significantly affect final yields. Soil water samples have been collected at the 3-ft depth from two of the 4 replications and nitrate determinations have been completed. Nitrogen uptake by the crop and leaching of nitrate during the season has been completed. On the basis of a single year's crop of corn at Becker, MN it appears that direct soil incorporation of fall tree leaves applied and incorporated in the fall can produce a similar yield following current U of M soil test recommendations when application rates are held to 40 dry tons to the acre or less. Other crops and other soils may be different. A four to five year study would be a useful addition to this study.

Project Results Use and Dissemination

This study was published in the Field Research in Soil Science 1993, Miscellaneous Publication 79-1993, Minnesota Agricultural Experiment Station. This publication is a widely used reference for County Extension Educators and other soil science professionals. These results will be incorporated into presentation at Experiment Station field days and MES staff training as appropriate.

University of Minnesota

Field Research in Soil Science 1993



June 30, 1993 LCMR Final Report

Title: Land Spreading of Yard Waste - Waste 12(b)

Program Manager: Thomas R. Halbach
439 Borlaug Hall
Soil Science Department
University of Minnesota
St. Paul, MN 55108
(612) 625-3135

A.M.L. 1991. Ch.254, Art.1 Sec.14 Subd.12(b)

Attachment A

LAND SPREADING OF YARD WASTE

Carl Rosen, Thomas Halbach, Jean Molina, Dave Birong, Jennifer Weiszel

ABSTRACT: A field experiment at the Sand Plain Research Farm in Becker, Minn. was conducted to determine the effects of applying yard waste applications (primarily tree leaves) on corn production and soil nitrate movement. The yard waste was applied in the fall of 1991. Treatments included four rates of yard waste (0, 20, 40, and 80 T/A) with either 0 fertilizer N applied, 200 lbs N/A during the 1992 growing season, or 66 lbs N/A applied with the yard waste plus 200 lbs N/A applied during the growing season. Yard waste application initially inhibited growth and depressed tissue nitrogen composition of developing corn plants. The inhibitory effect diminished when fertilizer N was applied. These results suggest that soil N was immobilized for 5-6 weeks after planting. By harvest, corn grain yield increased with increasing yard waste application when no fertilizer N was applied, presumably due to release of nitrogen and possibly other nutrients from the yard waste. When N was added during the growing season, with or without fall applied N, the effect of yard waste on grain yield was generally not significant. Maturity, as measured by % moisture in the grain, was delayed with yard waste application. Yard waste application tended to decrease nitrate leaching during the first year after application. Highest nitrate-N concentrations in soil water at the three foot depth were recorded when N was applied in the fall with or without yard waste. During the first year after yard waste application, acceptable yields were obtained at all rates of applied yard waste combined with 200 lb N/A without significant nitrate losses.

Until recently, yard wastes (tree leaves and grass clippings) accounted for 15-20% of the bulk in landfills. In 1990 (metro counties) and in 1992 (greater Minnesota), regulations were passed that prohibited yard wastes from being put in landfills. Because of this legislation, alternatives to landfilling yard waste need immediate attention. Some options for using or recycling the yard waste include: 1) backyard composting and application of the compost to gardens; 2) municipal composting followed by land application of the compost; and 3) direct land application of noncomposted yard waste. While backyard composting is a desirable way to handle yard waste, not all homeowners desire to compost their own yard waste. Several problems with municipal yard waste composting include finding an acceptable site, controlling nutrient runoff, and controlling odors. Direct land application of noncomposted yard waste may be more efficient than composting and does not have the same problems associated with composting. Land application of yard waste may require an adjustment of nitrogen requirements, because of its generally low available nitrogen content. In addition, the effects on nitrogen use and crop production in general need to be ascertained. Therefore, the objectives of this study were to: 1) Determine the effects of direct application and incorporation of noncomposted yard waste (primarily tree leaves), with and without fertilizer nitrogen, on productivity of irrigated field corn, and 2) Characterize nitrogen release from the leaves during the growing in terms of availability for crop needs and movement through the soil profile.

PROCEDURES

The experiment was conducted at the Sand Plain Research Farm in Becker, MN on a Hubbard loamy sand soil. Initial soil chemical characteristics include (0-6"): organic matter, 1.7%; pH (1:1 soil:water), 6.8; Bray P, 26 ppm; K (NH_4OAc), 61 ppm. Extractable (KCl) nitrate-N and ammonium-N in the top 3 feet were 30 lbs/A and 4 lbs/A, respectively. The previous crop was rye. Yard waste was collected in October 1991 and applied to 15' x 35' plots with a front end loader on October 31, 1991. The yard waste primarily consisted of tree leaves, although some garden plants and grass clippings were also present. Subsamples of yard waste applied to each plot were collected for chemical analysis. The following 12 treatments were tested: 0, 20, 40, 80 dry tons/A yard waste (no added N); these same treatments with 200 lb N/A applied during 1992; these same treatments with 66 lb N/A applied in the fall of 1991 plus 200 lb N/A applied during 1992. The fertilizer N source used in all cases was urea. An average of 30% moisture was assumed for application of all yard waste treatments. The experimental design was a randomized complete block with 4 replications. The leaves were incorporated with a rototiller after application (fall 1991) and the whole field was moldboard plowed one week prior to planting in 1992. In addition, 235 lbs/A 0-0-22 and 200 lbs/A 0-0-60 were broadcast and incorporated prior to planting. Pioneer hybrid 3751 (100 day maturity) was planted on April 28, 1992 at a population of 30,700 seeds/A (2.5 ft. between rows). At planting, 185 lbs/A 0-14-42 was banded 2 inches to

[1]Funding for this project was provided by the Legislative Commission for Minnesota Resources
[2]Extension Soil Scientist, Extension Waste Management Specialist, Professor, Junior Scientist, and Senior Research Plot Technician, respectively, Department of Soil Science.

the side and two inches below the seed. On May 27, 100 lbs N/A was sidedressed with a hand pushed Gandy fertilizer applicator and cultivated in. Additional N at a rate of 50 lbs/A per application was applied with the Gandy applicator on June 17 and June 22 and irrigated in with 0.5 inch of water. Irrigation was used to supplement rainfall (Figure 1).

Soil samples at the 0-8 inch depth were collected from each plot before planting. After harvest, soil samples were collected from 0-6, 6-12, 12-24 and 24-36 inch depths. Soil nitrate and ammonium were determined on 2 N KCl extracts.

Suction tubes with ceramic cups were installed at a depth of 3 feet in two replications of each treatment. Suction tubes at the 6 foot depth were installed in two reps for the control and 40 T/A yard waste plus 266 lbs of N treatments. Water samples were collected every two weeks through the growing season and analyzed for nitrate. On one set of water samples (September 11), a more extensive elemental analysis was performed using an ICP spectrophotometer.

Whole plant samples (4 per plot) were collected at the three leaf stage (May 26) before fertilizer N was applied in 1992. Whole plant samples (4 per plot) at the 8-12 leaf stage were collected on June 26 after all fertilizer N was applied. Ear leaf samples at 50% silking were collected on July 28. Two, 20 foot rows were harvested for grain and stover yield from each plot on October 10. Subsamples of stover and grain plus cob were taken for moisture determinations, shelling percentages, and nitrogen analyses. Plant tissue samples were dried and then ground through a 30 mesh screen. Following Kjeldahl digestion, total nitrogen in plant tissues was determined using conductimetric procedures.

RESULTS

Yard Waste Elemental Composition: The yard waste had an acid pH (Table 1). The average moisture content was 30% with a range of 18.6 - 48.1%. The outer part of the pile tended to be drier than the inner part. The C/N ratio averaged 37.8%, which is on the low side for leaves, but is in a range that should initially immobilize N. The yard waste contained 21.2 lbs N/dry ton, 3.2 lbs P/dry ton (7.4 lbs P_2O_5), and 14.4 lbs K/dry ton (17.3 lbs K_2O). The yard waste contained significant quantities of Ca, Mg and S. Trace elements were also present in the yard waste, but were not at levels considered to be detrimental to the environment.

Corn Growth and Yield: Initial growth of corn was significantly inhibited as leaf application rate increased (Table 2). Application of N tended to minimize the negative effect of yard waste application on initial corn growth. Greatest growth at the 8-12 leaf stage occurred when N was applied in the Fall and during the growing season. Yard waste application rate up to 40 T/A tended to increase final stand count. At the 80 T/A rate, stand count declined. Stand count also increased with increasing fertilizer N rate. At harvest, increasing yard waste rates increased grain yield when no N was applied, indicating a significant release of N from the yard waste. However, when N was added during the growing season with or without fall applied N, the effect of yard waste on grain yield was generally not significant. There was a slight decrease in grain yield at the highest yard waste rate and when fall N plus 200 lb N/A was applied. Stover yield increased with increasing yard waste application and fertilizer N rate. Yard waste and low fertilizer N tended to delay maturity as measured by higher kernel moisture percentage.

Tissue Nitrogen Concentrations: Nitrogen concentrations in whole plants sampled at the 3 leaf stage decreased as yard waste application increased (Table 3). These results indicate that early in the season N was immobilized by the yard waste. Fall applied N significantly increased N concentrations in the plant. By the 8-12 leaf stage, yard waste application was beginning to have a positive effect on N concentrations in the plant, while the effect of fall application of N began to diminish. Ear leaf N increased with increasing yard waste application when no fertilizer N was applied, but was not affected by yard waste when fertilizer N was applied. Application of fertilizer N increased N concentrations in the ear leaf. Cob N concentrations were not affected by yard waste application and were not consistently affected by fertilizer N application. Stover N concentrations tended to increase with increasing yard waste application, primarily when no fertilizer N was applied. Application of fertilizer N also increased N concentrations in the stover. Kernel N increased with increasing application of yard waste and increasing fertilizer N application. As with other tissues, the effect of yard waste was most pronounced when fertilizer N was not applied.

Soil Nitrogen Content: Soil nitrogen increased with increasing yard waste application in the top 6 inches, but was not significantly affected by yard waste at the lower depths (Table 4). Soil nitrogen increased with increasing fertilizer N application, with the fall applied N treatment having the highest residual N in the top 3 feet. It is interesting to note, however, that the initial soil nitrate-N content of 30 lbs/A was higher than the soil nitrate-N content following any of the fertilizer N and/or yard waste treatments.

<u>Soil Water Elemental Concentrations</u>: Elemental concentrations in soil water sampled on September 11 are presented in Table 5. Al, B, Cd, Cr, Cu, Fe, Mo, Ni, and Pb were generally below detection limits of the ICP. Ca, K, Na, and S tended to increase with increasing yard waste application. P concentrations tended to increase with increasing yard waste when no fertilizer N was applied, but was not consistently affected when fertilizer N was applied. Except for soil water nitrate (see below), other elements determined in soil water were not affected by yard waste application or fertilizer N.

<u>Soil Water Nitrate Concentrations</u>: Concentrations of nitrate-N in soil water as affected by treatments are presented in Figures 2-13. Yard waste applications tended to decrease nitrate concentrations in soil water at the three foot depth when fertilizer N was not applied. The control treatment had the highest water nitrate-N concentrations with levels slightly above 10 ppm. When yard waste was applied nitrate-N concentrations were less than 10 ppm. Nitrate-N concentrations at the three foot depth, when fertilizer N was applied during the season, tended to be highest when 80 T/A yard waste was applied at mid-season. However, by the end of the season, the 0 yard waste treatment with fertilizer N had the highest nitrate concentrations. Nitrate-N concentrations in soil water were greatest when fertilizer N was applied in the fall. Highest concentrations at mid-season were recorded when 0 T/A leaves were applied. Yard waste application tended to decrease nitrate-N concentrations; however, compared to the other N treatments, fall applied N resulted in the highest losses at the end of the growing season. From these measurements, yard waste amendments appear to reduce nitrate-N losses during the first growing season after application.

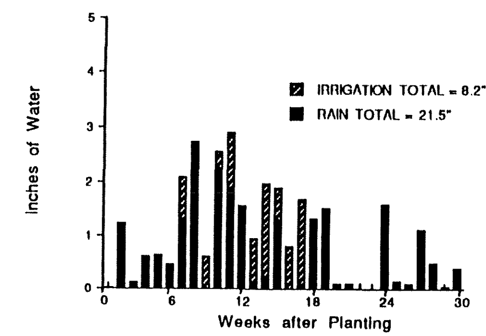


Figure 1. Rainfall and irrigation provided over the 1992 growing season.

Table 1. Elemental concentrations of original yard waste samples.

	Mean	Standard Deviation	Minimum	Maximum	lbs element/ dry ton
pH	4.9	0.2	4.4	5.5	
% moisture	29.7	7.7	18.6	48.6	
C to N ratio	37.9	3.2	29.6	42.6	
Macroelements (%)					
Carbon	39.76	3.49	33.56	45.95	795.2
Nitrogen	1.06	0.12	0.81	1.46	21.2
Phosphorus	0.16	0.02	0.12	0.20	3.2
Potassium	0.72	0.14	0.47	1.16	14.4
Calcium	2.33	0.25	1.75	2.75	46.6
Magnesium	0.37	0.04	0.27	0.49	7.4
Sulfur	0.19	0.02	0.15	0.22	3.8
Microelements (ppm)					
Aluminum	1052	464	254	1960	2.1
Boron	65	9	48	97	0.13
Cadmium	<0.52	0.35	<0.16	1.30	<0.10
Chromium	7.5	3.5	1.6	14.4	0.015
Copper	8.4	1.2	5.6	10.7	0.016
Iron	969	334	359	1755	1.9
Lead	<15.5	7.7	<2.2	39.6	<0.031
Manganese	249	40	177	399	0.50
Nickel	<6.5	3.3	<0.9	13.4	0.013
Sodium	105	23	60	163	0.21
Zinc	61	9	40	85	0.12

Table 2. Effect of leaf and nitrogen application on whole plant dry matter at the 8-12 leaf stage, final stand count, grain and stover yield, and kernel moisture.

Leaf rate	Nitrogen application	Whole plant dry matter (8-12 leaf)	Final stand count	Grain yield	Dry stover	Kernel moisture
-tons/A-	--lbs/A--	-grams/plant-	-plants/A-	-bu/A-	-tons/A-	- % -
0	0	16.0	26463	76	1.25	36
20	0	5.5	26789	99	1.37	39
40	0	8.8	28532	124	1.68	38
80	0	6.0	26681	130	1.86	36
0	200	21.8	27770	188	2.48	29
20	200	12.5	27334	185	3.06	34
40	200	9.3	27770	188	3.05	35
80	200	10.5	27770	182	3.17	35
0	66+200	29.3	27660	195	2.91	31
20	66+200	25.5	28859	203	3.01	30
40	66+200	15.0	28859	195	3.15	35
80	66+200	13.0	27661	176	2.95	34
Significance		**	NS	**	**	**
BLSD (5%)		9.3	--	20	0.50	3
Main effects						
Leaf Rate						
0		22.3	27298	153	2.22	32
20		14.5	27661	162	2.48	34
40		11.0	28387	169	2.63	36
80		9.8	27370	162	2.66	35
Significance		**	NS	NS	*	**
BLSD (5%)		5.3	--	--	0.34	2
Linear		**	NS	NS	**	**
Quadratic		*	*	*	NS	**
Nitrogen Application						
	0	9.0	27116	107	1.54	37
	200	13.5	27661	186	2.94	33
	66+200	20.8	28260	192	3.01	32
Significance		**	*	**	**	**
BLSD (5%)		4.3	892	10	0.24	2
Interaction						
Leaf x Nitrogen		NS	NS	**	NS	*

NS = nonsignificant, * = significant at 5%, ** = significant at 1%.

Table 3. Effect of leaf and nitrogen application on percent nitrogen present at various growth stages and in various plant tissues.

Leaf rate	Nitrogen application	Whole plant 3 leaf stage	Whole plant 8-12 leaf stage	Ear leaf silking stage	Cob	Stover	Kernel
-tons/A-	--lbs/A--	% Nitrogen					
0	0	4.19	1.74	1.34	0.31	0.38	0.92
20	0	3.19	2.49	1.97	0.29	0.42	1.01
40	0	3.03	2.57	2.05	0.28	0.47	1.12
80	0	2.80	3.00	2.31	0.27	0.52	1.24
0	200	4.21	3.14	2.89	0.25	0.53	1.26
20	200	3.20	3.80	2.94	0.26	0.58	1.29
40	200	3.16	3.96	2.68	0.24	0.61	1.35
80	200	3.19	3.71	3.04	0.26	0.60	1.37
0	66+200	4.32	3.08	3.00	0.26	0.57	1.35
20	66+200	4.39	3.30	2.51	0.26	0.65	1.38
40	66+200	4.10	3.57	2.95	0.26	0.63	1.41
80	66+200	3.60	3.66	2.94	0.27	0.55	1.41
Significance		**	**	**	**	**	**
BLSD (5%)		0.72	0.40	0.76	0.03	0.12	0.09
Main effects							
Leaf Rate							
0		4.24	2.66	2.35	0.27	0.49	1.18
20		3.59	3.20	2.47	0.27	0.55	1.23
40		3.43	3.36	2.56	0.26	0.57	1.29
80		3.20	3.46	2.76	0.26	0.56	1.34
Significance		**	**	NS	NS	NS	**
BLSD (5%)		0.39	0.23	--	--	--	0.05
Linear		**	**	NS	NS	NS	**
Quadratic		*	**	NS	NS	NS	NS
Nitrogen Application							
	0	3.30	2.45	1.92	0.29	0.45	1.07
	200	3.44	3.65	2.89	0.25	0.58	1.32
	66+200	4.10	3.40	2.84	0.26	0.60	1.39
Significance		**	**	**	**	**	**
BLSD (5%)		0.34	0.19	0.33	0.01	0.05	0.04
Interaction							
Leaf x Nitrogen		NS	NS	NS	NS	NS	*

NS = nonsignificant, * = significant at 5%, ** = significant at 1%.

Table 4. Effect of leaf and nitrogen application on soil nitrate-N (lbs/A) in the top three feet at the end of the growing season.

Leaf rate	Nitrogen application	sample depth (inches) 0 - 6	6 - 12	12 - 24	24 - 36	Total
-tons/A-	--lbs/A--	lbs nitrate-N/A				
0	0	0.78	0.74	0.75	0.72	2.98
20	0	1.24	0.99	0.94	0.64	3.81
40	0	1.90	1.54	1.47	0.67	5.58
80	0	2.96	2.53	1.36	1.12	7.97
0	200	2.35	2.34	1.67	0.74	7.09
20	200	4.22	3.78	2.24	1.22	11.46
40	200	5.30	4.10	2.63	1.25	13.28
80	200	6.34	3.76	2.10	0.79	12.99
0	66+200	2.73	3.29	1.54	1.18	8.74
20	66+200	7.98	9.50	6.82	3.14	27.44
40	66+200	7.96	6.69	2.93	1.42	18.99
80	66+200	9.20	5.10	3.31	2.19	19.80
Significance		**	**	**	**	**
BLSD (5%)		3.41	4.62	2.96	1.24	10.80
Main effects						
Leaf Rate						
	0	1.95	2.12	1.32	0.88	6.27
	20	4.48	4.76	3.33	1.67	14.23
	40	5.05	4.11	2.34	1.11	12.61
	80	6.17	3.80	2.26	1.37	13.59
	Significance	**	NS	NS	NS	*
	BLSD (5%)	1.94	--	--	--	6.57
	Linear	**	NS	NS	NS	NS
	Quadratic	NS	NS	NS	NS	NS
Nitrogen Application						
	0	1.72	1.45	1.13	0.79	5.08
	200	4.55	3.49	2.16	1.00	11.20
	66+200	6.97	6.14	3.65	1.98	18.74
	Significance	**	**	**	**	**
	BLSD (5%)	1.57	1.93	1.28	0.54	4.78
Interaction						
	Leaf x Nitrogen	NS	NS	NS	NS	NS

NS = nonsignificant, * = significant at 5%, ** = significant at 1%.

Table 5. Effect of leaf and nitrogen application on elemental composition of soil water collected at 3' from suction tubes - Sept. 11, 1992.

Leaf rate	Nitrogen application	Al	B	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	S	Zn
-tons/A-	--lbs/A--	ppm																
0	0	<0.18	<0.02	44	<0.006	<0.01	<0.03	<0.02	1.6	6	0.015	<0.01	6	<0.022	0.08	<0.09	33	0.11
20	0	<0.18	<0.03	55	<0.006	<0.01	0.06	<0.02	1.7	10	0.037	<0.01	38	0.028	0.08	<0.09	73	0.35
40	0	<0.18	0.17	111	<0.006	<0.01	<0.03	<0.02	1.6	13	0.052	<0.01	12	0.028	0.10	<0.09	97	0.15
80	0	<0.18	0.07	123	<0.006	<0.01	<0.03	0.03	3.8	14	0.017	<0.01	47	<0.024	0.21	<0.09	117	0.09
0	200	<0.18	<0.02	66	<0.006	<0.01	<0.03	<0.02	1.9	12	0.029	<0.01	12	<0.026	0.17	<0.09	58	0.17
20	200	<0.18	0.28	62	<0.006	<0.01	<0.03	<0.02	0.9	5	0.035	<0.01	17	<0.027	0.10	<0.09	45	0.20
40	200	<0.18	<0.02	81	<0.006	<0.01	<0.04	<0.02	1.6	8	0.027	<0.01	22	<0.023	0.08	<0.09	55	0.10
80	200	<0.18	<0.27	94	<0.006	<0.01	<0.05	<0.02	1.7	16	0.035	<0.01	27	<0.029	0.12	<0.09	83	0.13
0	66+200	<0.18	<0.15	89	<0.006	<0.01	<0.03	<0.02	2.7	10	0.036	<0.01	18	<0.029	0.07	<0.09	73	0.26
20	66+200	<0.18	<0.03	78	<0.006	<0.01	<0.03	<0.02	4.0	12	0.038	<0.01	24	<0.026	0.08	<0.09	67	0.19
40	66+200	<0.18	<0.04	67	<0.006	<0.01	<0.03	0.03	3.5	14	0.036	<0.01	22	<0.030	0.11	<0.09	65	0.19
80	66+200	<0.18	0.04	106	<0.006	<0.01	<0.03	0.04	8.3	20	0.096	<0.01	19	0.035	0.10	<0.09	86	0.25
Significance		—	—	NS	—	—	—	—	NS	NS	NS	—	NS	—	*	—	NS	NS
BLSD (5%)		—	—	—	—	—	--	—	—	—	—	—	—	—	0.08	—	—	—
Main effects																		
Leaf Rate																		
	0	<0.18	<0.06	66	<0.006	<0.01	<0.03	<0.02	2.1	9	0.027	<0.01	12	<0.025	0.11	<0.09	55	0.18
	20	<0.18	<0.13	67	<0.006	<0.01	<0.03	<0.02	2.3	9	0.036	<0.01	24	<0.027	0.09	<0.09	60	0.23
	40	<0.18	<0.08	86	<0.006	<0.01	<0.03	<0.02	2.2	12	0.038	<0.01	19	<0.027	0.10	<0.09	72	0.15
	80	<0.18	<0.13	108	<0.006	<0.01	<0.04	<0.03	4.6	16	0.049	<0.01	31	<0.029	0.14	<0.09	96	0.16
	Significance	—	—	NS	—	—	—	—	NS	NS	NS	—	NS	—	*	—	*	NS
	BLSD (5%)	—	—	—	—	—	—	—	—	—	—	—	—	—	0.04	—	28	—
	Linear	—	—	*	—	—	—	—	NS	*	NS	—	*	—	*	—	**	NS
	Quadratic	—	—	NS	—	—	—	—	NS	NS	NS	—	NS	—	*	—	NS	NS
Nitrogen Application																		
	0	<0.18	<0.08	87	<0.006	<0.01	<0.03	<0.02	2.2	11	0.029	<0.01	24	<0.025	0.12	<0.09	81	0.15
	200	<0.18	<0.15	76	<0.006	<0.01	<0.03	<0.02	1.5	10	0.031	<0.01	20	<0.026	0.12	<0.09	60	0.15
	66+200	<0.18	<0.06	85	<0.006	<0.01	<0.03	<0.02	4.7	14	0.051	<0.01	21	<0.030	0.09	<0.09	73	0.22
	Significance	—	—	NS	—	—	—	—	NS	NS	NS	—	NS	—	NS	—	NS	NS
	BLSD (5%)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Interaction																		
	Leaf x Nitrogen	—	—	NS	—	—	—	—	NS	NS	NS	—	NS	—	*	—	NS	NS

NS = not significant, * = significant at 5%, ** = significant at 1%.

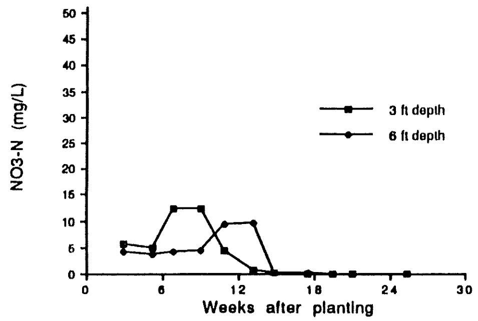


Figure 2. Nitrate-N concentration in soil water at 3 and 6 ft. depths over the 1992 growing season. Treatment 1: no leaves, no nitrogen applied.

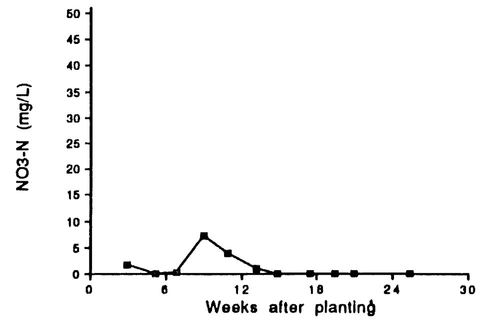


Figure 3. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 2: 20 tons/A leaves, no nitrogen applied.

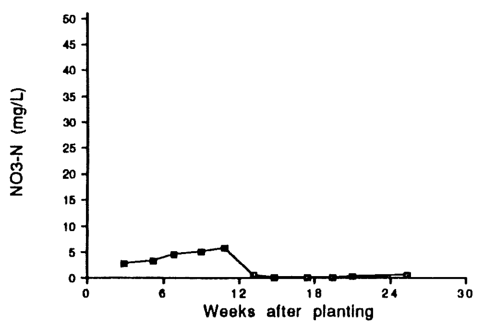


Figure 4. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 3: 40 tons/A leaves, no nitrogen applied.

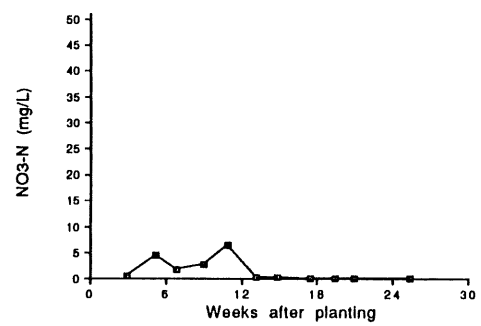


Figure 5. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 4: 80 tons/A leaves, no nitrogen applied.

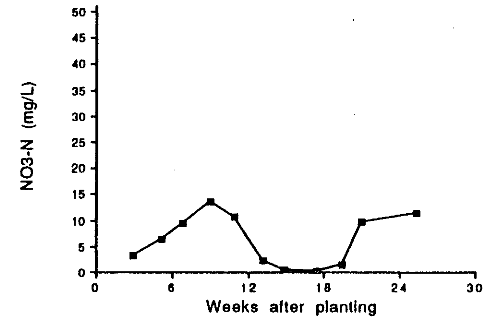


Figure 6. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 5: no leaves, 200 lbs/A nitrogen applied applied during the growing season.

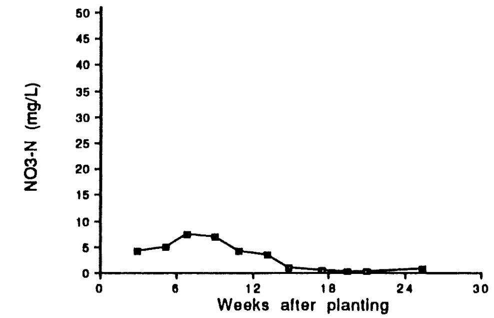


Figure 7. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 6: 20 tons/A leaves, 200 lbs/A nitrogen applied during the growing season.

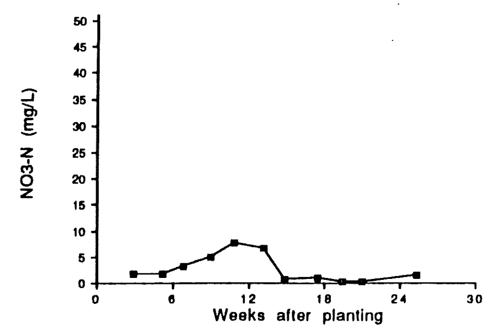


Figure 8. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 7: 40 tons/A leaves, 200 lbs/A nitrogen applied during the growing season.

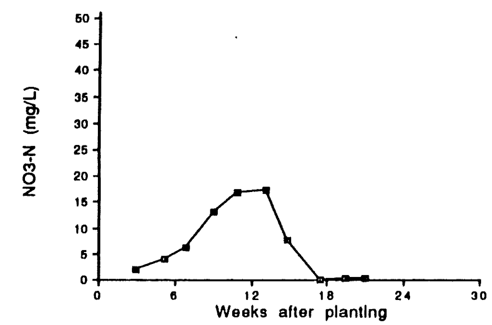


Figure 9. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 8: 80 tons/A leaves, 200 lbs/A nitrogen applied during the growing season.

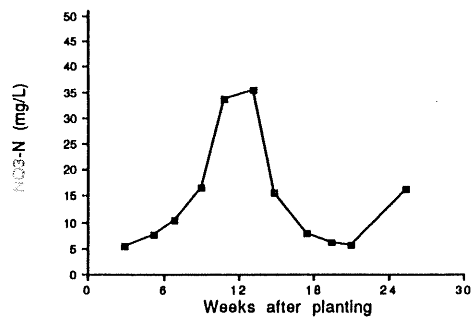


Figure 10. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 9: no leaves, 66 lbs/A nitrogen fall applied and 200 lbs/A applied during the growing season.

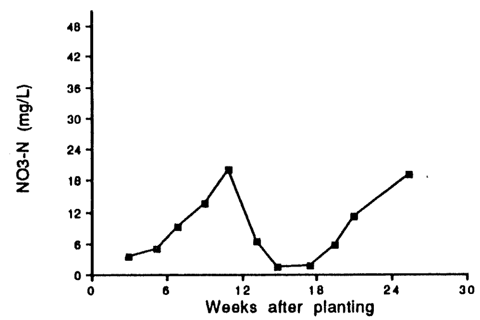


Figure 11. Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 10: 20 tons/A leaves, 66 lbs/A nitrogen fall applied and 200 lbs/A applied during the growing season.

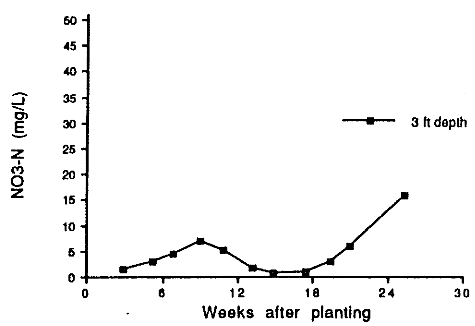


Figure 12: Nitrate-N concentration in soil water at the three ft. depth over the 1992 growing season. Treatment 11: 40 tons/A leaves, 66 lbs/A nitrogen fall applied and 200 lbs/A applied during the growing season.

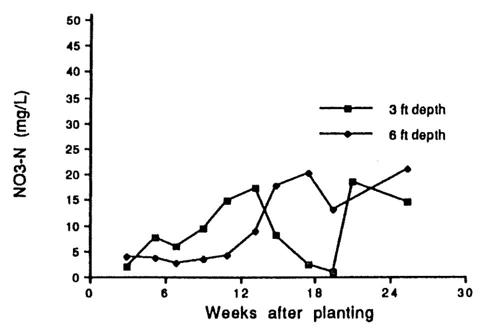


Figure 13: Nitrate-N concentration in soil water at 3 and 6 ft. depths over the 1992 growing season. Treatment 12: 80 tons/A leaves, 66 lbs/A nitrogen fall applied and 200 lbs/A applied during the growing season.

June 30, 1993 LCMR Final Report

Title: Land Spreading of Yard Waste - Waste 12(b)

Program Manager: Thomas R. Halbach
439 Borlaug Hall
Soil Science Department
University of Minnesota
St. Paul, MN 55108
(612) 625-3135

A.M.L. 1991. Ch.254, Art.1 Sec.14 Subd.12(b)

Attachment B

Project Report Summary

Project objectives.

The goal of this project was to develop a computer simulation model that would predict the nitrogen affects from direct application of yard waste on Minnesota crops and soils. The project's two primary objectives were forecast user accessibility and accuracy. User accessibility was accomplished by designing software that is menu-driven and user-friendly. Accuracy is measured by comparing simulation results with field trials from the Becker experiment station.

Research model modifications.

Phase one of the project called for modify the research model NCSWAP version 1.0. The baseline programming structure was developed by Dr. J.A.E. Molina of the University's Soil Science Department. This program was written for scientific researcher concerned with microbial carbon-nitrogen exchange and plant nitrogen use. Many of the features incorporated in version 1.0 were beyond the concerns of yard waste managers, and thus in the interest of improving program run-time many parameters were fixed or eliminated.

The initial research model's 7,000 lines of computer code were reduced to 4,500 lines, and inefficient algorithms were re-designed. Combined with modifications to the input-output routines, dramatic improvements were made in the program's run-time. To assure the integrity of the system following these changes, a lengthy error-checking process was conducted of the model's intermediate calculations and data exchanges among the many subroutines.

User interface development.

The project's second phase was the design of a program "shell" to give users an easy access point for testing yard waste application scenarios. User's are able to choose crop management options, as well as alternative environmental conditions. Version 1.1 allows the user to set planting and harvest dates, the type and amount of yard waste to be applied, plus the amount and incorporation depth of inorganic nitrogen. Environmental variables include climatic conditions (rain and air temperature) and field soil type. Each scenario results in information on crop growth and stress measures, as well as data on the soil profile nitrogen balance. These results are based on assumptions about initial field conditions and the expected outcome of a baseline reference crop.

Validation and Calibration.

The project's final phase was to calibrate the model using data from yard waste application trials conducted at the Becker experiment station during 1992. The findings of this comparison are detailed in section 6 of this report. While the model fails to accurately predict the Becker trial results, it does appear to have potential as a forecasting devise.

Future program development potential.

A number of system changes would enhance both the accuracy and accessibility of NCSWAP version 1.1. Each section of this report details some aspect of the modelling system, and with each section are suggestions for potential improvements. In addition to these modifications, further testing against actual field results is needed to calibrate the model for a wider variety of crops and conditions.

Report outline.

This report is organized into the following sections:

Section 1.	User interface screens.
Section 2.	Model baseline assumptions.
Section 3.	Model baseline input files.
Section 4.	Model baseline results -- full report.
Section 5.	Factor relationship testing.
Section 6.	Becker simulations and trial results.
Appendix A.	User interface source code.
Appendix B.	Main program source code.

Use of the software.

The diskette included with this report contains a copy of NCSWAP version 1.1. To initiate the program type SWAP2D. A co-processor is required for the program to execute. This version does not print a detailed report with each simulation, such as that found in section 4. It is important to remember that while the program exhibits a proper set of factor relationships, additional calibration is needed to improve the accuracy of point estimates.

Section 1. User Interface Screens.

New software was developed to allow user's a fast and direct method for testing yard waste application scenarios. NCSWAP version 1.1 is really two programs, one operating within the other. The user interface screens found in this section are created by the "shell" program SWAP2D. The source code for this program can be found in Appendix A.

Five screens make up the user interface:

Screen 1 is an introduction screen that appears only at the start of the program.

Screen 2 is the menu from which alternative scenarios are created. The user can change options by using a mouse, or by tabbing from one option to the next. A carriage return actives the simulation.

Screen 3 is displayed while the program is calculating the simulation results.

Screen 4 displays the simulation results of the screen 2 scenario.

Screen 5 allows the user to quit the program or run another scenario by returning to screen 2.

Some suggestions for improving the interface portion of the program might include:

Improvements to screen 2:

* develop input values for other crops; potatoes, small grains.

* modify the C:N ratio dialog to allow actual carbon nitrogen ratios when they are available, or require the user to input a value based on some guidelines found in a help screen.

* eliminate the N form dialog and have the user input directly through the N rate dialog the amount of nitrogen applied. Again, a help screen could offer the user guidelines for calculating the nitrogen actually applied given some N form such as urea.

* allow for split (or multiple) N applications. This would also have had an impact on the Becker results of section 6.

* modify the rainfall and air-temp dialogs to let the user

choose an actual climate year for their location. A complete set of climate files (rainfall, air and soil temperatures, pan-evaporation) would create a more accurate scenario than the current structure which substitutes rainfall or air temperature file without making adjustments to the soil temperature and pan-evaporation data.

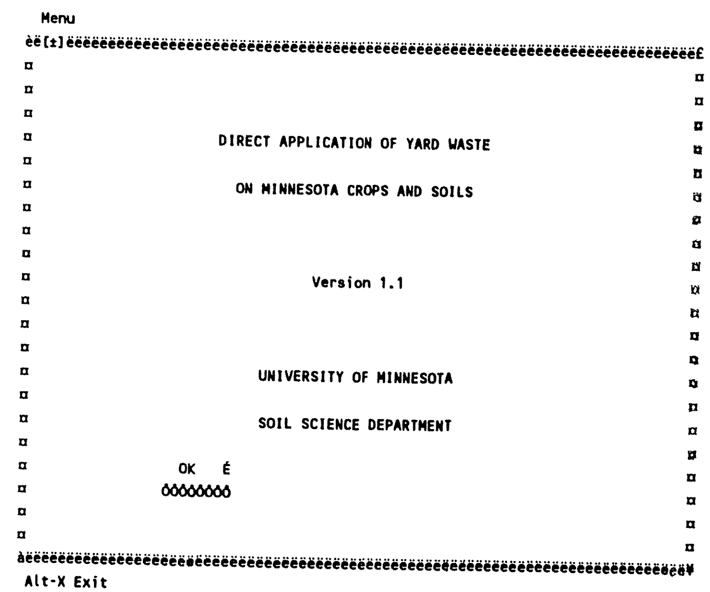
* activate the percent total N and initial N input lines, also make allowance for changing the bulk density of the top layers when residue is added.

* alter the CAP LOCK requirement for inputting dates.

Improvements to screen 4:

* modifications should be made to eliminate any information which may confuse the user, or provide additional information to help the user interpret the result. Additional changes might include a summary of the simulation options chosen in screen 2 displayed on the screen.

* Add a second screen detailing the scenario results or provide the user the option of printing out a more complete analysis of the simulation.



SCREEN 1

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                        Rainfall         ¤
¤                                     N Form                ( ) Dry          ¤
¤                    C:N Ratio        ( ) Ammon. Nitrate    () Average      ¤
¤ Crop               ( ) Grass  -  20:1  ( ) Urea           ( ) Wet          ¤
¤ () Corn           () Leaves -  40:1  ( ) Liquid Nitrogen                 ¤
¤ ( ) Future         ( ) Leaves -  70:1  () Anhydrous Ammon  Air-temp        ¤
¤ ( ) Future         ( ) Wood   - 150:1  ( ) Ammon. Sulfate  ( ) Hot          ¤
¤                                                            () Average      ¤
¤ Plant on  APR 28   Apply on  APR 2     Apply on   MAY 30   ( ) Cold         ¤
¤                                                                            ¤
¤ SeedRate   30700   Rate Ton/Ac  20     NRate (lb/ac) 200   Soil Type       ¤
¤                                                            ( ) Sand         ¤
¤ Harvest   OCT 12   Incorporation       Apply Method        () Loam         ¤
¤                    ( ) None            ( ) Surface         ( ) Clay         ¤
¤                    ( ) Shallow [0-6"]  () Shallow [0-6"]                   ¤
¤                    () Deep [0-12"]    ( ) Deep [0-12"]    % total N   99   ¤
¤                                                                            ¤
¤                                                            N init ppm 99    ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë    Ok    Éëëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

Screen 2.

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
¤                    PLEASE WAIT  -- Science takes time                      ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

Screen 3

```
Menu

Amount N left in the residue    128.31    (lb/ac)

Inorganic N leached       .01    (lb/ac)

Net immobil(-)/mineralizat(+)    30.45    (lb/ac)

Denitrification    29.18    (lb/ac)

Top mass @ 15.5 H2O  14804.88    (lb/ac)

Moisture deficit in crop      .00    (inches)

Nitrogen deficit in crop     5.02    (lb/ac)

Organic Nitrogen pool CHANGE    273.51    (lb/ac)

Inorganic N in profile    79.57    (lb/ac)

Ok     Quit

Alt-X Exit
```

Screen 4.

```
Menu

Amount N left in the residue    128.31    (lb/ac)

Inorganic N leached       .01    (lb/ac)

Net immobil(-)/mineralizat(+)    30.45    (lb/ac)

    Yes or No

        Quit Now ?

  Mo      Yes      No

  Ni

Organic Nitrogen pool CHANGE    273.51    (lb/ac)

Inorganic N in profile    79.57    (lb/ac)

Ok     Quit

Alt-X Exit
```

Screen 5.

Section 2. Model baseline assumptions.

This section outlines the baseline or default assumptions about initial soil conditions and crop management practices for the Becker field trials in 1992. Some of these assumptions are fixed values in the model, others are subject to change through the user interface. The following schematics help illustrate the "art" of setting the model's initial conditions.

Figure 1. Crop development assumptions.

The cropping option chosen for the baseline simulation is corn planted on April 28 at a seed rate of 30,700 plants per acre, and harvested on October 12. Key fixed crop development stages, set in relation to the date of plant emergence, are show on the top half of figure 1. Below are the rates of growth for root and topmass development. These assumptions need to reflect the actual growing conditions (at Becker), and the development pattern of the corn hybrid used in the reference growth curve.

Figure 2. Initial physical and hydraulic soil properties.

The bulk density and gravimetric water properties assumed in the model and those actually found at Becker are compared in this schematic. Four gravimetric water content settings are required; initial conditions (cubic centimeters per gram), the wilt point, field capacity, and saturation point. This figure also demonstrates the arbitrary allocation of a few discrete field measurements to the 6 cm. measurement continuum which makes up the model profile.

Figure 3. Initial inorganic nitrogen.

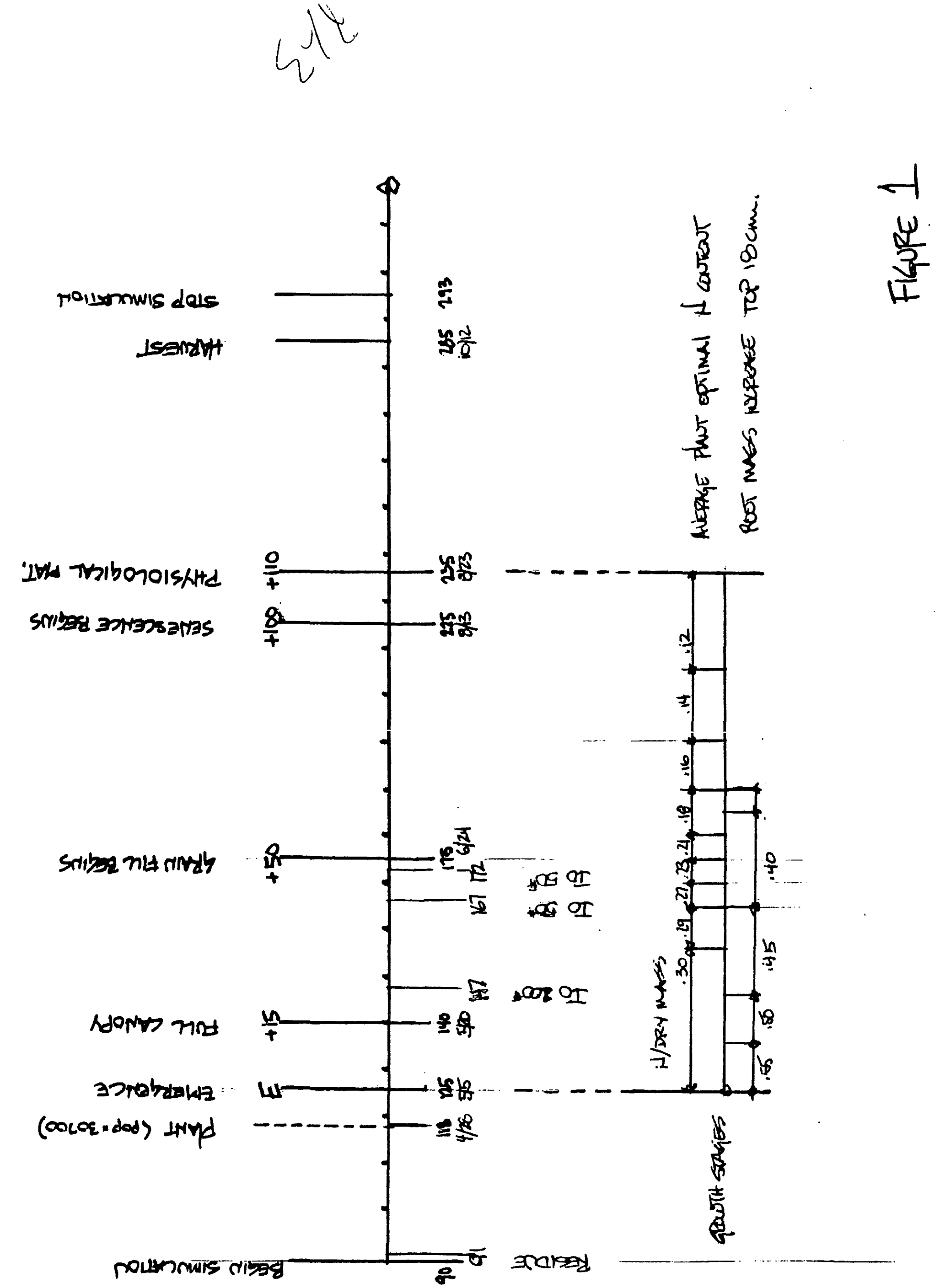
Initial soil profile NO3 and NH4 value (parts per million) are allocated to the models three horizons, from Becker data gathered from three field measurement depths.

Figure 4. Pool I -- microbial mass.

Carbon and nitrogen levels are assumed at 6 parts to 1 part for the microbial mass. No actual Becker data is available.

Figure 5. Pool II -- nutrient humus.

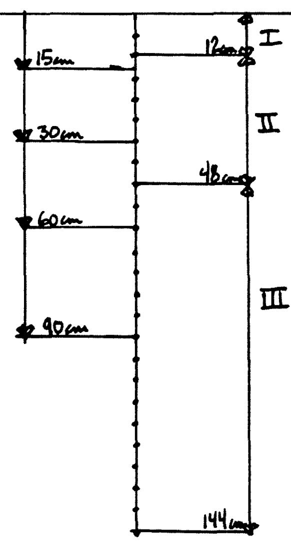
Carbon and nitrogen (ppm) levels are estimated from Becker data on soil percent organic matter taken from three sampling depths, and a rule-of-thumb allocation formula.



INITIAL PHYSICAL & HYDRAULIC PROPERTIES

BECKER

B.D	GRAVIMETRIC H_2O CONTENT INITIAL	W.P.	F.C.	SAT.
1.55	N/A	.037	.13	.269
1.60	N/A	.036	.12	.248
1.62	N/A	.025	.082	.24
1.66	N/A	.012	.052	.226
gm/cm³	-	cm³/g	cm³/g	cm³/g



MODEL

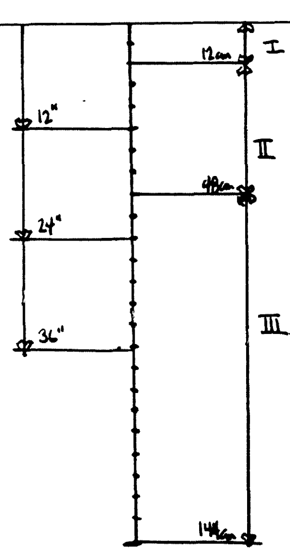
Layer	BD	GRAVIMETRIC H_2O CONTENT INITIAL	W.P	F.C.	SAT.
I	1.55	.090	.037	.130	.269
II	1.60	.075	.030	.120	.248
III	1.66	.060	.012	.065	.226
	g/cm³	ml/g	ml/g	ml/g	ml/g

FIGURE 2

INITIAL INORGANIC NITROGEN

BECKER

NO_3	NH_4
3.4	.745
2.70	.095
1.41	.11
ppm	ppm



MODEL

Layer	NO_3	NH_4 (10% soluble)
I	3.4	.75
II	2.7	.10
III	1.4	.11
	ppm	ppm

FIGURE 3.

POOL I - MICROBIAL MASS

BECKER

— NO DATA —

MODEL

Depth	Zone	C ppm	N ppm	C:N
0–12 cm	I	6	1	6:1
12–48 cm	II	6	1	6:1
48–144 cm	III	6	1	6:1

FIGURE 4

POOL II - NUTRIENT HUMUS

BECKER

Depth	% ORGANIC MATTER
0–12"	1.5
12"–24"	.75
24"–36"	.10

MODEL

Depth	Zone	C ppm	N ppm	C:N
0–12 cm	I	150	10	15:1
12–48 cm	II	75	5	15:1
48–144 cm	III	15	1	15:1

FIGURE 5

Section 3. Model baseline input files.

This section contains the data files needed to run the baseline scenario of NCSWAP version 1.1. Files ending in .AVG are data files for the "average" or baseline scenario. Alternative files, ending for example in .WET or .DRY, are also used by the program to simulate alternative conditions, such as a wet or dry annual rainfall. Files ending in .PRN or .INC contain constant values. A complete set of data input files can be found in the subdirectory A:\DATAIN of the project documentation disk.

The following data files are examined in turn:

File Name	Data set
DATA8.AVG	Soil temperature
DATA11.AVG	Pan-evaporation
DATA12.AVG	Rainfall Events
DATA13.PRN	Reference Crop Air Temperature
DATA14.AVG	Actual Air Temperature
DATA55.INC	Soil Physical and Hydrologic Properties

Two files are used to exchange information between the user interface and the main model.

DATA56.PRN	Interface-to-Model simulation parameters
DATA58.PRN	Model-to-Interface simulation results

Information needed to run the model

Soil conditions

Nitrogen content for each soil horizon
- inorganic NO3 and NH4 (ppm)
- organic Pool I -- microbial mass C:N ratio and ppm carbon
- organic Pool II -- nutrient humus C:N ratio and ppm carbon

bulk density (gm/cm3)

gravimetric water content (ml/gm)
- initial content
- stress point
- field capacity
- saturation

Climatic data

daily rainfall (and irrigation) and duration
daily high and low air temperatures
weekly average pan-evaporation amounts
weekly average soil temperature (for each horizon)
reference crop daily high / low air temperatures

Reference crop

planting seed rate
maximum plant population
optimal plant population

date of planting (emergence)
days (after emergence) to full canopy
days (after emergence) until grain fill begins
days (after emergence) until senescence begins
days (after emergence) until physiological maturity is reached

topmass and rootmass growth stages -- days and rates
reference crop growth curve coefficients (topmass and grain)
maximum yields

Nitrogen management -- inorganic and organic (residue)

date of application(s)
amount of nitrogen applied
depth of incorporation

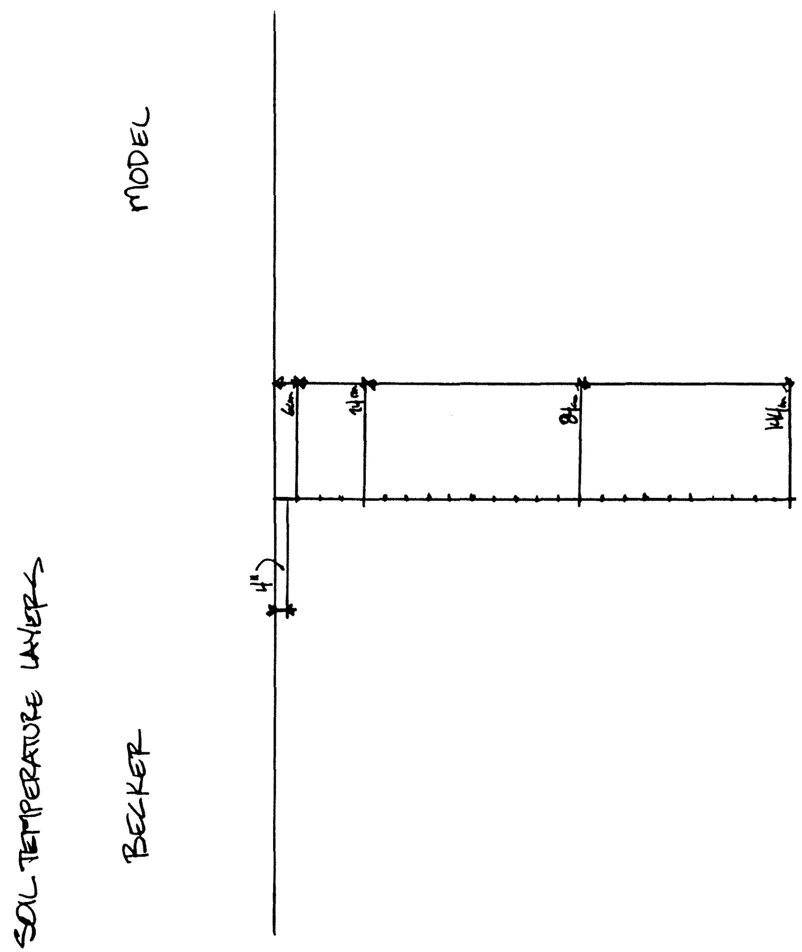
DATA8.AVG -- soil temperature data (degrees Celsius)

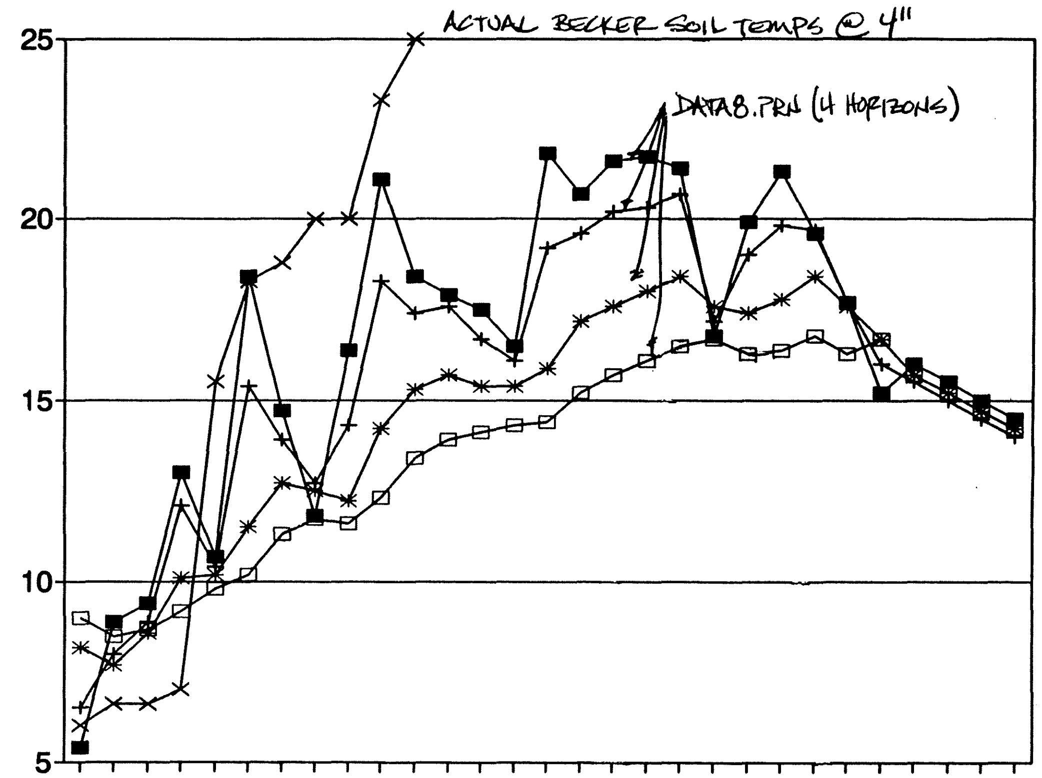
This file contains the weekly average soil temperatures for the designated number (4) of soil temperature horizons. The values in DATA8.AVG correspond in number to the baseline time period (29 weeks), but are not based on actual soil temperature readings. Actual values from Becker are limited to 10 weekly average temperatures taken at a depth of 4 inches in early spring.

An input file of unknown origin, file DATA8.AVG has no clear relationship to Becker soil conditions, and appears to understate the actual temperatures in 1992. (See the graph showing the soil temperature file data compared to the limited data from Becker.) Based on this comparison, soil temperatures are arbitrarily increased by 10 percent on all four horizons. Two outcomes using the baseline scenario versus the cooler temperature regime of DATA8.AVG demonstrate the impact of this crude adjustment.

-------- C:\NCSWAP\DATA8.PRN

5.400000	6.500000	8.200000	9.000000
8.900000	8.000000	7.700000	8.500000
9.400000	8.900000	8.600000	8.700000
13.000000	12.100000	10.100000	9.200000
10.700000	10.400000	10.200000	9.800000
18.400000	15.400000	11.500000	10.200000
14.700000	13.900000	12.700000	11.300000
11.800000	12.700000	12.500000	11.700000
16.400000	14.300000	12.200000	11.600000
21.100000	18.300000	14.200000	12.300000
18.400000	17.400000	15.300000	13.400000
17.900000	17.600000	15.700000	13.900000
17.500000	16.700000	15.400000	14.100000
16.500000	16.100000	15.400000	14.300000
21.800000	19.200000	15.900000	14.400000
20.700000	19.600000	17.200000	15.200000
21.600000	20.200000	17.600000	15.700000
21.700000	20.300000	18.000000	16.100000
21.400000	20.700000	18.400000	16.500000
16.800000	17.200000	17.600000	16.700000
19.900000	19.000000	17.400000	16.300000
21.300000	19.800000	17.800000	16.400000
19.600000	19.700000	18.400000	16.800000
17.700000	17.700000	17.600000	16.300000
15.200000	16.000000	16.700000	16.700000
16.000000	15.500000	15.700000	15.700000
15.500000	15.000000	15.200000	15.200000
15.000000	14.500000	14.700000	14.700000
14.500000	14.000000	14.200000	14.200000


SOIL TEMPERATURE LAYERS
BECKER
MODEL
4"
6cm
24cm
84cm
144cm


ACTUAL BECKER SOIL TEMPS @ 4"
DATA8.PRN (4 HORIZONS)
25
20
15
10
5

```
Menu
 ...ount N left in the residue     133.69    (lb/ac)
        Inorganic N leached           .01    (lb/ac)
 Net immobil(-)/mineralizat(+)       6.31    (lb/ac)
             Denitrification        27.23    (lb/ac)
        Top mass @ 15.5 H2O      14626.68    (lb/ac)
     Moisture deficit in crop         .00    (inches)
     Nitrogen deficit in crop        8.65    (lb/ac)
  Organic Nitrogen pool CHANGE     293.10    (lb/ac)
       Inorganic N in profile       61.00    (lb/ac)
               Ok               Quit
Alt-X Exit
```

Baseline using DATA8
NO TEMPERATURE INCREASE

```
Menu
 ...ount N left in the residue     128.31    (lb/ac)
        Inorganic N leached           .01    (lb/ac)
 Net immobil(-)/mineralizat(+)      30.45    (lb/ac)
             Denitrification        29.18    (lb/ac)
        Top mass @ 15.5 H2O      14804.88    (lb/ac)
     Moisture deficit in crop         .00    (inches)
     Nitrogen deficit in crop        5.02    (lb/ac)
  Organic Nitrogen pool CHANGE     273.51    (lb/ac)
       Inorganic N in profile       79.57    (lb/ac)
               Ok               Quit
Alt-X Exit
```

Baseline using DATA8
INCREASED BY 10%

DATA11.AVG -- pan-evaporation data (cm)

This file contains (52) weekly value for pan-evaporation in 1992 at the Becker experiment station. The program skips the weeks not required for the simulation period. Alternative scenarios use the values from the alternative year.

-------- C:\NCSWAP\DATA11.AVG

```
0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0.64,4.7,5.6,3.86,4.86,6.14,5.71,7.28,5.0,3.02,7.86,8.5,
5.57,5.71,6.14,6.0,6.14,6.0,5.28,3.14,3.86,5.7,2.57,3.28,1.25,
1.,1.5,.5,0,0,0,0,0,0,0,0,0,0
```

DATA12.AVG -- rain fall events (cm)

This file contains the rainfall (and irrigation) amounts for the 1992 simulation period; day 90 to day 272. Each event has an associated duration or length of time the event lasted. Since no actual data is available, duration is arbitrarily set at approximately 1 centimeter per hour for rain events greater than 1 centimeter. Each file begins with a number indicating how many events (in this case 60) occurred over the simulation period. The baseline scenario uses 1992 Becker rainfall and irrigation amounts totaling just over 64 cm.

```
-------- C:\NCSWAP\DATA12.AVG

60
  99,   0.1778, 1
 100,   0.1524, 1
 104,   0.1778, 1
 107,   0.1016, 1
 108,   0.1778, 1
 109,   0.5334, 1
 110,   0.0254, 1
 111,   0.0254, 1
 123,   0.0508, 1
 124,   0.0508, 1
 130,    3.048, 3
 131,   0.0254, 1
 132,   0.0254, 1
 135,    0.254, 1
 138,   0.4572, 1
 141,   0.3302, 1
 145,    1.524, 1
 146,   1:0508, 1
 151,   0.2,1
 152,   .57,1
 153,   0.2,1
 15     0.55,1
 15[illegible],  0.45,1
 158,   0.8636, 1
 159,    1.143, 1
 161,    1.905, 2
 165,   2.2606, 2
 166,   2.2606, 2
 167,    1.905, 2
 168,    0.127, 1
 172,   0.6604, 1
 175,    1.524, 1
 181,   1.4478, 1
 182,    4.953, 5
 183,    0.127, 1
 188,     2.54, 2
 190,   1.5748, 1
 192,   3.2512, 3
 194,   3.2512, 3
 196,    0.254, 1
 200,   0.4826, 1
 201,    2.032, 2
 202,   0.0508, 1
 203,   0.3048, 1
 208,     2.54, 2
 211,    1.905, 2
 212    0.5842, 1
 21[illegible]   0.5842, 1
 216,    1.524, 1
 218,   2.7178, 3
 222,    2.032, 2
 230,          , 3
 232,   0.2286, 1
 235,    1.524, 1
 236,   2.4638, 2
 23[illegible]    0.9144, 1
 24     1.0922, 1
 246,   0.3048, 1
 247,   0.0254, 1
 257,   0.0508, 1
```

DATA13.PRN -- Reference crop air temperature (degrees celsius)

This file contains the reference crop air temperature data. There is a high and low value for each day of the simulation. In this case, the reference crop temperature is the same as the actual air temperature file DATA14.AVG. The reason for this unity is to eliminate the (air temperature) stress variable from the baseline scenario. This is an important assumption, and one which raises some questions about the impact on the simulation outcome from specification of the reference crop growth curve.

-------- C:\NCSWAP\DATA13.PRN

91,	7.67,	-8.28
92,	13.46,	1.01
93,	10.66,	-4.26
94,	17.56,	2.86
95,	13.96,	3.48
96,	10.11,	-1.98
97,	12.81,	2.17
98,	11.99,	2.49
99,	4.58,	-0.95
100,	3.55,	-6.44
101,	0.88,	-9.11
102,	3.53,	-2.24
103,	8.15,	0.97
104,	5.84,	3.17
105,	9.10,	1.23
106,	10.14,	-2.44
107,	14.89,	6.21
108,	19.54,	11.02
109,	11.03,	2.35
110,	7.58,	1.50
111,	6.24,	1.31
112,	5.79,	-1.56
11[illegible]	9.74,	1.00
114,	7.49,	0.80
115,	9.33,	-0.38
116,	14.81,	-2.91
117,	22.86,	4.99
118,	26.03,	10.26
119,	28.22,	9.41
120,	31.17,	15.17
121,	19.77,	6.32
122,	17.78,	2.10
123,	14.15,	2.86
124,	17.19,	-2.29
125,	22.95,	4.40
126,	27.74,	11.19
127,	28.43,	11.79
128,	29.87,	7.93
129,	29.71,	17.38
130,	23.07,	15.14
131,	20.57,	8.51
132,	14.68,	4.09
133,	20.74,	7.28
134,	23.57,	12.99
135,	26.24,	16.19
136,	18.13,	7.76
137,	22.80,	7.19
138	28.50,	12.89
13[illegible]	30.04,	15.02
140,	27.36,	16.77
141,	25.16,	6.87
142,	15.12,	5.64
143,	13.17,	2.06

144,	11.06,	4.23
145,	17.96,	2.06
146,	20.36,	6.63
147-	22.23,	9.92
14	23.11,	8.62
149,	26.44,	6.24
150,	27.80,	8.82
151,	27.97,	12.61
152,	27.70,	9.51
153,	30.07,	15.20
154,	24.77,	12.55
155,	25.27,	8.23
156,	20.34,	8.52
157,	21.04,	6.61
158,	19.92,	11.70
159,	27.53,	14.06
160,	29.75,	15.64
161,	32.45,	15.69
162,	33.78,	15.75
163,	33.33,	15.16
164,	26.61,	16.01
165,	24.41,	14.67
166,	24.23,	15.34
167,	20.94,	16.42
168,	26.69,	16.89
169,	16.97,	4.10
170,	19.50,	2.67
171,	20.21,	3.16
172,	15.52,	10.84
17	24.36,	14.32
174,	23.82,	13.13
175,	21.77,	10.43
176,	21.53,	7.32
177,	25.23,	6.44
178,	29.18,	14.93
179,	23.45,	10.48
180,	19.74,	9.71
181,	30.02,	12.47
182,	20.62,	13.59
183,	21.46,	13.14
184,	21.89,	10.61
185,	24.26,	9.77
186,	25.06,	10.04
187,	27.42,	17.14
188,	29.42,	17.54
189,	27.95,	15.26
190,	24.27,	16.19
191,	22.44,	14.96
192,	25.84,	15.50
193,	21.43,	13.83
194,	25.58,	12.17
195,	23.19,	15.04
196,	25.25,	13.80
197,	25.63,	14.23
198	25.53,	13.07
19	23.95,	13.44
200,	21.91,	11.98
201,	24.93,	11.07
202,	16	10.60
203,	22	10.15
204,	22.41,	11.65
205,	25.76,	17.50
206,	27.31,	14.27
20	29.23,	10.00
20	26.51,	14.87
209,	23.58,	8.15
210,	24.38,	9.64
211,	26.57,	10.52
212,	29.15,	16.97
213,	24.31,	12.73
214,	22.67,	10.78
215,	24.56,	7.59
216,	25.76,	10.56
217,	22.24,	14.72
218,	24.23,	17.95
219,	32.05,	18.13
220,	33.79,	22.80
221,	25.69,	15.11
222,	26.09,	12.15
223,	19.67,	11.37
224,	20.93,	8.45
225,	22.89,	6.20
226,	23.06,	8.73
227,	24.15,	9.93
228,	23.18,	15.21
229,	25.49,	10.55
230,	25.70,	9.34
231,	26.67,	13.02
232,	26.06,	18.73
2	28.19,	18.14
234,	29.55,	18.88
235,	23.68,	15.58
236,	18.71,	11.00
237,	19.32,	10.89
238,	20.48,	10.60
239,	21.94,	10.06
240,	25.98,	13.52
241,	20.89,	10.69
242,	20.19,	7.61
243,	23.49,	8.10
244,	24.36,	14.74
245,	23.21,	9.30
246,	22.63,	13.01
247,	23.47,	14.41
248,	22.41,	8.83
249,	20.09,	7.78
250,	17.93,	6.19
251,	18.89,	9.93
252,	17.95,	5.75
253,	22.14,	4.89
254,	23.35,	15.46
255,	26.19,	14.31
256,	25.06,	11.38
257,	24.53,	8.61
258	28.29,	13.47
2	19.63,	11.22
260,	15.11,	3.35
261,	18.41,	2.26
262,	24.84,	10.46
263,	25.69,	8.25

264,	15.25,	2.54
265,	21.79,	2.66
266,	21.62,	11.92
267	23.24,	10.26
2[illegible]	17.43,	6.69
269,	22.10,	1.69
270,	12.96,	-1.01
271,	19.00,	-2.74
272,	25.16,	5.25
273,	30.00,	5.68
274,	32.05,	6.94
275,	23.62,	6.59
276,	21.88,	5.38
277,	22.69,	8.78
278,	15.77,	6.77
279,	8.25,	6.10
280,	9.11,	6.14
281,	12.58,	8.06
282,	15.11,	3.43
283,	18.90,	-0.83
284,	13.05,	2.50
285,	11.50,	0.09
286,	7.76,	-2.39
287,	6.33,	-3.24
288,	4.07,	-2.99
289,	7.18,	-3.85
290,	3.23,	-7.75
291,	4.07,	-6.12
292,	3.67,	-1.85
29[illegible]	12.85,	-0.60

DATA14.AVG -- Actual air temperature (degrees celsius)

This file contains the actual air temperature for Becker during the simulation period, with each day having a maximum and minimum temperature. For the baseline scenario these are the same values as the crop reference temperatures in DATA13.PRN.

-------- C:\NCSWAP\DATA14.AVG

91,	7.67,	-8.28
92,	13.46,	1.01
93,	10.66,	-4.26
94,	17.56,	2.86
95,	13.96,	3.48
96,	10.11,	-1.98
97,	12.81,	2.17
98,	11.99,	2.49
99,	4.58,	-0.95
100,	3.55,	-6.44
101,	0.88,	-9.11
102,	3.53,	-2.24
103,	8.15,	0.97
104,	5.84,	3.17
105,	9.10,	1.23
106,	10.14,	-2.44
107,	14.89,	6.21
108,	19.54,	11.02
109,	11.03,	2.35
110,	7.58,	1.50
111,	6.24,	1.31
112,	5.79,	-1.56
1[illegible]	9.74,	1.00
114,	7.49,	0.80
115,	9.33,	-0.38
116,	14.81,	-2.91
117,	22.86,	4.99
118,	26.03,	10.26
119,	28.22,	9.41
120,	31.17,	15.17
121,	19.77,	6.32
122,	17.78,	2.10
123,	14.15,	2.86
124,	17.19,	-2.29
125,	22.95,	4.40
126,	27.74,	11.19
127,	28.43,	11.79
128,	29.87,	7.93
129,	29.71,	17.38
130,	23.07,	15.14
131,	20.57,	8.51
132,	14.68,	4.09
133,	20.74,	7.28
134,	23.57,	12.99
135,	26.24,	16.19
136,	18.13,	7.76
137,	22.80,	7.19
13[illegible]	28.50,	12.89
1[illegible]	30.04,	15.02
140,	27.36,	16.77
141,	25.16,	6.87
142,	1[illegible],	5.64
143,	[illegible],	2.06
144,	11.06,	4.23
145,	17.96,	2.06
146,	20.36,	6.63
14[illegible]	22.23,	9.92
14[illegible]	23.11,	8.62
149,	26.44,	6.24
150,	27.80,	8.82
151,	27.97,	12.61
152,	27.70,	9.51
153,	30.07,	15.20
154,	24.77,	12.55
155,	25.27,	8.23
156,	20.34,	8.52
157,	21.04,	6.61
158,	19.92,	11.70
159,	27.53,	14.06
160,	29.75,	15.64
161,	32.45,	15.69
162,	33.78,	15.75
163,	33.33,	15.16
164,	26.61,	16.01
165,	24.41,	14.67
166,	24.23,	15.34
167,	20.94,	16.42
168,	26.69,	16.89
169,	16.97,	4.10
170,	19.50,	2.67
171,	20.21,	3.16
172,	15.52,	10.84
1[illegible]	24.36,	14.32
174,	23.82,	13.13
175,	21.77,	10.43
176,	21.53,	7.32
177,	25.23,	6.44
178,	29.18,	14.93
179,	23.45,	10.48
180,	19.74,	9.71
181,	30.02,	12.47
182,	20.62,	13.59
183,	21.46,	13.14
184,	21.89,	10.61
185,	24.26,	9.77
186,	25.06,	10.04
187,	27.42,	17.14
188,	29.42,	17.54
189,	27.95,	15.26
190,	24.27,	16.19
191,	22.44,	14.96
192,	25.84,	15.50
193,	21.43,	13.83
194,	25.58,	12.17
195,	23.19,	15.04
196,	25.25,	13.80
197,	25.63,	14.23
19[illegible]	25.53,	13.07
1[illegible]	23.95,	13.44
200,	21.91,	11.98
201,	24.93,	11.07
202,	16.84,	10.60
203,	22.99,	10.15

204,	22.41,	11.65
205,	25.76,	17.50
206,	27.31,	14.27
20[illegible]	29.23,	10.00
2[illegible]	26.51,	14.87
209,	23.58,	8.15
210,	24.38,	9.64
211,	26.57,	10.52
212,	29.15,	16.97
213,	24.31,	12.73
214,	22.67,	10.78
215,	24.56,	7.59
216,	25.76,	10.56
217,	22.24,	14.72
218,	24.23,	17.95
219,	32.05,	18.13
220,	33.79,	22.80
221,	25.69,	15.11
222,	26.09,	12.15
223,	19.67,	11.37
224,	20.93,	8.45
225,	22.89,	6.20
226,	23.06,	8.73
227,	24.15,	9.93
228,	23.18,	15.21
229,	25.49,	10.55
230,	25.70,	9.34
231,	26.67,	13.02
232,	26.06,	18.73
2[illegible]	28.19,	18.14
234,	29.55,	18.88
235,	23.68,	15.58
236,	18.71,	11.00
237,	19.32,	10.89
238,	20.48,	10.60
239,	21.94,	10.06
240,	25.98,	13.52
241,	20.89,	10.69
242,	20.19,	7.61
243,	23.49,	8.10
244,	24.36,	14.74
245,	23.21,	9.30
246,	22.63,	13.01
247,	23.47,	14.41
248,	22.41,	8.83
249,	20.09,	7.78
250,	17.93,	6.19
251,	18.89,	9.93
252,	17.95,	5.75
253,	22.14,	4.89
254,	23.35,	15.46
255,	26.19,	14.31
256,	25.06,	11.38
257,	24.53,	8.61
25[illegible]	28.29,	13.47
2[illegible]	19.63,	11.22
260,	15.11,	3.35
261,	18.41,	2.26
262,	24.84,	10.46
263,	25.69,	8.25
264,	15.25,	2.54
265,	21.79,	2.66
266,	21.62,	11.92
2[illegible]	23.24,	10.26
2[illegible]	17.43,	6.69
269,	22.10,	1.69
270,	12.96,	-1.01
271,	19.00,	-2.74
272,	25.16,	5.25
273,	30.00,	5.68
274,	32.05,	6.94
275,	23.62,	6.59
276,	21.88,	5.38
277,	22.69,	8.78
278,	15.77,	6.77
279,	8.25,	6.10
280,	9.11,	6.14
281,	12.58,	8.06
282,	15.11,	3.43
283,	18.90,	-0.83
284,	13.05,	2.50
285,	11.50,	0.09
286,	7.76,	-2.39
287,	6.33,	-3.24
288,	4.07,	-2.99
289,	7.18,	-3.85
290,	3.23,	-7.75
291,	4.07,	-6.12
292,	3.67,	-1.85
2[illegible]	12.85,	-0.60

DATA55.INC -- Soil physical and hydrologic properties

This file contains parameter specifications for soil properties under the three user options SAND, LOAM, and CLAY. These variables are incorporated into the program at compilation using an include statement. These are important assumptions that the user should be made aware of, and perhaps given the option to modify.

-------- C:\NCSWAP\DATA55.INC

```
c     data statements for soil type    rev. 9/31/92; 3/16/93
c      Becker corn '92

      character*5 soiltex(9)
      real sta(12,9)

c     bdh,thi,td,ksat,fcsat
      data (sta(1,i),i=1,9) /1.2,1.5,1.6,1.55,1.6,1.66,1.2,1.25,1.3/
      data (sta(2,i),i=1,9) /.084,.067,.063,.09,.075,.06,.25,.24,.231/
      data (sta(3,i),i=1,9) /3*.05,.037,.03,.012,3*.14/
      data (sta(4,i),i=1,9) /9*99/
      data(sta(5,i),i=1,9) /.1836,.2307,.2533,
     1.485,.4838,.2888,.548,.568,.589/

c     anh3,ano3
      data (sta(6,i),i=1,9) / 2,1,1,.745,.1,.11,2,1,1/
      data (sta(7,i),i=1,9) /10,2,2,3.4,2.7,1.4,10,2,2/

c     conc1, 14, 6, 2, seratio
      data (sta(8,i),i=1,9) /  .5, .5,.1, .5, .5,.1, .5, .5,.1/
      data (sta(9,i),i=1,9) /  .5, .5,.1, .5, .5,.1, .5, .5,.1/
      data (sta(10,i),i=1,9) / 9*0/
       lata (sta(11,i),i=1,9) / 30,3,1,10,5,1,30,3,1/
      data (sta(12,i),i=1,9) / 3*.5,3*.1,3*.1/

      data soiltex / 'sand1','sand2','sand3','beck1','beck2','beck3',
     1'clay1','clay2','clay3'/
```

DATA56.PRN and DATA58.PRN

These two files are used to communicate between the user interface program and the main model program. They are written and read, back and forth, for each simulation run.

-------- C:\NCSWAP\DATA56.PRN

```
APR 28
30700
OCT 12
1
1
APR 2
20
2
MAY 30
200
1
1
1
```

-------- C:\NCSWAP\DATA58.PRN

128.31
.01
30.45
29.18
14804.88
.00
5.02
273.51
79.57

Section 4. Model baseline results -- full report.

This section contains the full (baseline) report, file OUT3.PRN. This report reprints the input files (from section 3), and the outcome values on the last day of the run. Generating the full report is useful for debugging and other purposes, but slows the program runtime, especially when executed from a diskette. Therefore, the demonstration disk program does not generate this report. (See section 2 for more details on the baseline scenario.)

-------- C:\NCSWAP\OUT3.PRN

1

------- SUMMARY OF MAJOR OPTIONS SELECTED FOR THIS RUN -------

ITEMS: OPTIONS SPECIFIED

------- TIME VARIABLES -------

REFERENCE DATE:
MONTH = 1
DAY = 1

DAYS OF RUN RELATIVE TO REFERENCE DATE:
STARTING DAY = 91
STOPPING DAY = 293
HARVEST DAY = 282

COMPUTATIONAL TIME STEPS (DAY):	SOIL BIOLOGICAL TRANSFORMATIONS	ROOT AND CROP TOP GROWTH	INFILTRATION
DAYS WITH WATER INFILTRATION	.20	1.00	.20
DAYS WITH NO WATER INFILTRATION	1.00	1.00	----

------- PROFILE GEOMETRY -------

NUMBER OF HORIZONS = 3

HORIZONS: DEPTHS FROM SURFACE TO LOWER BOUNDARIES (CM) = 12.0 48.0 144.0

THICKNESS OF SEGMENTS (CM) = 6.0

NUMBER OF DEPTH INCREMENTS FOR HYDRAULIC PROCESSES = 31

NUMBER OF TEMPERATURE LAYERS = 4

TEMPERATURE LAYER DEPTHS (CM) = 6.0 24.0 84.0 144.0

------- INITIAL CHEMICAL AND BIOCHEMICAL PROPERTIES PER HORIZON -------

HORIZON	TOTAL NH4 PPM N	NO3 PPM N	UREA PPM N	POOL I (MICROBIAL MASS) PPM C	C/N	POOL II (NUTRIENT HUMUS) PPM C	C/N	RATIO OF SOLUBLE TO TOTAL NH4
1	.7	3.4	.0	6.0	6.0	100.0	10.0	.1
2	.1	2.7	.0	6.0	6.0	50.0	10.0	.1
3	.1	1.4	.0	1.2	6.0	10.0	10.0	.1

NITRIFICATION (PPM N/DAY)

HORIZON	DAYS 91-150	151-160	161-170	171-293
1	20.0	20.0	20.0	20.0
2	20.0	20.0	20.0	20.0
3	20.0	20.0	20.0	20.0

DENITRIFICATION CONSTANT AT WATER SATURATION : CSTDEN= 6.00(PPM C / PPM N)

REDUCTION FACTOR AT 80.00 PERCENT WATER SATURATION :DENITRIFICATION, .90 ; NITRIFICATION , .10

REDUCTION FACTOR TO SOLUTES FLOW : .80

------- INITIAL PHYSICAL PROPERTIES PER HORIZON -------

HORIZON	-- TEXTURE --	BULK DENSITY (GM/CM**3)	'RIBBON' WHEN WET YES (1) NO (0)
1	beck1	1.55	0
2	beck2	1.60	0
3	beck3	1.66	0

------- INITIAL HYDRAULIC PROPERTIES PER HORIZON -------

		-----WATER CONTENT-----						
HORIZON	GRAVIMETRIC WATER CONTENT (ML/GM)	AT WATER STRESS GRAVIMETRIC (ML/GM)	VOLUMETRIC (ML/CM**3)	AT SATURATION GRAVIMETRIC (ML/GM)	VOLUMETRIC (ML/CM**3)	AT WATER FIELD CAPACITY GRAVIMETRIC (ML/GM)	VOLUMETRIC (ML/CM**3)	PERCENT SATURATION
1	.090	.037	.057	.268	.415	.130	.201	48.50
2	.075	.030	.048	.248	.396	.120	.192	48.38
3	.060	.012	.020	.225	.374	.065	.108	28.88

HORIZON	SATURATED HYDRAULIC CONDUCTIVITY (CM/DAY)	SUCTION AT THE WETTING FRONT (CM)
1	99.00	
2	99.00	
3	99.00	

MODERATLY TO EXCESSIVELY WELL DRAINED SOIL

------- SURFACE PROPERTIES -------

FRACTION OF SURFACE THAT IS BARE .20
REDUCTION IN EVAPORATION DUE TO RESIDUE .80
NUMBER OF TOP SEGMENTS CONTRIBUTING TO EVAPORATION 1

------- WATER APPLICATIONS (RAINFALL, IRRIGATION, . . .) -------

TOTAL APPLIED: 64.1 CM

DAY	AMOUNT (CM)	NITROGEN CONTENT (PPM N) NH4-N	NO3-N	DURATION (HRS)
99	.18	.0000E+00	.0000E+00	1.0
100	.15	.0000E+00	.0000E+00	1.0
104	.18	.0000E+00	.0000E+00	1.0
107	.10	.0000E+00	.0000E+00	1.0
108	.18	.0000E+00	.0000E+00	1.0
109	.53	.0000E+00	.0000E+00	1.0
110	.03	.0000E+00	.0000E+00	1.0
111	.03	.0000E+00	.0000E+00	1.0
123	.05	.0000E+00	.0000E+00	1.0
124	.05	.0000E+00	.0000E+00	1.0
130	3.05	.0000E+00	.0000E+00	3.0
131	.03	.0000E+00	.0000E+00	1.0
132	.03	.0000E+00	.0000E+00	1.0
135	.25	.0000E+00	.0000E+00	1.0
138	.46	.0000E+00	.0000E+00	1.0
141	.33	.0000E+00	.0000E+00	1.0
145	1.52	.0000E+00	.0000E+00	1.0
146	1.05	.0000E+00	.0000E+00	1.0
151	.20	.0000E+00	.0000E+00	1.0
152	.57	.0000E+00	.0000E+00	1.0
153	.20	.0000E+00	.0000E+00	1.0
154	.55	.0000E+00	.0000E+00	1.0
156	.45	.0000E+00	.0000E+00	1.0
158	.86	.0000E+00	.0000E+00	1.0
159	1.14	.0000E+00	.0000E+00	1.0
161	1.90	.0000E+00	.0000E+00	2.0
165	2.26	.0000E+00	.0000E+00	2.0
166	2.26	.0000E+00	.0000E+00	2.0
167	1.90	.0000E+00	.0000E+00	2.0
168	.13	.0000E+00	.0000E+00	1.0
172	.66	.0000E+00	.0000E+00	1.0
175	1.52	.0000E+00	.0000E+00	1.0
181	1.45	.0000E+00	.0000E+00	1.0
182	4.95	.0000E+00	.0000E+00	5.0
183	.13	.0000E+00	.0000E+00	1.0
188	2.54	.0000E+00	.0000E+00	2.0
190	1.57	.0000E+00	.0000E+00	1.0
192	3.25	.0000E+00	.0000E+00	3.0
194	3.25	.0000E+00	.0000E+00	3.0
196	.25	.0000E+00	.0000E+00	1.0
200	.48	.0000E+00	.0000E+00	1.0
201	2.03	.0000E+00	.0000E+00	2.0
202	.05	.0000E+00	.0000E+00	1.0
203	.30	.0000E+00	.0000E+00	1.0
208	2.54	.0000E+00	.0000E+00	2.0
211	1.90	.0000E+00	.0000E+00	2.0
212	.58	.0000E+00	.0000E+00	1.0
215	.58	.0000E+00	.0000E+00	1.0
216	1.52	.0000E+00	.0000E+00	1.0
218	2.72	.0000E+00	.0000E+00	3.0
222	2.03	.0000E+00	.0000E+00	2.0
230	2.54	.0000E+00	.0000E+00	3.0
232	.23	.0000E+00	.0000E+00	1.0
235	1.52	.0000E+00	.0000E+00	1.0
236	2.46	.0000E+00	.0000E+00	2.0
237	.91	.0000E+00	.0000E+00	1.0
243	1.09	.0000E+00	.0000E+00	1.0
246	.30	.0000E+00	.0000E+00	1.0
247	.03	.0000E+00	.0000E+00	1.0
257	.05	.0000E+00	.0000E+00	1.0

----------WEEKLY PAN EVAPORATION DATA (CM)---------

1: .00; 2: .00; 3: .00; 4: .00; 5: .00; 6: .00; 7: .00; 8: .00; 9: .00; 10: .00; 11: .00; 12: .00; 13: .00;
14: .00; 15: .64; 16:4.70; 17:5.60; 18:3.86; 19:4.86; 20:6.14; 21:5.71; 22:7.28; 23:5.00; 24:3.02; 25:7.86; 26:8.50;
27:5.57; 28:5.71; 29:6.14; 30:6.00; 31:6.14; 32:6.00; 33:5.28; 34:3.14; 35:3.86; 36:5.70; 37:2.57; 38:3.28; 39:1.25;
40:1.00; 41:1.50; 42: .50; 43: .00; 44: .00; 45: .00; 46: .00; 47: .00; 48: .00; 49: .00; 50: .00; 51: .00; 52: .00;

------- DAILY MAX, MIN, & AVE AIR TEMPERATURES (DEG CELSIUS) -------

DAY	MAXIMUM	MINIMUM	AVERAGE	DAY	MAXIMUM	MINIMUM	AVERAGE	DAY	MAXIMUM	MINIMUM	AVERAGE	DAY	MAXIMUM	MINIMUM	AVERAGE
91	7.67	-8.28	-.30	92	13.46	1.01	7.24	93	10.66	-4.26	3.20	94	17.56	2.86	10.21
95	13.96	3.48	8.72	96	10.11	-1.98	4.06	97	12.81	2.17	7.49	98	11.99	2.49	7.24
99	4.58	-.95	1.81	100	3.55	-6.44	-1.45	101	.88	-9.11	-4.11	102	3.53	-2.24	.64
103	8.15	.97	4.56	104	5.84	3.17	4.51	105	9.10	1.23	5.16	106	10.14	-2.44	3.85
107	14.89	6.21	10.55	108	19.54	11.02	15.28	109	11.03	2.35	6.69	110	7.58	1.50	4.54
111	6.24	1.31	3.77	112	5.79	-1.56	2.12	113	9.74	1.00	5.37	114	7.49	.80	4.14
115	9.33	-.38	4.47	116	14.81	-2.91	5.95	117	22.86	4.99	13.93	118	26.03	10.26	18.15
119	28.22	9.41	18.81	120	31.17	15.17	23.17	121	19.77	6.32	13.05	122	17.78	2.10	9.94
123	14.15	2.86	8.51	124	17.19	-2.29	7.45	125	22.95	4.40	13.68	126	27.74	11.19	19.47
127	28.43	11.79	20.11	128	29.87	7.93	18.90	129	29.71	17.38	23.54	130	23.07	15.14	19.10
131	20.57	8.51	14.54	132	14.68	4.09	9.39	133	20.74	7.28	14.01	134	23.57	12.99	18.28
135	26.24	16.19	21.22	136	18.13	7.76	12.94	137	22.80	7.19	14.99	138	28.50	12.89	20.69
139	30.04	15.02	22.53	140	27.36	16.77	22.07	141	25.16	6.87	16.01	142	15.12	5.64	10.38
143	13.17	2.06	7.61	144	11.06	4.23	7.65	145	17.96	2.06	10.01	146	20.36	6.63	13.50
147	22.23	9.92	16.08	148	23.11	8.62	15.86	149	26.44	6.24	16.34	150	27.80	8.82	18.31
151	27.97	12.61	20.29	152	27.70	9.51	18.60	153	30.07	15.20	22.64	154	24.77	12.55	18.66
155	25.27	8.23	16.75	156	20.34	8.52	14.43	157	21.04	6.61	13.83	158	19.92	11.70	15.81
159	27.53	14.06	20.80	160	29.75	15.64	22.69	161	32.45	15.69	24.07	162	33.78	15.75	24.76
163	33.33	15.16	24.25	164	26.61	16.01	21.31	165	24.41	14.67	19.54	166	24.23	15.34	19.78
167	20.94	16.42	18.68	168	26.69	16.89	21.79	169	16.97	4.10	10.53	170	19.50	2.67	11.09
171	20.21	3.16	11.68	172	15.52	10.84	13.18	173	24.36	14.32	19.34	174	23.82	13.13	18.48
175	21.77	10.43	16.10	176	21.53	7.32	14.43	177	25.23	6.44	15.84	178	29.18	14.93	22.06
179	23.45	10.48	16.97	180	19.74	9.71	14.73	181	30.02	12.47	21.25	182	20.62	13.59	17.10
183	21.46	13.14	17.30	184	21.89	10.61	16.25	185	24.26	9.77	17.01	186	25.06	10.04	17.55
187	27.42	17.14	22.28	188	29.42	17.54	23.48	189	27.95	15.26	21.60	190	24.27	16.19	20.23
191	22.44	14.96	18.70	192	25.84	15.50	20.67	193	21.43	13.83	17.63	194	25.58	12.17	18.88
195	23.19	15.04	19.11	196	25.25	13.80	19.52	197	25.63	14.23	19.93	198	25.53	13.07	19.30
199	23.95	13.44	18.69	200	21.91	11.98	16.94	201	24.93	11.07	18.00	202	16.84	10.60	13.72
203	22.99	10.15	16.57	204	22.41	11.65	17.03	205	25.76	17.50	21.63	206	27.31	14.27	20.79
207	29.23	10.00	19.61	208	26.51	14.87	20.69	209	23.58	8.15	15.86	210	24.38	9.64	17.01
211	26.57	10.52	18.55	212	29.15	16.97	23.06	213	24.31	12.73	18.52	214	22.67	10.78	16.73
215	24.56	7.59	16.08	216	25.76	10.56	18.16	217	22.24	14.72	18.48	218	24.23	17.95	21.09
219	32.05	18.13	25.09	220	33.79	22.80	28.30	221	25.69	15.11	20.40	222	26.09	12.15	19.12
223	19.67	11.37	15.52	224	20.93	8.45	14.69	225	22.89	6.20	14.55	226	23.06	8.73	15.89
227	24.15	9.93	17.04	228	23.18	15.21	19.19	229	25.49	10.55	18.02	230	25.70	9.34	17.52
231	26.67	13.02	19.85	232	26.06	18.73	22.40	233	28.19	18.14	23.17	234	[illegible].55	18.88	24.22
235	23.68	15.58	[illegible]3	236	18.71	11.00	14.85	237	19.32	10.89	15.10	238	[illegible]48	10.60	15.54

239	21.94	10.06	16.00	240	25.98	13.52	19.75	241	20.89	10.69	15.79	242	20.19	7.61	13.90
243	23.49	8.10	15.80	244	24.36	14.74	19.55	245	23.21	9.30	16.25	246	22.63	13.01	17.82
247	23.47	14.41	18.94	248	22.41	8.83	15.62	249	20.09	7.78	13.94	250	17.93	6.19	12.06
251	18.89	9.93	14.41	252	17.95	5.75	11.85	253	22.14	4.89	13.51	254	23.35	15.46	19.41
255	26.19	14.31	20.25	256	25.06	11.38	18.22	257	24.53	8.61	16.57	258	28.29	13.47	20.88
259	19.63	11.22	15.42	260	15.11	3.35	9.23	261	18.41	2.26	10.34	262	24.84	10.46	17.65
263	25.69	8.25	16.97	264	15.25	2.54	8.90	265	21.79	2.66	12.23	266	21.62	11.92	16.77
267	23.24	10.26	16.75	268	17.43	6.69	12.06	269	22.10	1.69	11.90	270	12.96	-1.01	5.97
271	19.00	-2.74	8.13	272	25.16	5.25	15.20	273	30.00	5.68	17.84	274	32.05	6.94	19.49
275	23.62	6.59	15.11	276	21.88	5.38	13.63	277	22.69	8.78	15.74	278	15.77	6.77	11.27
279	8.25	6.10	7.18	280	9.11	6.14	7.63	281	12.58	8.06	10.32	282	15.11	3.43	9.27
283	18.90	-.83	9.03	284	13.05	2.50	7.78	285	11.50	.09	5.80	286	7.76	-2.39	2.68
287	6.33	-3.24	1.54	288	4.07	-2.99	.54	289	7.18	-3.85	1.66	290	3.23	-7.75	-2.26
291	4.07	-6.12	-1.02	292	3.67	-1.85	.91	293	12.85	-.60	6.13				

------- INORGANIC NITROGEN APPLICATIONS -------

DAY	DEPTH INTERVAL (CM)	N15/TOTAL-N NH4-N	N15/TOTAL-N NO3-N	AMOUNTS (KG/HA) NH4-N	AMOUNTS (KG/HA) NO3-N	AMOUNTS (KG/HA) UREA
150	0- 15			.2247E+03	.0000E+00	.0000E+00

------- ORGANIC APPLICATIONS -------

RESIDUE	NOTE	DAY	DEPTH INTERVAL (CM)	N15/ TOTAL-N	C/N	SPECIFIC RATE OF DECOMPOSITION (PER DAY) LABILE	RECALCITRANT	-- S --
5, 6	GRASS CLIPPINGS	92	0- 30		40.0	.045	.001	1.000

RESIDUE	AMOUNT INCORPORATED ---- (KG C/HA) ----- LABILE	RECALCITRANT	AMOUNT APPLIED TO SURFACE ----- (KG C/HA) ----- LABILE	RECALCITRANT	FRACTION COVERAGE
5, 6	******	.0	.0	.0	.80

------- TILLAGE EVENTS -------

DATE	DEPTH (CM)	BULK DENSITY MINIMUM	BULK DENSITY MAXIMUM	FRACTION INCORPORATION	FRACTION COVERAGE	SATURATED HYDRAULIC CONDUCTIVITY (CM/DAY) MINIMUM	MAXIMUM	DEPRESSION STORAGE (CM) MINIMUM	MAXIMUM

------- CROP TOP -------
(15 PERCENT WATER CONTENT)

DAYS AFTER EMERGENCE TO: GRAIN FILLING	PHYSIOLOGICAL MATURITY	DAY OF EMERGENCE	PLANT POPULATION (PLT/HA)	--- FULL CANOPY --- TOP MASS (KG/HA)	DAYS PAST EMERGENCE	EVAPORATION FRACTION	ONSET OF SENESCENCE DAYS BEFORE MATURITY
50	110	125	75829	.5296E+02	15	.150	10

MAXIMUM TOP MASS (KG/HA)	TOP MASS REGRESSION PARAMETERS (PER PLANT BASIS)	MAXIMUM GRAIN YIELD (KG/HA)	GRAIN YIELD REGRESSION PARAMETERS (PER PLANT BASIS)	OPTIMUM PLANT POPULATION (PLT/HA)	TOP SOIL TEMPERATURE CONTROLS CROP GROWTH (DAY AFTER EMERGENCE)
.2000E+05	.1008E+01 .9269E+01 -.2563E+00 .2424E-02 -.9117E-05	.1000E+05	.1015E+01 .3555E+01 -.2514E+00 .6459E-02 -.7598E-04	60001	

------- ROOTS -------

ROOT PENETRATION (CM/DAY) 0 - 50 DAYS	> 50 DAYS	SHOOT TO ROOT RATIO (S/R) INITIAL	SLOPE VS TIME	RATIO OF EXUDATE & SLOUGH TO TOTAL ROOT MASS INCREASE	ROOT MASS GROWTH STOPS (DAYS PAST EMERGENCE)
2.000	.220	.500	.136	.120	65

GROWTH STAGE (DAY PAST EMERGENCE)	FRACTION OF ROOT MASS INCREASE IN TOP 18.0 CM
0- 10	.550
11- 20	.500
21- 40	.450
41- 60	.400

ROOTING DEPTH AT EMERGENCE
15.0 CM

------- AVERAGE PLANT OPTIMAL NITROGEN CONTENT -------

GROWTH STAGE DAY	XXXXXXXXXXX	N/DRY MASS RATIO	RATIO OF ROOT TO TOP N PERCENTAGE
30		.3000E-01	.1000E+01
40		.2940E-01	.1000E+01
45		.2700E-01	.1000E+01
50		.2300E-01	.1000E+01
55		.2100E-01	.1000E+01
65		.1800E-01	.1000E+01
75		.1600E-01	.1000E+01
90		.1400E-01	.1000E+01
110		.1200E-01	.1000E+01

AVERAGE CARBON FRACTION (DRY MASS BASIS): .40

DAY = 91 4/ 1

INITIAL CHEMICAL, BIOCHEMICAL, AND PHYSICAL PROPERTIES
(BOTTOM SEGMENT INCLUDED)

SEGMENT	DEPTH CM	WATER CONTENT ML/ML	ADSORBED NH4-N PPM N	SOLUBLE NH4-N PPM N	NO3-N PPM N	UREA-N PPM N	POOL I MICROBIAL MASS PPM C	POOL II HUMADS PPM C
2	6.0	.1395E+00	.6705E+00	.7450E-01	.3400E+01	.0000E+00	.6000E+01	.1000E+03
3	12.0	.1395E+00	.6705E+00	.7450E-01	.3400E+01	.0000E+00	.6000E+01	.1000E+03
4	18.0	.1200E+00	.9000E-01	.1000E-01	.2700E+01	.0000E+00	.6000E+01	.5000E+02
5	24.0	.1200E+00	.9000E-01	.1000E-01	.2700E+01	.0000E+00	.6000E+01	.5000E+02

6	30.0	.1200E+00	.9000E-01	.1000E-01	.2700E+01	.0000E+00	.6000E+01	.5000E+02
7	36.0	.1200E+00	.9000E-01	.1000E-01	.2700E+01	.0000E+00	.6000E+01	.5000E+02
8	42.0	.1200E+00	.9000E-01	.1000E-01	.2700E+01	.0000E+00	.6000E+01	.5000E+02
9	48.0	.1200E+00	.9000E-01	.1000E-01	.2700E+01	.0000E+00	.6000E+01	.5000E+02
10	54.0	.9960E-01	.9900E-01	.1100E-01	.1400E+01	.0000E+00	.1200E+01	.1000E+02
11	60.0	.9960E-01	.9900E-01	.1100E-01	.1400E+01	.0000E+00	.1200E+01	.1000E+02
12	66.0	.9960E-01	.9900E-01	.1100E-01	.1400E+01	.0000E+00	.1200E+01	.1000E+02
13	72.0	.9960E-01	.9900E-01	.1100E-01	.1400E+01	.0000E+00	.1200E+01	.1000E+02
14	78.0	.9960E-01	.9900E-01	.1100E-01	.1400E+01	.0000E+00	.1200E+01	.1000E+02
15	84.0	.9960E-01	.9900E-01	.1100E-01	.1400E+01	.0000E+00	.1200E+01	.1000E+02
16	90.0	.9960E-01	.9900E-01	.1100E-01	.1400E+01	.0000E+00	.1200E+01	.1000E+02
17	96.0	.9960E-01	.9900E-01	.1100E-01	.1400E+01	.0000E+00	.1200E+01	.1000E+02
18	102.0	.9960E-01	.9900E-01	.1100E-01	.1400E+01	.0000E+00	.1200E+01	.1000E+02
19	108.0	.9960E-01	.9900E-01	.1100E-01	.1400E+01	.0000E+00	.1200E+01	.1000E+02
20	114.0	.9960E-01	.9900E-01	.1100E-01	.1400E+01	.0000E+00	.1200E+01	.1000E+02
21	120.0	.9960E-01	.9900E-01	.1100E-01	.1400E+01	.0000E+00	.1200E+01	.1000E+02
22	126.0	.9960E-01	.9900E-01	.1100E-01	.1400E+01	.0000E+00	.1200E+01	.1000E+02
23	132.0	.9960E-01	.9900E-01	.1100E-01	.1400E+01	.0000E+00	.1200E+01	.1000E+02
24	138.0	.9960E-01	.9900E-01	.1100E-01	.1400E+01	.0000E+00	.1200E+01	.1000E+02

***** ORGANIC APPLICATION. DAY NUMBER 92.
DEPTHS: .0 TO 30.0 CM (SEGMENTS 2 TO 6).
AMOUNT, PER SEGMENT, ADDED TO RESIDUE SLOTS 5 AND 6,
WITH CORRESPONDING CHARACTERISTICS:
LABILE FRACTION
CARBON .2730E+05 UG
NITROGEN .6824E+03 UG
C/N .4000E+02
RECALCITRANT FRACTION
CARBON .0000E+00 UG
NITROGEN .0000E+00 UG
C/N .4000E+02
AMOUNT LEFT ON SURFACE: LABILE, .0000E+00; RECALCITRANT, .0000E+00 UG C

***** INORGANIC NITROGEN APPLIED. DAY NUMBER 150.
DEPTHS: .0 TO 15.0 CM (SEGMENTS 2 TO 4).
AMOUNT ADDED TO EACH SEGMENT:
TOTAL NH4 .7491E+03 UG
NO3 .0000E+00 UG
UREA .0000E+00 UG

***** CROP HAS REACHED PHYSIOLOGICAL MATURITY:
DAY 234; 110 DAYS, DEGREE DAYS PAST EMERGENCE
61 DAYS, DEGREE DAYS PAST BEGINNING GRAIN FILLING

*** LIVE ROOT MASS NOW ACCESSIBLE TO MICROBIAL ACTIVITY. DAY 235

--------------------TOP--------------------				----------ROOT (BEFORE DEGRAD)----------			
TOP MASS	TOP N MASS	CROP GRAIN MASS	RATIO OF	ROOT MASS	RATIO OF	ROOT N	RATIO OF
KG/HA	KG/HA	KG/HA	N TO TOP	KG/HA	SHOOT TO ROOT	MASS	N TO ROOT
15.5	[illegible]T	15.5PERCENT	DRY MATTER	15.5 PERCENT		KG/HA	DRY MATTER

H2O		H2O		H2O			
.1548E+05	.1423E+03	.9115E+04	.0109	.7534E+03	20.545	.1329E+02	.0149

----- GROWTH REDUCTION RATIOS -----

ACTUAL/POTENTIAL ROOT LENGTH		ACTUAL/POTENTIAL N UPTAKE		ACTUAL/POTENTIAL N PERCENTAGE		ACTUAL/POTENTIAL H2O UPTAKE		ACTUAL/REFERENCE TEMPERATURE		ACTUAL/OPTIMUM PLANT POPULATION
CURRENT VALUE	RUNNING AVERAGE	CURRENT VALUE	RUNNING AVERAGE	CURRENT VALUE	RUNNING AVERAGE	CURRENT VALUE	RUNNING AVERAGE	CURRENT VALUE	RUNNING AVERAGE	.LE.1.
.100	.100	.220	.539	.909	.879	1.000	1.000	1.000	1.001	1.000

------- NITROGEN IN PLANT (TOP + ROOT) -------

N UPTAKE FROM SOIL GM N/PLANT KG N/HA	PLANT N GM N/PLANT KG N/HA	RATIO OF N TO TOTAL DRY MATTER IN PLANT	PLANT N15 GM N15/PLANT KG N15/HA	N15/TOTAL N IN PLANT	PLANT N GAS LOSS GM N/PLANT KG N/HA	N EXUDATE (ROOT) GM N/PLANT KG N/HA
.2076E+01	.2052E+01	.0113			.0000E+00	.2390E-01
.1574E+03	.1556E+03				.0000E+00	.1812E+01

----- DEFICIT IN CROP (ABOVE GROUND + ROOT) -----

DEFICIT MOISTURE: .000 CM H2O
DEFICIT NITROGEN, REFERENCE - ACTUAL CROP N: 31.334 KG/HA
DEFICIT N SYMB FIXED, POTENTIAL - ACTUAL (TEMP H2O FACTORS): 10.000 KG N/HA

NOTE: TO CONVERT UG/CM2 TO KG/HA, DIVIDE UG/CM2 BY 10.; 1.0 CM2 AREA IS ASSUMED UNLESS SPECIFIED OTHERWISE
TO CONVERT KG/HA TO G/PLANT, MULTIPLY KG/HA BY .13188E-01

DAY = 293 10/20

SEGMENT	DEPTH CM	WATER CONTENT ML/ML	ADSORBED NH4-N PPM N	SOLUBLE NH4-N PPM N	NO3-N PPM N	UREA-N PPM N	POOL I MICROBIAL MASS PPM C	POOL II HUMADS PPM C
2	6.0	.1564E+00	.9000E-19	.1000E-19	.1346E+02	.0000E+00	.2864E+03	.4488E+03
3	12.0	.2013E+00	.9000E-19	.1000E-19	.1354E+02	.0000E+00	.2815E+03	.4317E+03
4	18.0	.1917E+00	.9000E-19	.1000E-19	.1088E+02	.0000E+00	.2886E+03	.3835E+03
5	24.0	.1917E+00	.9000E-19	.1000E-19	.6482E+01	.0000E+00	.3144E+03	.3616E+03
6	30.0	.1917E+00	.9000E-19	.1000E-19	.3929E+01	.0000E+00	.3145E+03	.3409E+03
7	36.0	.1917E+00	.9000E-19	.1000E-19	.7818E+00	.0000E+00	.3449E+01	.3075E+02
8	42.0	.1917E+00	.9000E-19	.1000E-19	.7632E+00	.0000E+00	.3079E+01	.3061E+02
9	48.0	.1917E+00	.9000E-19	.1000E-19	.7595E+00	.0000E+00	.2869E+01	.3065E+02
10	54.0	.1079E+00	.9000E-19	.1000E-19	.1757E+00	.0000E+00	.1284E+01	.7576E+01
11	60.0	.1079E+00	.9000E-19	.1000E-19	.1543E+00	.0000E+00	.1160E+01	.7474E+01
12	66.0	.1079E+00	.9000E-19	.1000E-19	.1417E+00	.0000E+00	.1092E+01	.7577E+01
13	72.0	.1079E+00	.9000E-19	.1000E-19	.1323E+00	.0000E+00	.1018E+01	.7522E+01
14	78.0	.1079E+00	.9000E-19	.1000E-19	.1283E+00	.0000E+00	.9690E+00	.7554E+01
15	84.0	.1079E+00	.9000E-19	.1000E-19	.1253E+00	.0000E+00	.9238E+0[illegible]	.7556E+01
16	90.0	.10[illegible]	.9000E-19	.1000E-19	.1217E+00	.0000E+00	.8746E+[illegible]	.7483E+01

17	96.0	.1079E+00	.9000E-19	.1000E-19	.1185E+00	.0000E+00	.8297E+00	.7401E+01
18	102.0	.1079E+00	.9000E-19	.1000E-19	.1173E+00	.0000E+00	.7999E+00	.7404E+01
19	108.0	.1079E+00	.9000E-19	.1000E-19	.1195E+00	.0000E+00	.7968E+00	.7631E+01
20	114.0	.1079E+00	.9000E-19	.1000E-19	.1172E+00	.0000E+00	.7509E+00	.7526E+01
21	120.0	.1079E+00	.9000E-19	.1000E-19	.1161E+00	.0000E+00	.7136E+00	.7478E+01
22	126.0	.1079E+00	.9000E-19	.1000E-19	.1160E+00	.0000E+00	.6775E+00	.7438E+01
23	132.0	.1079E+00	.9000E-19	.1000E-19	.1161E+00	.0000E+00	.6427E+00	.7390E+01
24	138.0	.1079E+00	.9000E-19	.1000E-19	.1150E+00	.0000E+00	.6185E+00	.7420E+01

SEGMENT	DEPTH CM	ROOT MASS PPM C	RESIDUE (ROOT-SLOUGH) PPM C	RESIDUE 5,6 PPM C	RESIDUE 7,8 PPM C	RESIDUE 9,10 PPM C	RESIDUE 11,12 PPM C	RESIDUE 13,14 PPM C
2	6.0	.2853E+02	.1094E+00	.1081E+03	.0000E+00	.0000E+00	.0000E+00	.0000E+00
3	12.0	.2856E+02	.1184E+00	.1052E+03	.0000E+00	.0000E+00	.0000E+00	.0000E+00
4	18.0	.2766E+02	.1296E+00	.1216E+03	.0000E+00	.0000E+00	.0000E+00	.0000E+00
5	24.0	.3350E+02	.1956E+00	.1719E+03	.0000E+00	.0000E+00	.0000E+00	.0000E+00
6	30.0	.1680E+02	.1214E+00	.2061E+03	.0000E+00	.0000E+00	.0000E+00	.0000E+00
7	36.0	.1119E+02	.5132E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
8	42.0	.8381E+01	.3731E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
9	48.0	.6654E+01	.3174E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
10	54.0	.5627E+01	.8506E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
11	60.0	.4777E+01	.7101E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
12	66.0	.4130E+01	.6798E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
13	72.0	.3617E+01	.5884E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
14	78.0	.3200E+01	.5614E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
15	84.0	.2851E+01	.5246E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
16	90.0	.2547E+01	.4562E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
17	96.0	.2281E+01	.3977E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
18	102.0	.2044E+01	.3787E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
19	108.0	.1790E+01	.4587E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
20	114.0	.1546E+01	.3805E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
21	120.0	.1315E+01	.3205E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
22	126.0	.1083E+01	.2633E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
23	132.0	.8676E+00	.2089E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
24	138.0	.6803E+00	.1730E-01	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00

SEGMENT	DEPTH CM	FRACTION OF TOTAL ROOTS PER SEGMENT	CUMULATIVE N UPTAKE UG N/SEG	CUMULATIVE IMMOBILIZATION UG N/SEG	CUMULATIVE MINERALIZATION UG N/SEG	CUMULATIVE NET IMMOBILIZATION (<0) MINERALIZATION (>0) UG N/SEG	CUMULATIVE H2O UPTAKE CM/SEG	CUMULATIVE DENITRIFICATION UG N/SEG
2	6.0	.139	.1473E+03	.5283E+04	.5189E+04	-.1305E+03	.5637E+01	.1063E+03
3	12.0	.139	.1801E+03	.5041E+04	.4971E+04	-.1006E+03	.5511E+01	.4035E+02
4	18.0	.139	.1520E+03	.4813E+04	.4702E+04	-.1132E+03	.5178E+01	.2228E+01
5	24.0	.168	.9046E+02	.4448E+04	.4306E+04	-.1421E+03	.4854E+01	.0000E+00
6	30.0	.084	.3395E+02	.4161E+04	.4025E+04	-.1353E+03	.3054E+01	.0000E+00
7	36.0	.056	.1899E+03	.4654E+02	.7221E+02	.2567E+02	.2104E+01	.0000E+00
8	42.0	.042	.2418E+03	.4322E+02	.6883E+02	.2561E+02	.1601E+01	.0000E+00
9	48.0	.033	.1830E+03	.4099E+02	.6642E+02	.2542E+02	.1329E+01	.0000E+00
10	54.0	.029	.7844E+02	.1023E+02	.1382E+02	.3594E+01	.1116E+01	.0000E+00
11	60.0	.025	.4657E+02	.9560E+01	.1326E+02	.3697E+01	.1011E+01	.0000E+00
12	66.0	.022	.2109E+02	.8747E+01	.1229E+02	.3546E+01	.7112E+00	.0000E+00
13	72.0	.019	.1750E+02	.8338E+01	.1194E+02	.3600E+01	.5717E+00	.0000E+00
14	78.0	.017	.1742E+02	.7862E+01	.1141E+02	.3543E+01	.5412E+00	.0000E+00
15	84.0	.015	.1732E+02	.7503E+01	.1103E+02	.3527E+01	.4894E+00	.0000E+00
16	90.0	.013	.1752E+02	.7326E+01	.1093E+02	.3607E+01	.4785E+00	.0000E+00
17	96.0	.012	.1763E+02	.7198E+01	.1089E+02	.3697E+01	.4984E+00	.0000E+00
18	102.0	.011	.1758E+02	.6955E+01	.1064E+02	.3682E+01	.4723E+00	.0000E+00
19	108.0	.009	.1726E+02	.6321E+01	.9706E+01	.3385E+01	.3267E+00	.0000E+00
20	114.0	.008	.1739E+02	.6254E+01	.9755E+01	.3500E+01	.3339E+00	.0000E+00
21	120.0	.007	.1745E+02	.6111E+01	.9659E+01	.3548E+01	.3336E+00	.0000E+00
22	126.0	.006	.1750E+02	.5958E+01	.9551E+01	.3593E+01	.3362E+00	.0000E+00
23	132.0	.005	.1757E+02	.5829E+01	.9483E+01	.3654E+01	.3137E+00	.0000E+00
24	138.0	.004	.1763E+02	.5578E+01	.9208E+01	.3630E+01	.2929E+00	.0000E+00

---- POOL I ---- MICROBIAL MASS UG N	UG N15	---- POOL II ---- HUMADS UG N	UG N15	----- RESIDUES ----- UG C	UG N	AVERAGE C/N
.2385E+04		.2062E+04		.6795E+04	.1702E+03	.3992E+02

----- EXCHANGES OF WATER AND NITROGEN ACROSS SYSTEM BOUNDARIES -----

PAN EVAPORATION .1014E+03 CM H2O TO DATE

TRANSPIRATION CM H2O TO DATE	EVAPORATION CM H2O TO DATE	INFILTRATION CM H2O TO DATE	RUNOFF CM H2O TO DATE	WATER LEACHED CM H2O TO DATE	N LEACHED UG N TO DATE	N15 LEACHED UG N15 TO DATE
.5418E+02	.5304E+01	.6411E+02	.0000E+00	.8261E+00	.1350E+00	

----- BIOLOGICAL NITROGEN TRANSFORMATIONS -----

NET IMMOBILIZATION (<0) MINERALIZATION(>0) UG N TO DATE	IMMOBILIZATION UG N TO DATE	MINERALIZATION UG N TO DATE	NON-SYMBIOTIC N FIXATION UG N TO DATE	DENITRIFICATION UG N TO DATE	SYMBIOTIC N FIXATION UG N TO DATE
-.4911E+03	.2399E+05	.2356E+05	.0000E+00	.1489E+03	

--------------------TOP--------------------				----------ROOT (BEFORE DEGRAD)----------			
TOP MASS KG/HA 15.5 PERCENT H2O	TOP N MASS KG/HA	CROP GRAIN MASS KG/HA 15.5PERCENT H2O	RATIO OF N TO TOP DRY MATTER	ROOT MASS KG/HA 15.5 PERCENT H2O	RATIO OF SHOOT TO ROOT	ROOT N MASS KG/HA	RATIO OF N TO ROOT DRY MATTER
.1548E+05	.1423E+03	.9115E+04	.0109	.7534E+03	20.545	.1329E+02	.0149

----- GROWTH REDUCTION RATIOS -----

ACTUAL/POTENTIAL ROOT LENGTH		ACTUAL/POTENTIAL N UPTAKE		ACTUAL/POTENTIAL N PERCENTAGE		ACTUAL/POTENTIAL H2O UPTAKE		ACTUAL/REFERENCE TEMPERATURE		ACTUAL/OPTIMUM PLANT POPULATION
CURRENT VALUE	RUNNING AVERAGE	CURRENT VALUE	RUNNING AVERAGE	CURRENT VALUE	RUNNING AVERAGE	CURRENT VALUE	RUNNING AVERAGE	CURRENT VALUE	RUNNING AVERAGE	.LE.1.
.100	.100	.220	.539	.909	.879	1.000	1.000	1.000	1.001	1.000

------- NITROGEN IN PLANT (TOP + ROOT) -------

N UPTAKE FROM SOIL GM N/PLANT KG N/HA	PLANT N GM N/PLANT KG N/HA	RATIO OF N TO TOTAL DRY MATTER IN PLANT	PLANT N15 GM N15/PLANT KG N15/HA	N15/TOTAL N IN PLANT	PLANT N GAS LOSS GM N/PLANT KG N/HA	N EXUDATE (ROOT) GM N/PLANT KG N/HA

.2076E+01	.2052E+01	.0113	.0000E+00	.2390E-01
.1574E+03	.1556E+03		.0000E+00	.1812E+01

----- DEFICIT IN CROP (ABOVE GROUND + ROOT) -----

DEFICIT MOISTURE: .000 CM H2O
DEFICIT NITROGEN, REFERENCE - ACTUAL CROP N: 31.334 KG/HA
DEFICIT N SYMB FIXED, POTENTIAL - ACTUAL (TEMP H2O FACTORS): .000 KG N/HA

NOTE: TO CONVERT UG/CM2 TO KG/HA, DIVIDE UG/CM2 BY 10.; 1.0 CM2 AREA IS ASSUMED UNLESS SPECIFIED OTHERWISE
TO CONVERT KG/HA TO G/PLANT, MULTIPLY KG/HA BY .13188E-01

DAY = 293 10/20

------- NITROGEN MASS BALANCE -------

	TOTAL N (UG PER SQUARE CM)	N15
INITIAL INORGANIC N	.4640E+03	
INITIAL POOL I+II N	.7295E+03	
INITIAL TOTAL N	.1193E+04	
JRRENT INORGANIC N	.4967E+03	
CURRENT POOLI+II N	.4447E+04	
CURRENT RESIDUE N	.1702E+03	
CURRENT PLANT RESIDUAL ROOT N	.9736E+02	
CURRENT PLANT TOP N	.1423E+04	
CURRENT TOTAL N	.6634E+04	
TOTAL CHANGE OF NITROGEN CONTENT IN SYSTEM	.5441E+04	
TOTAL INORGANIC N APPLIED	.2247E+04	
TOTAL ORGANIC N APPLIED	.3412E+04	
TOTAL N LEACHED	.1350E+00	
TOTAL N NON SYMB FIXATION	.0000E+00	
TOTAL N DENITRIFICATION	.1489E+03	
TOTAL N GAS LOSS FROM PLANT	.0000E+00	
TOTAL N LOSS IN DRAIN	.0000E+00	
TOTAL N GAIN FROM WATER TABLE TO PLANT	.0000E+00	
TOTAL MOVEMENT OF NITROGEN THROUGH SYSTEM BOUNDARIES	.5510E+04	
DIFFERENCE BETWEEN GLOBAL CHANGE AND BOUNDARY FLUXES	.6906E+02	

------- WATER MASS BALANCE (CM) -------

INITIAL WATER CONTENT	.1496E+02	
CURRENT WATER CONTENT	.1876E+02	OF WHICH .0000E+00CM ARE PONDED
CHANGE IN WATER CONTENT	.3799E+01	
TOTAL WATER INPUT	.6411E+02	
TOTAL EVAPORATION	.5304E+01	
TOTAL TRANSPIRATION	.5418E+02	OF WHICH .0000E+00CM FROM WATER TABLE
TOTAL H2O LEACHED	.8261E+00	
TOTAL RUNOFF	.0000E+00	
TOTAL DRAIN	.0000E+00	
TOTAL WATER MOVEMENT THROUGH SYSTEM BOUNDARIES	.3799E+01	
DIFFERENCE BETWEEN GLOBAL CHANGE AND BOUNDARY FLUXES	-.8702E-04	

1

FINAL CONDITIONS PER SOIL HORIZON:

HORIZON	DEPTH CM	GRAVIMETRIC WATER CONTENT (ML/GM)	TOTAL NH4 PPM N	NO3 PPM N	POOL I PPM N LABILE	POOL I PPM N RECALCITRANT	POOL II PPM N LABILE	POOL II PPM N RECALCITRANT
1	12.0	.115	.000	13.499	4.762	42.562	.000	44.024
2	48.0	.120	.000	3.932	2.906	22.843	.000	19.634
3	144.0	.065	.000	.128	.019	.127	.000	.750

	HORIZON	DEPTH CM	CARBON KG C/HA LABILE	CARBON KG C/HA RECALCITRANT	C/N RATIO	
TOP (DRY)	-	-	1412.65	3819.39	36.8	
RESIDUES 1, 2	1	12.0	3.23	49.86	19.4	.00000
(ROOT RESIDUAL)	2	48.0	6.15	93.86	19.4	.00000
	3	138.0	3.82	34.38	20.9	.00000
RESIDUES 3, 4	1	12.0	.00	.21	20.9	.00000
(ROOT SLOUGH)	2	48.0	.00	.54	20.5	.00000
	3	138.0	.00	.69	21.5	.00000
		SURFACE	.00	.00		
RESIDUES 5, 6	1	12.0	198.36	.00	40.0	.00000
	2	48.0	479.70	.00	40.0	.00000
	3	138.0	.00	.00	.0	.00000

Section 5.   Factor relationship testing.

This section demonstrates the models responsiveness to changes in individual inputs under the user's control. Each factor is adjusted up or down, while all other factors are held constant. The following is a summary of the response in terms of yield:

Variable	change	yield impact
Planting date	earlier later	decrease decrease
Seed rate	increase decrease	no change no change
Harvest	earlier later (harvest beyond last day of input data)	no change error
C:N ratio	decrease increase	increase decrease
Apply residue	earlier later	increase decrease
Residue amount	decrease increase	increase decrease
Residue Incorporation	none shallow	increase decrease
N form	all forms (actual amount of N input regardless of form)	no impact
N date	earlier later	decrease decrease
N amount	increase decrease	increase decrease
N application	surface deep	decrease increase
Rainfall	dry wet	decrease decrease
Air-temp	hot cold	decrease decrease
Soil type	sand clay	decrease decrease

(Percent total N and initial N variables are not operational.)

```
 Menu
[±] Simulation
Name  Farmer Tom   Field  South 40                              Rainfall
                                        N Form                  ( ) Dry
                   C:N Ratio            ( ) Ammon. Nitrate      () Average
Crop               ( ) Grass  -  20:1   ( ) Urea                ( ) Wet
() Corn            () Leaves -   40:1   ( ) Liquid Nitrogen
( ) Future         ( ) Leaves -  70:1   () Anhydrous Ammon      Air-temp
( ) Future         ( ) Wood   - 150:1   ( ) Ammon. Sulfate      ( ) Hot
                                                                () Average
Plant on  APR 28   Apply on  APR 2      Apply on    MAY 30      ( ) Cold

SeedRate   30700   Rate Ton/Ac  20      NRate (lb/ac) 200       Soil Type
                                                                ( ) Sand
Harvest   OCT 12   Incorporation        Apply Method            () Loam
                   ( ) None             ( ) Surface             ( ) Clay
                   ( ) Shallow [0-6"]   () Shallow [0-6"]
                   () Deep [0-12"]     ( ) Deep [0-12"]      % total N   99

                                                                N init ppm 99

                                  Ok
Alt-X Exit
```

BASELINE

```
 Menu
[±] 0 []

    unt N left in the residue      49.75    (lb/ac)

          Inorganic N leached        .01    (lb/ac)

 Net immobil(-)/mineralizat(+)    -43.71    (lb/ac)

              Denitrification      13.25    (lb/ac)

          Top mass @ 15.5 H2O   13776.67    (lb/ac)

      Moisture deficit in crop       .00    (inches)

      Nitrogen deficit in crop     27.89    (lb/ac)

  Organic Nitrogen pool CHANGE    330.85    (lb/ac)

         Inorganic N in profile    44.20    (lb/ac)

                 Ok    É        Quit  É
               00000000        00000000
Alt-X Exit
```

```
Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                          Rainfall        ¤
¤                                        N Form               ( ) Dry         ¤
¤                    C:N Ratio           ( ) Ammon. Nitrate   () Average      ¤
¤ Crop               ( ) Grass  -  20:1  ( ) Urea             ( ) Wet         ¤
¤ () Corn            () Leaves -  40:1   ( ) Liquid Nitrogen                  ¤
¤ ( ) Future         ( ) Leaves -  70:1  () Anhydrous Ammon   Air-temp        ¤
¤ ( ) Future         ( ) Wood   - 150:1  ( ) Ammon. Sulfate   ( ) Hot         ¤
¤                                                             () Average      ¤
¤ Plant on  APR 2    Apply on  APR 2     Apply on   MAY 30    ( ) Cold        ¤
¤                                                                             ¤
¤ SeedRate   30700   Rate Ton/Ac  20     NRate (lb/ac) 200    Soil Type       ¤
¤                                                             ( ) Sand        ¤
¤ Harvest   OCT 12   Incorporation       Apply Method         () Loam         ¤
¤                    ( ) None            ( ) Surface          ( ) Clay        ¤
¤                    ( ) Shallow [0-6"]  () Shallow [0-6"]                    ¤
¤                    () Deep [0-12"]     ( ) Deep [0-12"]     % total N   99  ¤
¤                                                                             ¤
¤                                                             N init ppm 99   ¤
¤                                                                             ¤
¤                                                                             ¤
¤                                                                             ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë   Ok   Éëëëëëëëëëëëëëëëëëëëëëëëëë¥
Alt-X Exit
```

PLANT SOONER

```
Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                             ¤
¤     unt N left in the residue     76.96    (lb/ac)                          ¤
¤                                                                             ¤
¤           Inorganic N leached      3.03    (lb/ac)                          ¤
¤                                                                             ¤
¤ Net immobil(-)/mineralizat(+)    -78.55    (lb/ac)                          ¤
¤                                                                             ¤
¤               Denitrification      9.34    (lb/ac)                          ¤
¤                                                                             ¤
¤        Top mass @ 15.5 H2O   11173.84     (lb/ac)                           ¤
¤                                                                             ¤
¤       Moisture deficit in crop     8.36    (inches)                         ¤
¤                                                                             ¤
¤       Nitrogen deficit in crop    50.52    (lb/ac)                          ¤
¤                                                                             ¤
¤ Organic Nitrogen pool CHANGE     355.47    (lb/ac)                          ¤
¤                                                                             ¤
¤          Inorganic N in profile   32.90    (lb/ac)                          ¤
¤                                                                             ¤
¤                 Ok   É        Quit  É                                       ¤
¤               ÕÕÕÕÕÕÕÕ       ÕÕÕÕÕÕÕÕ                                       ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¥
Alt-X Exit
```

```
Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                          Rainfall        ¤
¤                                        N Form               ( ) Dry         ¤
¤                    C:N Ratio           ( ) Ammon. Nitrate   () Average      ¤
¤ Crop               ( ) Grass  -  20:1  ( ) Urea             ( ) Wet         ¤
¤ () Corn            () Leaves -  40:1   ( ) Liquid Nitrogen                  ¤
¤ ( ) Future         ( ) Leaves -  70:1  () Anhydrous Ammon   Air-temp        ¤
¤ ( ) Future         ( ) Wood   - 150:1  ( ) Ammon. Sulfate   ( ) Hot         ¤
¤                                                             () Average      ¤
¤ Plant on  MAY 28   Apply on  APR 2     Apply on   MAY 30    ( ) Cold        ¤
¤                                                                             ¤
¤ SeedRate   30700   Rate Ton/Ac  20     NRate (lb/ac) 200    Soil Type       ¤
¤                                                             ( ) Sand        ¤
¤ Harvest   OCT 12   Incorporation       Apply Method         () Loam         ¤
¤                    ( ) None            ( ) Surface          ( ) Clay        ¤
¤                    ( ) Shallow [0-6"]  () Shallow [0-6"]                    ¤
¤                    () Deep [0-12"]     ( ) Deep [0-12"]     % total N   99  ¤
¤                                                                             ¤
¤                                                             N init ppm 99   ¤
¤                                                                             ¤
¤                                                                             ¤
¤                                                                             ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë   Ok   Éëëëëëëëëëëëëëëëëëëëëëëëëë¥
Alt-X Exit
```

PLANT LATER

```
Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                             ¤
¤     unt N left in the residue    105.06    (lb/ac)                          ¤
¤                                                                             ¤
¤           Inorganic N leached     19.38    (lb/ac)                          ¤
¤                                                                             ¤
¤ Net immobil(-)/mineralizat(+)    -66.62    (lb/ac)                          ¤
¤                                                                             ¤
¤               Denitrification     15.50    (lb/ac)                          ¤
¤                                                                             ¤
¤        Top mass @ 15.5 H2O   13287.92     (lb/ac)                           ¤
¤                                                                             ¤
¤       Moisture deficit in crop      .00    (inches)                         ¤
¤                                                                             ¤
¤       Nitrogen deficit in crop    31.06    (lb/ac)                          ¤
¤                                                                             ¤
¤ Organic Nitrogen pool CHANGE     337.30    (lb/ac)                          ¤
¤                                                                             ¤
¤          Inorganic N in profile    2.85    (lb/ac)                          ¤
¤                                                                             ¤
¤                 Ok   É        Quit  É                                       ¤
¤               ÕÕÕÕÕÕÕÕ       ÕÕÕÕÕÕÕÕ                                       ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¥
Alt-X Exit
```

```
Menu
Simulation
Name  Farmer Tom   Field  South 40                        Rainfall
                                       N Form              ( ) Dry
                    C:N Ratio          ( ) Ammon. Nitrate  () Average
Crop                ( ) Grass  -  20:1 ( ) Urea            ( ) Wet
() Corn             () Leaves -  40:1  ( ) Liquid Nitrogen
( ) Future          ( ) Leaves -  70:1 () Anhydrous Ammon  Air-temp
( ) Future          ( ) Wood   - 150:1 ( ) Ammon. Sulfate  ( ) Hot
                                                            () Average
Plant on  APR 28    Apply on  APR 2    Apply on   MAY 30    ( ) Cold

SeedRate   27700    Rate Ton/Ac  20    NRate (lb/ac) 200    Soil Type
                                                            ( ) Sand
Harvest   OCT 12    Incorporation      Apply Method         () Loam
                    ( ) None           ( ) Surface          ( ) Clay
                    ( ) Shallow [0-6"] () Shallow [0-6"]
                    () Deep [0-12"]    ( ) Deep [0-12"]     % total N   99

                                                            N init ppm 99

                                  Ok
Alt-X Exit
```

DECREASE SEEDRATE

```
Menu
0
   unt N left in the residue      49.75   (lb/ac)

          Inorganic N leached       .01   (lb/ac)

Net immobil(-)/mineralizat(+)    -43.71   (lb/ac)

             Denitrification      13.25   (lb/ac)

         Top mass @ 15.5 H2O   13776.67   (lb/ac)

      Moisture deficit in crop      .00   (inches)

      Nitrogen deficit in crop    27.89   (lb/ac)

  Organic Nitrogen pool CHANGE   330.85   (lb/ac)

        Inorganic N in profile    44.20   (lb/ac)

              Ok           Quit
Alt-X Exit
```

```
Menu
Simulation
Name  Farmer Tom   Field  South 40                        Rainfall
                                       N Form              ( ) Dry
                    C:N Ratio          ( ) Ammon. Nitrate  () Average
Crop                ( ) Grass  -  20:1 ( ) Urea            ( ) Wet
() Corn             () Leaves -  40:1  ( ) Liquid Nitrogen
( ) Future          ( ) Leaves -  70:1 () Anhydrous Ammon  Air-temp
( ) Future          ( ) Wood   - 150:1 ( ) Ammon. Sulfate  ( ) Hot
                                                            () Average
Plant on  APR 28    Apply on  APR 2    Apply on   MAY 30    ( ) Cold

SeedRate   33700    Rate Ton/Ac  20    NRate (lb/ac) 200    Soil Type
                                                            ( ) Sand
Harvest   OCT 12    Incorporation      Apply Method         () Loam
                    ( ) None           ( ) Surface          ( ) Clay
                    ( ) Shallow [0-6"] () Shallow [0-6"]
                    () Deep [0-12"]    ( ) Deep [0-12"]     % total N   99

                                                            N init ppm 99

                                  Ok
Alt-X Exit
```

INCREASE SEEDRATE

```
Menu
0
   unt N left in the residue      49.75   (lb/ac)

          Inorganic N leached       .01   (lb/ac)

Net immobil(-)/mineralizat(+)    -43.71   (lb/ac)

             Denitrification      13.25   (lb/ac)

         Top mass @ 15.5 H2O   13776.67   (lb/ac)

      Moisture deficit in crop      .00   (inches)

      Nitrogen deficit in crop    27.89   (lb/ac)

  Organic Nitrogen pool CHANGE   330.85   (lb/ac)

        Inorganic N in profile    44.20   (lb/ac)

              Ok           Quit
Alt-X Exit
```

```
 Menu
                          Simulation
 Name  Farmer Tom    Field  South 40                      Rainfall
                                        N Form            ( ) Dry
                     C:N Ratio          ( ) Ammon. Nitrate  () Average
 Crop                ( ) Grass  -  20:1  ( ) Urea          ( ) Wet
 () Corn             () Leaves -  40:1  ( ) Liquid Nitrogen
 ( ) Future          ( ) Leaves -  70:1  () Anhydrous Ammon  Air-temp
 ( ) Future          ( ) Wood   - 150:1  ( ) Ammon. Sulfate  ( ) Hot
                                                          () Average
 Plant on  APR 28    Apply on  APR 2    Apply on   MAY 30  ( ) Cold

 SeedRate   30700    Rate Ton/Ac  20    NRate (lb/ac) 200  Soil Type
                                                          ( ) Sand
 Harvest    SEP 12   Incorporation      Apply Method       () Loam
                     ( ) None           ( ) Surface        ( ) Clay
                     ( ) Shallow [0-6"]  () Shallow [0-6"]
                     () Deep [0-12"]    ( ) Deep [0-12"]   % total N   99

                                                          N init ppm 99

                                   Ok
 Alt-X Exit
```

```
 Menu
                                   0
   ount N left in the residue     49.75    (lb/ac)

            Inorganic N leached     .01    (lb/ac)

  Net immobil(-)/mineralizat(+)  -43.71    (lb/ac)

                 Denitrification  13.25    (lb/ac)

           Top mass @ 15.5 H20  13776.67   (lb/ac)

        Moisture deficit in crop    .00    (inches)

        Nitrogen deficit in crop  27.89    (lb/ac)

   Organic Nitrogen pool CHANGE  330.85    (lb/ac)

           Inorganic N in profile  44.20   (lb/ac)

                   Ok   É        Quit  É
 Alt-X Exit
```

HARVEST SOONER

```
 Menu
                          Simulation
 Name  Farmer Tom    Field  South 40                      Rainfall
                                        N Form            ( ) Dry
                     C:N Ratio          ( ) Ammon. Nitrate  () Average
 Crop                ( ) Grass  -  20:1  ( ) Urea          ( ) Wet
 () Corn             () Leaves -  40:1  ( ) Liquid Nitrogen
 ( ) Future          ( ) Leaves -  70:1  () Anhydrous Ammon  Air-temp
 ( ) Future          ( ) Wood   - 150:1  ( ) Ammon. Sulfate  ( ) Hot
                                                          () Average
 Plant on  APR 28    Apply on  APR 2    Apply on   MAY 30  ( ) Cold

 SeedRate   30700    Rate Ton/Ac  20    NRate (lb/ac) 200  Soil Type
                                                          ( ) Sand
 Harvest    NOV 12   Incorporation      Apply Method       () Loam
                     ( ) None           ( ) Surface        ( ) Clay
                     ( ) Shallow [0-6"]  () Shallow [0-6"]
                     () Deep [0-12"]    ( ) Deep [0-12"]   % total N   99

                                                          N init ppm 99

                                   Ok
 Alt-X Exit
```

```
 Menu
                                   0
   ount N left in the residue    330.85    (lb/ac)

            Inorganic N leached   44.20    (lb/ac)

  Net immobil(-)/mineralizat(+)            (lb/ac)

                 Denitrification           (lb/ac)

           Top mass @ 15.5 H20             (lb/ac)

        Moisture deficit in crop           (inches)

        Nitrogen deficit in crop           (lb/ac)

   Organic Nitrogen pool CHANGE            (lb/ac)

           Inorganic N in profile          (lb/ac)

                   Ok   É        Quit  É
 Alt-X Exit
```

HARVEST LATER
(BEYOND LAST DAY OF DATA)

```
Menu
[±] Simulation
Name  Farmer Tom   Field  South 40                         Rainfall
                                      N Form               ( ) Dry
                   C:N Ratio          ( ) Ammon. Nitrate   () Average
Crop               () Grass  -  20:1  ( ) Urea             ( ) Wet
() Corn            ( ) Leaves -  40:1 ( ) Liquid Nitrogen
( ) Future         ( ) Leaves -  70:1 () Anhydrous Ammon   Air-temp
( ) Future         ( ) Wood   - 150:1 ( ) Ammon. Sulfate   ( ) Hot
                                                           () Average
Plant on  APR 28   Apply on  APR 2    Apply on   MAY 30    ( ) Cold

SeedRate   30700   Rate Ton/Ac  20    NRate (lb/ac) 200    Soil Type
                                                           ( ) Sand
Harvest   OCT 12   Incorporation      Apply Method         () Loam
                   ( ) None           ( ) Surface          ( ) Clay
                   ( ) Shallow [0-6"] () Shallow [0-6"]
                   () Deep [0-12"]    ( ) Deep [0-12"]     % total N   99

                                                           N init ppm 99

                         Ok
Alt-X Exit
```

lower C:N ratio

```
Menu
[±] 0 []

   ount N left in the residue     29.45    (lb/ac)

         Inorganic N leached       1.66    (lb/ac)

 Net immobil(-)/mineralizat(+)    82.35    (lb/ac)

             Denitrification       9.15    (lb/ac)

         Top mass @ 15.5 H2O   15218.43    (lb/ac)

      Moisture deficit in crop      .00    (inches)

      Nitrogen deficit in crop      .24    (lb/ac)

  Organic Nitrogen pool CHANGE    81.74    (lb/ac)

        Inorganic N in profile   145.07    (lb/ac)

                  Ok        Quit
Alt-X Exit
```

```
Menu
[±] Simulation
Name  Farmer Tom   Field  South 40                         Rainfall
                                      N Form               ( ) Dry
                   C:N Ratio          ( ) Ammon. Nitrate   () Average
Crop               ( ) Grass  -  20:1 ( ) Urea             ( ) Wet
() Corn            ( ) Leaves -  40:1 ( ) Liquid Nitrogen
( ) Future         () Leaves -  70:1  () Anhydrous Ammon   Air-temp
( ) Future         ( ) Wood   - 150:1 ( ) Ammon. Sulfate   ( ) Hot
                                                           () Average
Plant on  APR 28   Apply on  APR 2    Apply on   MAY 30    ( ) Cold

SeedRate   30700   Rate Ton/Ac  20    NRate (lb/ac) 200    Soil Type
                                                           ( ) Sand
Harvest   OCT 12   Incorporation      Apply Method         () Loam
                   ( ) None           ( ) Surface          ( ) Clay
                   ( ) Shallow [0-6"] () Shallow [0-6"]
                   () Deep [0-12"]    ( ) Deep [0-12"]     % total N   99

                                                           N init ppm 99

                         Ok
Alt-X Exit
```

RAISE C:N RATIO

```
Menu
[±] 0 []

   ount N left in the residue    114.99    (lb/ac)

         Inorganic N leached        .01    (lb/ac)

 Net immobil(-)/mineralizat(+)  -132.29    (lb/ac)

             Denitrification       8.32    (lb/ac)

         Top mass @ 15.5 H2O   10339.21    (lb/ac)

      Moisture deficit in crop      .00    (inches)

      Nitrogen deficit in crop    71.41    (lb/ac)

  Organic Nitrogen pool CHANGE   270.64    (lb/ac)

        Inorganic N in profile     4.08    (lb/ac)

                  Ok        Quit
Alt-X Exit
```

```
Menu
Simulation
Name  Farmer Tom     Field  South 40                        Rainfall
                                   N Form                   ( ) Dry
                     C:N Ratio     ( ) Ammon. Nitrate       () Average
Crop                 ( ) Grass  -  20:1  ( ) Urea           ( ) Wet
() Corn              () Leaves -  40:1  ( ) Liquid Nitrogen
( ) Future           ( ) Leaves -  70:1  () Anhydrous Ammon  Air-temp
( ) Future           ( ) Wood   - 150:1  ( ) Ammon. Sulfate  ( ) Hot
                                                            () Average
Plant on  APR 28     Apply on  MAR 2.   Apply on   MAY 30   ( ) Cold

SeedRate   30700     Rate Ton/Ac  20    NRate (lb/ac) 200   Soil Type
                                                            ( ) Sand
Harvest   OCT 12     Incorporation      Apply Method        () Loam
                     ( ) None           ( ) Surface         ( ) Clay
                     ( ) Shallow [0-6"] () Shallow [0-6"]
                     () Deep [0-12"]   ( ) Deep [0-12"]    % total N  99

                                                            N init ppm 99



Ok
Alt-X Exit
```

Apply residue sooner

```
Menu
0

ount N left in the residue        .19     (lb/ac)

        Inorganic N leached        .00     (lb/ac)

Net immobil(-)/mineralizat(+)    26.26     (lb/ac)

             Denitrification       .94     (lb/ac)

        Top mass @ 15.5 H20   15232.65     (lb/ac)

    Moisture deficit in crop       .00     (inches)

    Nitrogen deficit in crop       .00     (lb/ac)

  Organic Nitrogen pool CHANGE   -21.67    (lb/ac)

        Inorganic N in profile   98.61     (lb/ac)

              Ok  É       Quit  É
              òòòòòòòò    òòòòòòòò
Alt-X Exit
```

```
Menu
Simulation
Name  Farmer Tom     Field  South 40                        Rainfall
                                   N Form                   ( ) Dry
                     C:N Ratio     ( ) Ammon. Nitrate       () Average
Crop                 ( ) Grass  -  20:1  ( ) Urea           ( ) Wet
() Corn              () Leaves -  40:1  ( ) Liquid Nitrogen
( ) Future           ( ) Leaves -  70:1  () Anhydrous Ammon  Air-temp
( ) Future           ( ) Wood   - 150:1  ( ) Ammon. Sulfate  ( ) Hot
                                                            () Average
Plant on  APR 28     Apply on  MAY 2    Apply on   MAY 30   ( ) Cold

SeedRate   30700     Rate Ton/Ac  20    NRate (lb/ac) 200   Soil Type
                                                            ( ) Sand
Harvest   OCT 12     Incorporation      Apply Method        () Loam
                     ( ) None           ( ) Surface         ( ) Clay
                     ( ) Shallow [0-6"] () Shallow [0-6"]
                     () Deep [0-12"]   ( ) Deep [0-12"]    % total N  99

                                                            N init ppm 99



Ok
Alt-X Exit
```

Apply residue later

```
Menu
0

ount N left in the residue      72.52     (lb/ac)

        Inorganic N leached        .01     (lb/ac)

Net immobil(-)/mineralizat(+)   -79.49     (lb/ac)

             Denitrification     11.46     (lb/ac)

        Top mass @ 15.5 H20   11807.71     (lb/ac)

    Moisture deficit in crop       .00     (inches)

    Nitrogen deficit in crop     52.40     (lb/ac)

  Organic Nitrogen pool CHANGE   357.44    (lb/ac)

        Inorganic N in profile   34.73     (lb/ac)

              Ok  É       Quit  É
              òòòòòòòò    òòòòòòòò
Alt-X Exit
```

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                         Rainfall        ¤
¤                                      N Form                ( ) Dry         ¤
¤                    C:N Ratio         ( ) Ammon. Nitrate    () Average     ¤
¤ Crop               ( ) Grass  -  20:1  ( ) Urea            ( ) Wet         ¤
¤ () Corn            () Leaves -  40:1  ( ) Liquid Nitrogen               ¤
¤ ( ) Future         ( ) Leaves -  70:1  () Anhydrous Ammon  Air-temp       ¤
¤ ( ) Future         ( ) Wood   - 150:1  ( ) Ammon. Sulfate   ( ) Hot        ¤
¤                                                            () Average     ¤
¤ Plant on  APR 28   Apply on  APR 2     Apply on    MAY 30   ( ) Cold       ¤
¤                                                                            ¤
¤ SeedRate   30700   Rate Ton/Ac  10     NRate (lb/ac) 200    Soil Type      ¤
¤                                                            ( ) Sand       ¤
¤ Harvest   OCT 12   Incorporation       Apply Method         () Loam       ¤
¤                    ( ) None            ( ) Surface          ( ) Clay       ¤
¤                    ( ) Shallow [0-6"]  () Shallow [0-6"]                  ¤
¤                    () Deep [0-12"]    ( ) Deep [0-12"]    % total N   99  ¤
¤                                                                            ¤
¤                                                            N init ppm 99   ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë    Ok    Éëëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

less RESIDUE

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                            ¤
¤    ount N left in the residue      19.14    (lb/ac)                        ¤
¤                                                                            ¤
¤          Inorganic N leached         .20    (lb/ac)                        ¤
¤                                                                            ¤
¤ Net immobil(-)/mineralizat(+)     -14.25    (lb/ac)                        ¤
¤                                                                            ¤
¤              Denitrification        9.72    (lb/ac)                        ¤
¤                                                                            ¤
¤          Top mass @ 15.5 H2O    15218.43    (lb/ac)                        ¤
¤                                                                            ¤
¤      Moisture deficit in crop        .00    (inches)                       ¤
¤                                                                            ¤
¤      Nitrogen deficit in crop        .24    (lb/ac)                        ¤
¤                                                                            ¤
¤  Organic Nitrogen pool CHANGE     161.41    (lb/ac)                        ¤
¤                                                                            ¤
¤         Inorganic N in profile     49.35    (lb/ac)                        ¤
¤                                                                            ¤
¤                  Ok   É        Quit  É                                     ¤
¤                ÓÓÓÓÓÓÓÓ      ÓÓÓÓÓÓÓÓ                                      ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¾
 Alt-X Exit
```

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                         Rainfall        ¤
¤                                      N Form                ( ) Dry         ¤
¤                    C:N Ratio         ( ) Ammon. Nitrate    () Average     ¤
¤ Crop               ( ) Grass  -  20:1  ( ) Urea            ( ) Wet         ¤
¤ () Corn            () Leaves -  40:1  ( ) Liquid Nitrogen               ¤
¤ ( ) Future         ( ) Leaves -  70:1  () Anhydrous Ammon  Air-temp       ¤
¤ ( ) Future         ( ) Wood   - 150:1  ( ) Ammon. Sulfate   ( ) Hot        ¤
¤                                                            () Average     ¤
¤ Plant on  APR 28   Apply on  APR 2     Apply on    MAY 30   ( ) Cold       ¤
¤                                                                            ¤
¤ SeedRate   30700   Rate Ton/Ac  30     NRate (lb/ac) 200    Soil Type      ¤
¤                                                            ( ) Sand       ¤
¤ Harvest   OCT 12   Incorporation       Apply Method         () Loam       ¤
¤                    ( ) None            ( ) Surface          ( ) Clay       ¤
¤                    ( ) Shallow [0-6"]  () Shallow [0-6"]                  ¤
¤                    () Deep [0-12"]    ( ) Deep [0-12"]    % total N   99  ¤
¤                                                                            ¤
¤                                                            N init ppm 99   ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë    Ok    Éëëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

MORE RESIDUE

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                            ¤
¤    ount N left in the residue      82.47    (lb/ac)                        ¤
¤                                                                            ¤
¤          Inorganic N leached         .01    (lb/ac)                        ¤
¤                                                                            ¤
¤ Net immobil(-)/mineralizat(+)     -62.77    (lb/ac)                        ¤
¤                                                                            ¤
¤              Denitrification       14.75    (lb/ac)                        ¤
¤                                                                            ¤
¤          Top mass @ 15.5 H2O    10869.75    (lb/ac)                        ¤
¤                                                                            ¤
¤      Moisture deficit in crop        .00    (inches)                       ¤
¤                                                                            ¤
¤      Nitrogen deficit in crop      58.45    (lb/ac)                        ¤
¤                                                                            ¤
¤  Organic Nitrogen pool CHANGE     491.64    (lb/ac)                        ¤
¤                                                                            ¤
¤         Inorganic N in profile     54.21    (lb/ac)                        ¤
¤                                                                            ¤
¤                  Ok   É        Quit  É                                     ¤
¤                ÓÓÓÓÓÓÓÓ      ÓÓÓÓÓÓÓÓ                                      ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¾
 Alt-X Exit
```

```
Menu
Simulation
Name  Farmer Tom    Field  South 40                           Rainfall
                                         N Form               ( ) Dry
                    C:N Ratio            ( ) Ammon. Nitrate   () Average
Crop                ( ) Grass  -  20:1   ( ) Urea             ( ) Wet
() Corn             () Leaves -  40:1    ( ) Liquid Nitrogen
( ) Future          ( ) Leaves -  70:1   () Anhydrous Ammon   Air-temp
( ) Future          ( ) Wood   - 150:1   ( ) Ammon. Sulfate   ( ) Hot
                                                              () Average
Plant on  APR 28    Apply on  APR 2      Apply on    MAY 30   ( ) Cold

SeedRate   30700    Rate Ton/Ac  20      NRate (lb/ac) 200    Soil Type
                                                              ( ) Sand
Harvest   OCT 12    Incorporation        Apply Method         () Loam
                    () None              ( ) Surface          ( ) Clay
                    ( ) Shallow [0-6"]   () Shallow [0-6"]
                    ( ) Deep [0-12"]     ( ) Deep [0-12"]     % total N   99

                                                              N init ppm 99

                                  Ok
Alt-X Exit
```

NO INCORPORATION

```
Menu
0
  ount N left in the residue     51.75    (lb/ac)

           Inorganic N leached     .00    (lb/ac)

Net immobil(-)/mineralizat(+)   -17.80    (lb/ac)

                Denitrification   4.16    (lb/ac)

         Top mass @ 15.5 H2O  15210.15    (lb/ac)

       Moisture deficit in crop    .00    (inches)

       Nitrogen deficit in crop    .32    (lb/ac)

  Organic Nitrogen pool CHANGE  295.36    (lb/ac)

         Inorganic N in profile  51.65    (lb/ac)

               Ok          Quit
Alt-X Exit
```

```
Menu
Simulation
Name  Farmer Tom    Field  South 40                           Rainfall
                                         N Form               ( ) Dry
                    C:N Ratio            ( ) Ammon. Nitrate   () Average
Crop                ( ) Grass  -  20:1   ( ) Urea             ( ) Wet
() Corn             () Leaves -  40:1    ( ) Liquid Nitrogen
( ) Future          ( ) Leaves -  70:1   () Anhydrous Ammon   Air-temp
( ) Future          ( ) Wood   - 150:1   ( ) Ammon. Sulfate   ( ) Hot
                                                              () Average
Plant on  APR 28    Apply on  APR 2      Apply on    MAY 30   ( ) Cold

SeedRate   30700    Rate Ton/Ac  20      NRate (lb/ac) 200    Soil Type
                                                              ( ) Sand
Harvest   OCT 12    Incorporation        Apply Method         () Loam
                    ( ) None             ( ) Surface          ( ) Clay
                    () Shallow [0-6"]    () Shallow [0-6"]
                    ( ) Deep [0-12"]     ( ) Deep [0-12"]     % total N   99

                                                              N init ppm 99

                                  Ok
Alt-X Exit
```

SHALLOW INCORPORATION

```
Menu
0
   unt N left in the residue     43.22    (lb/ac)

           Inorganic N leached     .00    (lb/ac)

Net immobil(-)/mineralizat(+)   -39.73    (lb/ac)

                Denitrification  12.87    (lb/ac)

         Top mass @ 15.5 H2O  13715.32    (lb/ac)

       Moisture deficit in crop    .00    (inches)

       Nitrogen deficit in crop  27.72    (lb/ac)

  Organic Nitrogen pool CHANGE  324.63    (lb/ac)

         Inorganic N in profile  48.40    (lb/ac)

               Ok          Quit
Alt-X Exit
```

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                       Rainfall         ¤
¤                                      N Form              ( ) Dry          ¤
¤                     C:N Ratio        ( ) Ammon. Nitrate  () Average       ¤
¤ Crop                ( ) Grass  -  20:1  () Urea          ( ) Wet          ¤
¤ () Corn             () Leaves -  40:1  ( ) Liquid Nitrogen                ¤
¤ ( ) Future          ( ) Leaves -  70:1  ( ) Anhydrous Ammon  Air-temp     ¤
¤ ( ) Future          ( ) Wood   - 150:1  ( ) Ammon. Sulfate   ( ) Hot      ¤
¤                                                           () Average      ¤
¤ Plant on  APR 28    Apply on  APR 2     Apply on   MAY 30  ( ) Cold       ¤
¤                                                                           ¤
¤ SeedRate    30700   Rate Ton/Ac  20     NRate (lb/ac) 200  Soil Type      ¤
¤                                                            ( ) Sand       ¤
¤ Harvest   OCT 12    Incorporation       Apply Method       () Loam        ¤
¤                     ( ) None            ( ) Surface        ( ) Clay       ¤
¤                     ( ) Shallow [0-6"]  () Shallow [0-6"]                 ¤
¤                     () Deep [0-12"]   ( ) Deep [0-12"]   % total N   99   ¤
¤                                                                           ¤
¤                                                           N init ppm 99   ¤
¤                                                                           ¤
¤                                                                           ¤
¤                                                                           ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë    Ok    Éëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

CHANGE N FORM

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                           ¤
¤     unt N left in the residue     49.75    (lb/ac)                        ¤
¤                                                                           ¤
¤           Inorganic N leached       .01    (lb/ac)                        ¤
¤                                                                           ¤
¤ Net immobil(-)/mineralizat(+)    -43.71    (lb/ac)                        ¤
¤                                                                           ¤
¤               Denitrification     13.25    (lb/ac)                        ¤
¤                                                                           ¤
¤           Top mass @ 15.5 H20  13776.67    (lb/ac)                        ¤
¤                                                                           ¤
¤      Moisture deficit in crop       .00    (inches)                       ¤
¤                                                                           ¤
¤      Nitrogen deficit in crop     27.89    (lb/ac)                        ¤
¤                                                                           ¤
¤  Organic Nitrogen pool CHANGE    330.85    (lb/ac)                        ¤
¤                                                                           ¤
¤          Inorganic N in profile   44.20    (lb/ac)                        ¤
¤                                                                           ¤
¤                Ok    É         Quit  É                                    ¤
¤               000000000        00000000                                   ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¼
 Alt-X Exit
```

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                       Rainfall         ¤
¤                                      N Form              ( ) Dry          ¤
¤                     C:N Ratio        ( ) Ammon. Nitrate  () Average       ¤
¤ Crop                ( ) Grass  -  20:1  ( ) Urea         ( ) Wet          ¤
¤ () Corn             () Leaves -  40:1  ( ) Liquid Nitrogen                ¤
¤ ( ) Future          ( ) Leaves -  70:1  () Anhydrous Ammon  Air-temp      ¤
¤ ( ) Future          ( ) Wood   - 150:1  ( ) Ammon. Sulfate   ( ) Hot      ¤
¤                                                           () Average      ¤
¤ Plant on  APR 28    Apply on  APR 2     [redacted]       ( ) Cold         ¤
¤                                                                           ¤
¤ SeedRate    30700   Rate Ton/Ac  20     NRate (lb/ac) 200  Soil Type      ¤
¤                                                            ( ) Sand       ¤
¤ Harvest   OCT 12    Incorporation       Apply Method       () Loam        ¤
¤                     ( ) None            ( ) Surface        ( ) Clay       ¤
¤                     ( ) Shallow [0-6"]  () Shallow [0-6"]                 ¤
¤                     () Deep [0-12"]   ( ) Deep [0-12"]   % total N   99   ¤
¤                                                                           ¤
¤                                                           N init ppm 99   ¤
¤                                                                           ¤
¤                                                                           ¤
¤                                                                           ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë    Ok    Éëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

Apply N SOONER

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                           ¤
¤     ount N left in the residue    46.92    (lb/ac)                        ¤
¤                                                                           ¤
¤           Inorganic N leached       .01    (lb/ac)                        ¤
¤                                                                           ¤
¤ Net immobil(-)/mineralizat(+)    -46.56    (lb/ac)                        ¤
¤                                                                           ¤
¤               Denitrification     12.93    (lb/ac)                        ¤
¤                                                                           ¤
¤           Top mass @ 15.5 H20  12390.05    (lb/ac)                        ¤
¤                                                                           ¤
¤      Moisture deficit in crop       .00    (inches)                       ¤
¤                                                                           ¤
¤      Nitrogen deficit in crop     39.27    (lb/ac)                        ¤
¤                                                                           ¤
¤  Organic Nitrogen pool CHANGE    335.43    (lb/ac)                        ¤
¤                                                                           ¤
¤          Inorganic N in profile   53.06    (lb/ac)                        ¤
¤                                                                           ¤
¤                Ok    É         Quit  É                                    ¤
¤               00000000         00000000                                   ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¼
 Alt-X Exit
```

```
  Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                    Rainfall          ¤
¤                                       N Form           ( ) Dry           ¤
¤                    C:N Ratio          ( ) Ammon. Nitrate  () Average     ¤
¤ Crop               ( ) Grass  -  20:1 ( ) Urea         ( ) Wet           ¤
¤ () Corn            () Leaves -  40:1 ( ) Liquid Nitrogen                 ¤
¤ ( ) Future         ( ) Leaves -  70:1 () Anhydrous Ammon  Air-temp       ¤
¤ ( ) Future         ( ) Wood   - 150:1 ( ) Ammon. Sulfate  ( ) Hot        ¤
¤                                                        () Average        ¤
¤ Plant on  APR 28   Apply on  APR 2    Apply on   JUN 15  ( ) Cold        ¤
¤                                                                          ¤
¤ SeedRate   30700   Rate Ton/Ac  20    NRate (lb/ac) 200   Soil Type      ¤
¤                                                        ( ) Sand          ¤
¤ Harvest   OCT 12   Incorporation      Apply Method     () Loam           ¤
¤                    ( ) None           ( ) Surface      ( ) Clay          ¤
¤                    ( ) Shallow [0-6"] () Shallow [0-6"]                  ¤
¤                    () Deep [0-12"]   ( ) Deep [0-12"]  % total N   99    ¤
¤                                                                          ¤
¤                                                        N init ppm 99     ¤
¤                                                                          ¤
¤                                                                          ¤
¤                                                                          ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë   Ok   Éëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

Apply N later

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                 ¤
¤      ount N left in the residue    42.46    (lb/ac)             ¤
¤                                                                 ¤
¤           Inorganic N leached        .01    (lb/ac)             ¤
¤                                                                 ¤
¤ Net immobil(-)/mineralizat(+)     -36.19    (lb/ac)             ¤
¤                                                                 ¤
¤                Denitrification     18.73    (lb/ac)             ¤
¤                                                                 ¤
¤           Top mass @ 15.5 H2O   13034.55    (lb/ac)             ¤
¤                                                                 ¤
¤        Moisture deficit in crop      .00    (inches)            ¤
¤                                                                 ¤
¤        Nitrogen deficit in crop    34.19    (lb/ac)             ¤
¤                                                                 ¤
¤   Organic Nitrogen pool CHANGE    326.46    (lb/ac)             ¤
¤                                                                 ¤
¤          Inorganic N in profile    52.55    (lb/ac)             ¤
¤                                                                 ¤
¤                  Ok   É        Quit  É                          ¤
¤               ôôôôôôôô        ôôôôôôôô                          ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¥
Alt-X Exit
```

```
  Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                    Rainfall          ¤
¤                                       N Form           ( ) Dry           ¤
¤                    C:N Ratio          ( ) Ammon. Nitrate  () Average     ¤
¤ Crop               ( ) Grass  -  20:1 ( ) Urea         ( ) Wet           ¤
¤ () Corn            () Leaves -  40:1 ( ) Liquid Nitrogen                 ¤
¤ ( ) Future         ( ) Leaves -  70:1 () Anhydrous Ammon  Air-temp       ¤
¤ ( ) Future         ( ) Wood   - 150:1 ( ) Ammon. Sulfate  ( ) Hot        ¤
¤                                                        () Average        ¤
¤ Plant on  APR 28   Apply on  APR 2    Apply on   MAY 30  ( ) Cold        ¤
¤                                                                          ¤
¤ SeedRate   30700   Rate Ton/Ac  20    NRate (lb/ac) 150   Soil Type      ¤
¤                                                        ( ) Sand          ¤
¤ Harvest   OCT 12   Incorporation      Apply Method     () Loam           ¤
¤                    ( ) None           ( ) Surface      ( ) Clay          ¤
¤                    ( ) Shallow [0-6"] () Shallow [0-6"]                  ¤
¤                    () Deep [0-12"]   ( ) Deep [0-12"]  % total N   99    ¤
¤                                                                          ¤
¤                                                        N init ppm 99     ¤
¤                                                                          ¤
¤                                                                          ¤
¤                                                                          ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë   Ok   Éëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

DECREASE N AMT.

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                 ¤
¤      ount N left in the residue    53.52    (lb/ac)             ¤
¤                                                                 ¤
¤           Inorganic N leached        .01    (lb/ac)             ¤
¤                                                                 ¤
¤ Net immobil(-)/mineralizat(+)     -38.28    (lb/ac)             ¤
¤                                                                 ¤
¤                Denitrification     10.34    (lb/ac)             ¤
¤                                                                 ¤
¤           Top mass @ 15.5 H2O   10415.39    (lb/ac)             ¤
¤                                                                 ¤
¤        Moisture deficit in crop      .00    (inches)            ¤
¤                                                                 ¤
¤        Nitrogen deficit in crop    65.41    (lb/ac)             ¤
¤                                                                 ¤
¤   Organic Nitrogen pool CHANGE    324.54    (lb/ac)             ¤
¤                                                                 ¤
¤          Inorganic N in profile    40.08    (lb/ac)             ¤
¤                                                                 ¤
¤                  Ok   É        Quit  É                          ¤
¤               ôôôôôôôô        ôôôôôôôô                          ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¥
Alt-X Exit
```

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                          Rainfall          ¤
¤                                      N Form                 ( ) Dry           ¤
¤                    C:N Ratio         ( ) Ammon. Nitrate     () Average        ¤
¤ Crop               ( ) Grass  -  20:1  ( ) Urea             ( ) Wet           ¤
¤ () Corn            () Leaves -  40:1  ( ) Liquid Nitrogen                    ¤
¤ ( ) Future         ( ) Leaves -  70:1  () Anhydrous Ammon  Air-temp          ¤
¤ ( ) Future         ( ) Wood   - 150:1  ( ) Ammon. Sulfate   ( ) Hot           ¤
¤                                                             () Average        ¤
¤ Plant on  APR 28   Apply on  APR 2   Apply on    MAY 30     ( ) Cold          ¤
¤                                                                               ¤
¤ SeedRate   30700   Rate Ton/Ac  20   NRate (lb/ac) 250      Soil Type         ¤
¤                                                             ( ) Sand          ¤
¤ Harvest    OCT 12  Incorporation     Apply Method           () Loam           ¤
¤                    ( ) None          ( ) Surface            ( ) Clay          ¤
¤                    ( ) Shallow [0-6"]  () Shallow [0-6"]                      ¤
¤                    () Deep [0-12"]   ( ) Deep [0-12"]       % total N   99    ¤
¤                                                                               ¤
¤                                                             N init ppm 99     ¤
¤                                                                               ¤
¤                                                                               ¤
¤                                                                               ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë    Ok    Éëëëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

INCREASE N AMT.

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                               ¤
¤    ount N left in the residue      42.19    (lb/ac)                           ¤
¤                                                                               ¤
¤           Inorganic N leached        .06    (lb/ac)                           ¤
¤                                                                               ¤
¤  Net immobil(-)/mineralizat(+)    -46.31    (lb/ac)                           ¤
¤                                                                               ¤
¤               Denitrification      16.17    (lb/ac)                           ¤
¤                                                                               ¤
¤           Top mass @ 15.5 H20   15218.43    (lb/ac)                           ¤
¤                                                                               ¤
¤      Moisture deficit in crop        .00    (inches)                          ¤
¤                                                                               ¤
¤      Nitrogen deficit in crop        .24    (lb/ac)                           ¤
¤                                                                               ¤
¤   Organic Nitrogen pool CHANGE    336.70    (lb/ac)                           ¤
¤                                                                               ¤
¤         Inorganic N in profile     61.00    (lb/ac)                           ¤
¤                                                                               ¤
¤                  Ok   É        Quit  É                                        ¤
¤               ÕÕÕÕÕÕÕÕ       ÕÕÕÕÕÕÕÕ                                         ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¼
 Alt-X Exit
```

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                          Rainfall          ¤
¤                                      N Form                 ( ) Dry           ¤
¤                    C:N Ratio         ( ) Ammon. Nitrate     () Average        ¤
¤ Crop               ( ) Grass  -  20:1  ( ) Urea             ( ) Wet           ¤
¤ () Corn            () Leaves -  40:1  ( ) Liquid Nitrogen                    ¤
¤ ( ) Future         ( ) Leaves -  70:1  () Anhydrous Ammon  Air-temp          ¤
¤ ( ) Future         ( ) Wood   - 150:1  ( ) Ammon. Sulfate   ( ) Hot           ¤
¤                                                             () Average        ¤
¤ Plant on  APR 28   Apply on  APR 2   Apply on    MAY 30     ( ) Cold          ¤
¤                                                                               ¤
¤ SeedRate   30700   Rate Ton/Ac  20   NRate (lb/ac) 200      Soil Type         ¤
¤                                                             ( ) Sand          ¤
¤ Harvest    OCT 12  Incorporation     Apply Method           () Loam           ¤
¤                    ( ) None          () Surface             ( ) Clay          ¤
¤                    ( ) Shallow [0-6"]  ( ) Shallow [0-6"]                     ¤
¤                    () Deep [0-12"]   ( ) Deep [0-12"]       % total N   99    ¤
¤                                                                               ¤
¤                                                             N init ppm 99     ¤
¤                                                                               ¤
¤                                                                               ¤
¤                                                                               ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë    Ok    Éëëëëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

SURFACE APPLY N

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                               ¤
¤    ount N left in the residue      45.01    (lb/ac)                           ¤
¤                                                                               ¤
¤           Inorganic N leached        .01    (lb/ac)                           ¤
¤                                                                               ¤
¤  Net immobil(-)/mineralizat(+)    -39.19    (lb/ac)                           ¤
¤                                                                               ¤
¤               Denitrification      24.86    (lb/ac)                           ¤
¤                                                                               ¤
¤           Top mass @ 15.5 H20   12306.93    (lb/ac)                           ¤
¤                                                                               ¤
¤      Moisture deficit in crop        .00    (inches)                          ¤
¤                                                                               ¤
¤      Nitrogen deficit in crop      42.06    (lb/ac)                           ¤
¤                                                                               ¤
¤   Organic Nitrogen pool CHANGE    329.60    (lb/ac)                           ¤
¤                                                                               ¤
¤         Inorganic N in profile     51.30    (lb/ac)                           ¤
¤                                                                               ¤
¤                  Ok   É        Quit  É                                        ¤
¤               ÕÕÕÕÕÕÕÕ       ÕÕÕÕÕÕÕÕ                                         ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¼
 Alt-X Exit
```

```
 Menu
èè[±]êêêêêêêêêêêêêêêêêêêêêêêêêêêê Simulation êêêêêêêêêêêêêêêêêêêêêêêêêêêêêêê£
¤ Name  Farmer Tom   Field  South 40                     Rainfall         ¤
¤                                       N Form            ( ) Dry          ¤
¤                    C:N Ratio          ( ) Ammon. Nitrate  () Average    ¤
¤ Crop               ( ) Grass  -  20:1  ( ) Urea          ( ) Wet        ¤
¤ () Corn            () Leaves -  40:1  ( ) Liquid Nitrogen              ¤
¤ ( ) Future         ( ) Leaves -  70:1  () Anhydrous Ammon  Air-temp     ¤
¤ ( ) Future         ( ) Wood   - 150:1  ( ) Ammon. Sulfate  ( ) Hot      ¤
¤                                                          () Average     ¤
¤ Plant on  APR 28   Apply on  APR 2    Apply on    MAY 30  ( ) Cold      ¤
¤                                                                          ¤
¤ SeedRate   30700   Rate Ton/Ac  20    NRate (lb/ac) 200   Soil Type     ¤
¤                                                          ( ) Sand       ¤
¤ Harvest   OCT 12   Incorporation      Apply Method       () Loam        ¤
¤                    ( ) None           ( ) Surface        ( ) Clay       ¤
¤                    ( ) Shallow [0-6"]  ( ) Shallow [0-6"]                ¤
¤                    () Deep [0-12"]    () Deep [0-12"]   % total N   99  ¤
¤                                                                          ¤
¤                                                          N init ppm 99   ¤
¤                                                                          ¤
¤                                                                          ¤
¤                                                                          ¤
àêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêê    Ok    Éêêêêêêêêêêêêêêêêêêêêêêê¥
 Alt-X Exit
```

DEEP Apply N

```
 Menu
èè[±]êêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêê 0 êêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêê[]è£
¤                                                                          ¤
¤    ount N left in the residue      50.10     (lb/ac)                     ¤
¤                                                                          ¤
¤            Inorganic N leached       .01     (lb/ac)                     ¤
¤                                                                          ¤
¤  Net immobil(-)/mineralizat(+)    -42.87     (lb/ac)                     ¤
¤                                                                          ¤
¤                Denitrification      8.41     (lb/ac)                     ¤
¤                                                                          ¤
¤          Top mass @ 15.5 H20    14423.56     (lb/ac)                     ¤
¤                                                                          ¤
¤       Moisture deficit in crop       .00     (inches)                    ¤
¤                                                                          ¤
¤       Nitrogen deficit in crop     20.81     (lb/ac)                     ¤
¤                                                                          ¤
¤   Organic Nitrogen pool CHANGE    331.34     (lb/ac)                     ¤
¤                                                                          ¤
¤          Inorganic N in profile    42.80     (lb/ac)                     ¤
¤                                                                          ¤
¤                 Ok   É        Quit  É                                    ¤
¤               ôôôôôôôô      ôôôôôôôô                                     ¤
àêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêê¶\
 Alt-X Exit
```

```
 Menu
èè[±]êêêêêêêêêêêêêêêêêêêêêêêêêêêê Simulation êêêêêêêêêêêêêêêêêêêêêêêêêêêêêêê£
¤ Name  Farmer Tom   Field  South 40                     Rainfall         ¤
¤                                       N Form            () Dry           ¤
¤                    C:N Ratio          ( ) Ammon. Nitrate  ( ) Average   ¤
¤ Crop               ( ) Grass  -  20:1  ( ) Urea          ( ) Wet        ¤
¤ () Corn            () Leaves -  40:1  ( ) Liquid Nitrogen              ¤
¤ ( ) Future         ( ) Leaves -  70:1  () Anhydrous Ammon  Air-temp     ¤
¤ ( ) Future         ( ) Wood   - 150:1  ( ) Ammon. Sulfate  ( ) Hot      ¤
¤                                                          () Average     ¤
¤ Plant on  APR 28   Apply on  APR 2    Apply on    MAY 30  ( ) Cold      ¤
¤                                                                          ¤
¤ SeedRate   30700   Rate Ton/Ac  20    NRate (lb/ac) 200   Soil Type     ¤
¤                                                          ( ) Sand       ¤
¤ Harvest   OCT 12   Incorporation      Apply Method       () Loam        ¤
¤                    ( ) None           ( ) Surface        ( ) Clay       ¤
¤                    ( ) Shallow [0-6"]  ( ) Shallow [0-6"]                ¤
¤                    () Deep [0-12"]    () Deep [0-12"]   % total N   99  ¤
¤                                                                          ¤
¤                                                          N init ppm 99   ¤
¤                                                                          ¤
¤                                                                          ¤
¤                                                                          ¤
àêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêê    Ok    Éêêêêêêêêêêêêêêêêêêêêêêê¥
 Alt-X Exit
```

DRY YEAR - RAINFALL

```
 Menu
èè[±]êêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêê 0 êêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêê[]è£
¤                                                                          ¤
¤    ount N left in the residue     405.47     (lb/ac)                     ¤
¤                                                                          ¤
¤            Inorganic N leached       .00     (lb/ac)                     ¤
¤                                                                          ¤
¤  Net immobil(-)/mineralizat(+)   -147.33     (lb/ac)                     ¤
¤                                                                          ¤
¤                Denitrification      3.15     (lb/ac)                     ¤
¤                                                                          ¤
¤          Top mass @ 15.5 H20     6352.76     (lb/ac)                     ¤
¤                                                                          ¤
¤       Moisture deficit in crop     37.32     (inches)                    ¤
¤                                                                          ¤
¤       Nitrogen deficit in crop    111.87     (lb/ac)                     ¤
¤                                                                          ¤
¤   Organic Nitrogen pool CHANGE    326.63     (lb/ac)                     ¤
¤                                                                          ¤
¤          Inorganic N in profile    34.68     (lb/ac)                     ¤
¤                                                                          ¤
¤                 Ok   É        Quit  É                                    ¤
¤               ôôôôôôôô      ôôôôôôôô                                     ¤
àêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêêê¶\
 Alt-X Exit
```

```
 Menu
èé[±]éééééééééééééééééééééééééé Simulation éééééééééééééééééééééééééééééé£
¤ Name  Farmer Tom   Field  South 40                     Rainfall        ¤
¤                                   N Form               ( ) Dry         ¤
¤                    C:N Ratio      ( ) Ammon. Nitrate   ( ) Average     ¤
¤ Crop               ( ) Grass  -  20:1  ( ) Urea        () Wet          ¤
¤ () Corn            () Leaves -  40:1  ( ) Liquid Nitrogen              ¤
¤ ( ) Future         ( ) Leaves -  70:1  () Anhydrous Ammon  Air-temp    ¤
¤ ( ) Future         ( ) Wood   - 150:1  ( ) Ammon. Sulfate  ( ) Hot     ¤
¤                                                        () Average      ¤
¤ Plant on  APR 28   Apply on  APR 2   Apply on   MAY 30  ( ) Cold       ¤
¤                                                                        ¤
¤ SeedRate   30700   Rate Ton/Ac  20   NRate (lb/ac) 200  Soil Type      ¤
¤                                                        ( ) Sand        ¤
¤ Harvest   OCT 12   Incorporation     Apply Method      () Loam         ¤
¤                    ( ) None          ( ) Surface       ( ) Clay        ¤
¤                    ( ) Shallow [0-6"]  ( ) Shallow [0-6"]              ¤
¤                    () Deep [0-12"]   () Deep [0-12"]   % total N   99  ¤
¤                                                                        ¤
¤                                                        N init ppm 99   ¤
¤                                                                        ¤
¤                                                                        ¤
¤                                                                        ¤
àéééééééééééééééééééééééééééééééééééééééé    Ok    Éééééééééééééééééééééééé¥
 Alt-X Exit
```

WET YEAR - RAINFALL

```
 Menu
èé[±]éééééééééééééééééééééééééééééééé 0 éééééééééééééééééééééééééééééééé[]é£
¤                                                                        ¤
¤  ...unt N left in the residue     37.57    (lb/ac)                     ¤
¤                                                                        ¤
¤          Inorganic N leached      28.40    (lb/ac)                     ¤
¤                                                                        ¤
¤  Net immobil(-)/mineralizat(+)   -34.03    (lb/ac)                     ¤
¤                                                                        ¤
¤              Denitrification      14.57    (lb/ac)                     ¤
¤                                                                        ¤
¤          Top mass @ 15.5 H20   11106.25    (lb/ac)                     ¤
¤                                                                        ¤
¤      Moisture deficit in crop       .00    (inches)                    ¤
¤                                                                        ¤
¤      Nitrogen deficit in crop     58.42    (lb/ac)                     ¤
¤                                                                        ¤
¤  Organic Nitrogen pool CHANGE    324.71    (lb/ac)                     ¤
¤                                                                        ¤
¤         Inorganic N in profile    54.71    (lb/ac)                     ¤
¤                                                                        ¤
¤                 Ok   É        Quit  É                                  ¤
¤               ÒÒÒÒÒÒÒÒ      ÒÒÒÒÒÒÒÒ                                   ¤
àééééééééééééééééééééééééééééééééééééééééééééééééééééééééééééééééééééééé6)
 Alt-X Exit
```

```
 Menu
èé[±]éééééééééééééééééééééééééé Simulation éééééééééééééééééééééééééééééé£
¤ Name  Farmer Tom   Field  South 40                     Rainfall        ¤
¤                                   N Form               ( ) Dry         ¤
¤                    C:N Ratio      ( ) Ammon. Nitrate   () Average      ¤
¤ Crop               ( ) Grass  -  20:1  ( ) Urea        ( ) Wet         ¤
¤ () Corn            () Leaves -  40:1  ( ) Liquid Nitrogen              ¤
¤ ( ) Future         ( ) Leaves -  70:1  () Anhydrous Ammon  Air-temp    ¤
¤ ( ) Future         ( ) Wood   - 150:1  ( ) Ammon. Sulfate  () Hot      ¤
¤                                                        ( ) Average     ¤
¤ Plant on  APR 28   Apply on  APR 2   Apply on   MAY 30  ( ) Cold       ¤
¤                                                                        ¤
¤ SeedRate   30700   Rate Ton/Ac  20   NRate (lb/ac) 200  Soil Type      ¤
¤                                                        ( ) Sand        ¤
¤ Harvest   OCT 12   Incorporation     Apply Method      () Loam         ¤
¤                    ( ) None          ( ) Surface       ( ) Clay        ¤
¤                    ( ) Shallow [0-6"]  ( ) Shallow [0-6"]              ¤
¤                    () Deep [0-12"]   () Deep [0-12"]   % total N   99  ¤
¤                                                                        ¤
¤                                                        N init ppm 99   ¤
¤                                                                        ¤
¤                                                                        ¤
¤                                                                        ¤
àéééééééééééééééééééééééééééééééééééééééé    Ok    Éééééééééééééééééééééééé¥
 Alt-X Exit
```

HOT TEMP'S

```
 Menu
èé[±]éééééééééééééééééééééééééééééééé 0 éééééééééééééééééééééééééééééééé[]é£
¤                                                                        ¤
¤    ...unt N left in the residue   51.95    (lb/ac)                     ¤
¤                                                                        ¤
¤          Inorganic N leached        .00    (lb/ac)                     ¤
¤                                                                        ¤
¤  Net immobil(-)/mineralizat(+)   -44.35    (lb/ac)                     ¤
¤                                                                        ¤
¤              Denitrification       7.37    (lb/ac)                     ¤
¤                                                                        ¤
¤          Top mass @ 15.5 H20   15296.73    (lb/ac)                     ¤
¤                                                                        ¤
¤      Moisture deficit in crop       .00    (inches)                    ¤
¤                                                                        ¤
¤      Nitrogen deficit in crop     18.96    (lb/ac)                     ¤
¤                                                                        ¤
¤  Organic Nitrogen pool CHANGE    333.38    (lb/ac)                     ¤
¤                                                                        ¤
¤         Inorganic N in profile    40.53    (lb/ac)                     ¤
¤                                                                        ¤
¤                 Ok   É        Quit  É                                  ¤
¤               ÒÒÒÒÒÒÒÒ      ÒÒÒÒÒÒÒÒ                                   ¤
àééééééééééééééééééééééééééééééééééééééééééééééééééééééééééééééééééééééé6)
 Alt-X Exit
```

```
Menu
èè[±]èèèèèèèèèèèèèèèèèèèèèèèèèèèè Simulation èèèèèèèèèèèèèèèèèèèèèèèèèèèèèèè£
¤ Name  Farmer Tom   Field  South 40                           Rainfall        ¤
¤                                      N Form                  ( ) Dry         ¤
¤                    C:N Ratio         ( ) Ammon. Nitrate      () Average     ¤
¤ Crop               ( ) Grass  -  20:1 ( ) Urea               ( ) Wet         ¤
¤ () Corn            () Leaves -  40:1 ( ) Liquid Nitrogen                    ¤
¤ ( ) Future         ( ) Leaves -  70:1 () Anhydrous Ammon  Air-temp          ¤
¤ ( ) Future         ( ) Wood   - 150:1 ( ) Ammon. Sulfate  ( ) Hot            ¤
¤                                                            ( ) Average       ¤
¤ Plant on  APR 28   Apply on  APR 2    Apply on    MAY 30   () Cold          ¤
¤                                                                              ¤
¤ SeedRate    30700  Rate Ton/Ac  20    NRate (lb/ac) 200    Soil Type         ¤
¤                                                            ( ) Sand          ¤
¤ Harvest   OCT 12   Incorporation      Apply Method         () Loam          ¤
¤                    ( ) None           ( ) Surface          ( ) Clay          ¤
¤                    ( ) Shallow [0-6"] ( ) Shallow [0-6"]                     ¤
¤                    () Deep [0-12"]    () Deep [0-12"]    % total N    99    ¤
¤                                                                              ¤
¤                                                            N init ppm 99     ¤
¤                                                                              ¤
¤                                                                              ¤
¤                                                                              ¤
àèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèè    Ok    Éèèèèèèèèèèèèèèèèèèèèèèè¥
Alt-X Exit
```

Cold Temps

```
Menu
èè[±]èèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèè 0 èèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèè[]è£
¤                                                                              ¤
¤ \ ount N left in the residue     46.09    (lb/ac)                            ¤
¤                                                                              ¤
¤          Inorganic N leached       .81    (lb/ac)                            ¤
¤                                                                              ¤
¤  Net immobil(-)/mineralizat(+)   -43.67   (lb/ac)                            ¤
¤                                                                              ¤
¤              Denitrification      9.29    (lb/ac)                            ¤
¤                                                                              ¤
¤         Top mass @ 15.5 H2O  11558.70    (lb/ac)                            ¤
¤                                                                              ¤
¤         Moisture deficit in crop    .00    (inches)                          ¤
¤                                                                              ¤
¤         Nitrogen deficit in crop  39.74    (lb/ac)                           ¤
¤                                                                              ¤
¤  Organic Nitrogen pool CHANGE   331.74    (lb/ac)                            ¤
¤                                                                              ¤
¤          Inorganic N in profile   59.26    (lb/ac)                           ¤
¤                                                                              ¤
¤                 Ok   É        Quit  É                                        ¤
¤               ÒÒÒÒÒÒÒÒ      ÒÒÒÒÒÒÒÒ                                         ¤
àèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèè¼
Alt-X Exit
```

```
Menu
èè[±]èèèèèèèèèèèèèèèèèèèèèèèèèèèè Simulation èèèèèèèèèèèèèèèèèèèèèèèèèèèèèèè£
¤ Name  Farmer Tom   Field  South 40                           Rainfall        ¤
¤                                      N Form                  ( ) Dry         ¤
¤                    C:N Ratio         ( ) Ammon. Nitrate      () Average     ¤
¤ Crop               ( ) Grass  -  20:1 ( ) Urea               ( ) Wet         ¤
¤ () Corn            () Leaves -  40:1 ( ) Liquid Nitrogen                    ¤
¤ ( ) Future         ( ) Leaves -  70:1 () Anhydrous Ammon  Air-temp          ¤
¤ ( ) Future         ( ) Wood   - 150:1 ( ) Ammon. Sulfate  ( ) Hot            ¤
¤                                                            () Average       ¤
¤ Plant on  APR 28   Apply on  APR 2    Apply on    MAY 30   ( ) Cold          ¤
¤                                                                              ¤
¤ SeedRate    30700  Rate Ton/Ac  20    NRate (lb/ac) 200    Soil Type         ¤
¤                                                            () Sand          ¤
¤ Harvest   OCT 12   Incorporation      Apply Method         ( ) Loam          ¤
¤                    ( ) None           ( ) Surface          ( ) Clay          ¤
¤                    ( ) Shallow [0-6"] ( ) Shallow [0-6"]                     ¤
¤                    () Deep [0-12"]    () Deep [0-12"]    % total N    99    ¤
¤                                                                              ¤
¤                                                            N init ppm 99     ¤
¤                                                                              ¤
¤                                                                              ¤
¤                                                                              ¤
àèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèè    Ok    Éèèèèèèèèèèèèèèèèèèèèèèèè¥
Alt-X Exit
```

Sandy Soil

```
Menu
èè[±]èèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèè 0 èèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèè[]è£
¤                                                                              ¤
¤     unt N left in the residue    335.06    (lb/ac)                           ¤
¤                                                                              ¤
¤          Inorganic N leached     50.62    (lb/ac)                            ¤
¤                                                                              ¤
¤  Net immobil(-)/mineralizat(+)   -87.52   (lb/ac)                            ¤
¤                                                                              ¤
¤              Denitrification      1.44    (lb/ac)                            ¤
¤                                                                              ¤
¤         Top mass @ 15.5 H2O  12730.50    (lb/ac)                            ¤
¤                                                                              ¤
¤         Moisture deficit in crop  12.66    (inches)                          ¤
¤                                                                              ¤
¤         Nitrogen deficit in crop  41.17    (lb/ac)                           ¤
¤                                                                              ¤
¤  Organic Nitrogen pool CHANGE   284.71    (lb/ac)                            ¤
¤                                                                              ¤
¤          Inorganic N in profile    1.83    (lb/ac)                           ¤
¤                                                                              ¤
¤                 Ok   É        Quit  É                                        ¤
¤               ÒÒÒÒÒÒÒÒ      ÒÒÒÒÒÒÒÒ                                         ¤
àèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèèè¼
Alt-X Exit
```

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                          Rainfall       ¤
¤                                      N Form                 ( ) Dry        ¤
¤                    C:N Ratio         ( ) Ammon. Nitrate     () Average    ¤
¤ Crop               ( ) Grass  -  20:1 ( ) Urea              ( ) Wet        ¤
¤ () Corn           () Leaves -  40:1  ( ) Liquid Nitrogen                  ¤
¤ ( ) Future         ( ) Leaves -  70:1 () Anhydrous Ammon  Air-temp        ¤
¤ ( ) Future         ( ) Wood   - 150:1 ( ) Ammon. Sulfate    ( ) Hot        ¤
¤                                                             () Average    ¤
¤ Plant on  APR 28   Apply on  APR 2   Apply on    MAY 30     ( ) Cold       ¤
¤                                                                            ¤
¤ SeedRate   30700   Rate Ton/Ac  20   NRate (lb/ac) 200      Soil Type      ¤
¤                                                             ( ) Sand       ¤
¤ Harvest   OCT 12   Incorporation     Apply Method           ( ) Loam       ¤
¤                    ( ) None          ( ) Surface            () Clay       ¤
¤                    ( ) Shallow [0-6"] ( ) Shallow [0-6"]                   ¤
¤                    () Deep [0-12"]   () Deep [0-12"]     % total N   99   ¤
¤                                                                            ¤
¤                                                             N init ppm 99  ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë    Ok    Éëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

clay soil.

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                            ¤
¤      unt N left in the residue     27.28    (lb/ac)                        ¤
¤                                                                            ¤
¤            Inorganic N leached      1.83    (lb/ac)                        ¤
¤                                                                            ¤
¤  Net immobil(-)/mineralizat(+)    -21.68    (lb/ac)                        ¤
¤                                                                            ¤
¤                 Denitrification     11.85    (lb/ac)                        ¤
¤                                                                            ¤
¤            Top mass @ 15.5 H2O  13484.02    (lb/ac)                        ¤
¤                                                                            ¤
¤         Moisture deficit in crop       .00    (inches)                     ¤
¤                                                                            ¤
¤         Nitrogen deficit in crop     22.15    (lb/ac)                      ¤
¤                                                                            ¤
¤   Organic Nitrogen pool CHANGE    312.80    (lb/ac)                        ¤
¤                                                                            ¤
¤          Inorganic N in profile     77.41    (lb/ac)                        ¤
¤                                                                            ¤
¤                  Ok    É         Quit  É                                   ¤
¤                ÕÕÕÕÕÕÕÕ        ÕÕÕÕÕÕÕÕ                                    ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëá)
 Alt-X Exit
```

Section 6. Becker simulations and trial results.

This section contains the results for the eight treatments of residue and nitrogen used at Becker. The table below shows that the model fails to accurately predict the trial results.

Yield results and model estimates

Treatments		Corn Yield		
Residue (tons)	Nitrogen (lbs/acre)	Becker (lbs/acre)	Model	
0	0	6704	6715	
20	0	8165	5494	
40	0	10147	5494	
80	0	10856	5494	
0	200	15237	15233	
20	200	16358	13777	(baseline)
40	200	16491	8850	
80	200	16444	6758	

Among the reasons for this prediction failure may be:

-- the model does not begin soon enough; the residue was actually applied in the fall, not in the spring as the model assumes. This may be particularly significant, since the residue was almost immediately covered with a 30 inch blanket of insulating snow.

-- a single C:N ratio may not accurately reflect the amount of (labile) nitrogen available to the plant. With the tremendous amounts of residue applied, it is reasonable to assume a good deal more N was immediately available than the model is currently allowing with a single C:N ratio.

-- while the impact may not be significant, the model has no mechanism for seeds that fail to germinate. Consequently, the model kept the initial planting population of 30,700, while the field results showed final populations ranging from 26,463 to 28,859.

* Becker results are estimated from data in the report, "Land Spreading of Yard Waste", by Carl Rosen, Thomas Halbach, Jean Molina, Dave Birong, Jennifer Weiszel.

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                       Rainfall          ¤
¤                                       N Form             ( ) Dry           ¤
¤                    C:N Ratio          ( ) Ammon. Nitrate () Average        ¤
¤ Crop               ( ) Grass  -  20:1 ( ) Urea           ( ) Wet           ¤
¤ () Corn            () Leaves -  40:1  ( ) Liquid Nitrogen                  ¤
¤ ( ) Future         ( ) Leaves -  70:1 () Anhydrous Ammon Air-temp          ¤
¤ ( ) Future         ( ) Wood   - 150:1 ( ) Ammon. Sulfate ( ) Hot           ¤
¤                                                          () Average        ¤
¤ Plant on  APR 28   Apply on  APR 2    Apply on   MAY 30  ( ) Cold          ¤
¤                                                                            ¤
¤ SeedRate   30700   [illegible] Tons/Ac  0   NRate (lb/ac) 0   Soil Type    ¤
¤                                                          ( ) Sand          ¤
¤ Harvest   OCT 12   Incorporation      Apply Method       () Loam           ¤
¤                    ( ) None           ( ) Surface        ( ) Clay          ¤
¤                    ( ) Shallow [0-6"] () Shallow [0-6"]                    ¤
¤                    () Deep [0-12"]    ( ) Deep [0-12"]   % total N   99    ¤
¤                                                                            ¤
¤                                                          N init ppm 99     ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë     Ok    Éëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                            ¤
¤ Amount N left in the residue      .08    (lb/ac)                           ¤
¤                                                                            ¤
¤          Inorganic N leached      .00    (lb/ac)                           ¤
¤                                                                            ¤
¤ Net immobil(-)/mineralizat(+)    26.06    (lb/ac)                          ¤
¤                                                                            ¤
¤               Denitrification      .86    (lb/ac)                          ¤
¤                                                                            ¤
¤          Top mass @ 15.5 H20   6715.66    (lb/ac)                          ¤
¤                                                                            ¤
¤      Moisture deficit in crop      .00    (inches)                         ¤
¤                                                                            ¤
¤      Nitrogen deficit in crop   108.50    (lb/ac)                          ¤
¤                                                                            ¤
¤  Organic Nitrogen pool CHANGE   -23.87    (lb/ac)                          ¤
¤                                                                            ¤
¤        Inorganic N in profile     6.98    (lb/ac)                          ¤
¤                                                                            ¤
¤                Ok   É       Quit  É                                        ¤
¤              ÔÔÔÔÔÔÔÔ      ÔÔÔÔÔÔÔÔ                                        ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¼
 Alt-X Exit
```

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                       Rainfall          ¤
¤                                       N Form             ( ) Dry           ¤
¤                    C:N Ratio          ( ) Ammon. Nitrate () Average        ¤
¤ Crop               ( ) Grass  -  20:1 ( ) Urea           ( ) Wet           ¤
¤ () Corn            () Leaves -  40:1  ( ) Liquid Nitrogen                  ¤
¤ ( ) Future         ( ) Leaves -  70:1 () Anhydrous Ammon Air-temp          ¤
¤ ( ) Future         ( ) Wood   - 150:1 ( ) Ammon. Sulfate ( ) Hot           ¤
¤                                                          () Average        ¤
¤ Plant on  APR 28   Apply on  APR 2    Apply on   MAY 30  ( ) Cold          ¤
¤                                                                            ¤
¤ SeedRate   30700   [illegible]                           Soil Type         ¤
¤                                                          ( ) Sand          ¤
¤ Harvest   OCT 12   Incorporation      Apply Method       () Loam           ¤
¤                    ( ) None           ( ) Surface        ( ) Clay          ¤
¤                    ( ) Shallow [0-6"] () Shallow [0-6"]                    ¤
¤                    () Deep [0-12"]    ( ) Deep [0-12"]   % total N   99    ¤
¤                                                                            ¤
¤                                                          N init ppm 99     ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë     Ok    Éëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                            ¤
¤   ount N left in the residue    78.12    (lb/ac)                           ¤
¤                                                                            ¤
¤          Inorganic N leached      .01    (lb/ac)                           ¤
¤                                                                            ¤
¤ Net immobil(-)/mineralizat(+)     8.56    (lb/ac)                          ¤
¤                                                                            ¤
¤               Denitrification      .72    (lb/ac)                          ¤
¤                                                                            ¤
¤          Top mass @ 15.5 H20   5493.81    (lb/ac)                          ¤
¤                                                                            ¤
¤      Moisture deficit in crop      .00    (inches)                         ¤
¤                                                                            ¤
¤      Nitrogen deficit in crop   132.13    (lb/ac)                          ¤
¤                                                                            ¤
¤  Organic Nitrogen pool CHANGE   272.52    (lb/ac)                          ¤
¤                                                                            ¤
¤        Inorganic N in profile    13.24    (lb/ac)                          ¤
¤                                                                            ¤
¤                Ok   É       Quit  É                                        ¤
¤              ÔÔÔÔÔÔÔÔ      ÔÔÔÔÔÔÔÔ                                        ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¼
 Alt-X Exit
```

```
 Menu
èè[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                         Rainfall        ¤
¤                                        N Form              ( ) Dry         ¤
¤                   C:N Ratio            ( ) Ammon. Nitrate  () Average      ¤
¤ Crop              ( ) Grass  -  20:1   ( ) Urea            ( ) Wet         ¤
¤ () Corn           () Leaves -  40:1  ( ) Liquid Nitrogen                   ¤
¤ ( ) Future        ( ) Leaves -  70:1   () Anhydrous Ammon  Air-temp        ¤
¤ ( ) Future        ( ) Wood   - 150:1   ( ) Ammon. Sulfate  ( ) Hot         ¤
¤                                                            () Average      ¤
¤ Plant on  APR 28  Apply on  APR 2      Apply on    MAY 30  ( ) Cold        ¤
¤                                                                            ¤
¤ SeedRate   30700  [redacted]                               Soil Type       ¤
¤                                                            ( ) Sand        ¤
¤ Harvest   OCT 12  Incorporation        Apply Method        () Loam         ¤
¤                   ( ) None             ( ) Surface         ( ) Clay        ¤
¤                   ( ) Shallow [0-6"]   () Shallow [0-6"]                   ¤
¤                   () Deep [0-12"]     ( ) Deep [0-12"]     % total N   99  ¤
¤                                                                            ¤
¤                                                            N init ppm 99   ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë    Ok    Éëëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

```
 Menu
èè[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                            ¤
¤  Amount N left in the residue     165.83    (lb/ac)                        ¤
¤                                                                            ¤
¤          Inorganic N leached         .01    (lb/ac)                        ¤
¤                                                                            ¤
¤ Net immobil(-)/mineralizat(+)      11.82    (lb/ac)                        ¤
¤                                                                            ¤
¤              Denitrification         .73    (lb/ac)                        ¤
¤                                                                            ¤
¤          Top mass @ 15.5 H20     5493.81    (lb/ac)                        ¤
¤                                                                            ¤
¤      Moisture deficit in crop        .00    (inches)                       ¤
¤                                                                            ¤
¤      Nitrogen deficit in crop     132.37    (lb/ac)                        ¤
¤                                                                            ¤
¤  Organic Nitrogen pool CHANGE     546.17    (lb/ac)                        ¤
¤                                                                            ¤
¤        Inorganic N in profile      16.74    (lb/ac)                        ¤
¤                                                                            ¤
¤                  Ok   É         Quit  É                                    ¤
¤                66666666        66666666                                    ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¹
 Alt-X Exit
```

```
 Menu
èè[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                         Rainfall        ¤
¤                                        N Form              ( ) Dry         ¤
¤                   C:N Ratio            ( ) Ammon. Nitrate  () Average      ¤
¤ Crop              ( ) Grass  -  20:1   ( ) Urea            ( ) Wet         ¤
¤ () Corn           () Leaves -  40:1  ( ) Liquid Nitrogen                   ¤
¤ ( ) Future        ( ) Leaves -  70:1   () Anhydrous Ammon  Air-temp        ¤
¤ ( ) Future        ( ) Wood   - 150:1   ( ) Ammon. Sulfate  ( ) Hot         ¤
¤                                                            () Average      ¤
¤ Plant on  APR 28  Apply on  APR 2      Apply on    MAY 30  ( ) Cold        ¤
¤                                                                            ¤
¤ SeedRate   30700  [redacted]                               Soil Type       ¤
¤                                                            ( ) Sand        ¤
¤ Harvest   OCT 12  Incorporation        Apply Method        () Loam         ¤
¤                   ( ) None             ( ) Surface         ( ) Clay        ¤
¤                   ( ) Shallow [0-6"]   () Shallow [0-6"]                   ¤
¤                   () Deep [0-12"]     ( ) Deep [0-12"]     % total N   99  ¤
¤                                                                            ¤
¤                                                            N init ppm 99   ¤
¤                                                                            ¤
¤                                                                            ¤
¤                                                                            ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë    Ok    Éëëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

```
 Menu
èè[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                            ¤
¤   Amount N left in the residue    342.50    (lb/ac)                        ¤
¤                                                                            ¤
¤          Inorganic N leached         .01    (lb/ac)                        ¤
¤                                                                            ¤
¤ Net immobil(-)/mineralizat(+)      19.43    (lb/ac)                        ¤
¤                                                                            ¤
¤              Denitrification         .91    (lb/ac)                        ¤
¤                                                                            ¤
¤          Top mass @ 15.5 H20     5493.81    (lb/ac)                        ¤
¤                                                                            ¤
¤      Moisture deficit in crop        .00    (inches)                       ¤
¤                                                                            ¤
¤      Nitrogen deficit in crop     132.47    (lb/ac)                        ¤
¤                                                                            ¤
¤  Organic Nitrogen pool CHANGE    1091.96    (lb/ac)                        ¤
¤                                                                            ¤
¤        Inorganic N in profile      24.26    (lb/ac)                        ¤
¤                                                                            ¤
¤                  Ok   É         Quit  É                                    ¤
¤                66666666        66666666                                    ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¹
 Alt-X Exit
```

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                              Rainfall      ¤
¤                                        N Form                   ( ) Dry       ¤
¤                     C:N Ratio          ( ) Ammon. Nitrate       () Average    ¤
¤ Crop                ( ) Grass  -  20:1 ( ) Urea                 ( ) Wet       ¤
¤ () Corn             () Leaves -  40:1  ( ) Liquid Nitrogen                    ¤
¤ ( ) Future          ( ) Leaves -  70:1 () Anhydrous Ammon       Air-temp      ¤
¤ ( ) Future          ( ) Wood   - 150:1 ( ) Ammon. Sulfate       ( ) Hot       ¤
¤                                                                 () Average    ¤
¤ Plant on  APR 28    Apply on  APR 2    Apply on    MAY 30       ( ) Cold      ¤
¤                                                                               ¤
¤ SeedRate   30700    Rate Ton/Ac  0     NRate (lb/ac) 200        Soil Type     ¤
¤                                                                 ( ) Sand      ¤
¤ Harvest   OCT 12    Incorporation      Apply Method             () Loam       ¤
¤                     ( ) None           ( ) Surface              ( ) Clay      ¤
¤                     ( ) Shallow [0-6"] () Shallow [0-6"]                      ¤
¤                     () Deep [0-12"]    ( ) Deep [0-12"]         % total N  99 ¤
¤                                                                               ¤
¤                                                                 N init ppm 99 ¤
¤                                                                               ¤
¤                                                                               ¤
¤                                                                               ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë    Ok    Éëëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                               ¤
¤   Amount N left in the residue        .19     (lb/ac)                         ¤
¤                                                                               ¤
¤            Inorganic N leached        .00     (lb/ac)                         ¤
¤                                                                               ¤
¤ Net immobil(-)/mineralizat(+)       26.26     (lb/ac)                         ¤
¤                                                                               ¤
¤                Denitrification        .94     (lb/ac)                         ¤
¤                                                                               ¤
¤          Top mass @ 15.5 H2O    15232.65     (lb/ac)                          ¤
¤                                                                               ¤
¤       Moisture deficit in crop        .00     (inches)                        ¤
¤                                                                               ¤
¤       Nitrogen deficit in crop        .00     (lb/ac)                         ¤
¤                                                                               ¤
¤  Organic Nitrogen pool CHANGE      -21.67     (lb/ac)                         ¤
¤                                                                               ¤
¤         Inorganic N in profile      98.61     (lb/ac)                         ¤
¤                                                                               ¤
¤                  Ok    É           Quit  É                                    ¤
¤                ÔÔÔÔÔÔÔÔ            ÔÔÔÔÔÔ                                     ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¾
 Alt-X Exit
```

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South 40                              Rainfall      ¤
¤                                        N Form                   ( ) Dry       ¤
¤                     C:N Ratio          ( ) Ammon. Nitrate       () Average    ¤
¤ Crop                ( ) Grass  -  20:1 ( ) Urea                 ( ) Wet       ¤
¤ () Corn             () Leaves -  40:1  ( ) Liquid Nitrogen                    ¤
¤ ( ) Future          ( ) Leaves -  70:1 () Anhydrous Ammon       Air-temp      ¤
¤ ( ) Future          ( ) Wood   - 150:1 ( ) Ammon. Sulfate       ( ) Hot       ¤
¤                                                                 () Average    ¤
¤ Plant on  APR 28    Apply on  APR 2    Apply on    MAY 30       ( ) Cold      ¤
¤                                                                               ¤
¤ SeedRate   30700    Rate Ton/Ac  20    NRate (lb/ac) 200        Soil Type     ¤
¤                                                                 ( ) Sand      ¤
¤ Harvest   OCT 12    Incorporation      Apply Method             () Loam       ¤
¤                     ( ) None           ( ) Surface              ( ) Clay      ¤
¤                     ( ) Shallow [0-6"] () Shallow [0-6"]                      ¤
¤                     () Deep [0-12"]    ( ) Deep [0-12"]         % total N  99 ¤
¤                                                                               ¤
¤                                                                 N init ppm 99 ¤
¤                                                                               ¤
¤                                                                               ¤
¤                                                                               ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë    Ok    Éëëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

BASELINE

```
 Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                               ¤
¤   Amount N left in the residue      49.75     (lb/ac)                         ¤
¤                                                                               ¤
¤            Inorganic N leached        .01     (lb/ac)                         ¤
¤                                                                               ¤
¤ Net immobil(-)/mineralizat(+)      -43.71     (lb/ac)                         ¤
¤                                                                               ¤
¤                Denitrification      13.25     (lb/ac)                         ¤
¤                                                                               ¤
¤          Top mass @ 15.5 H2O    13776.67     (lb/ac)                          ¤
¤                                                                               ¤
¤       Moisture deficit in crop        .00     (inches)                        ¤
¤                                                                               ¤
¤       Nitrogen deficit in crop      27.89     (lb/ac)                         ¤
¤                                                                               ¤
¤  Organic Nitrogen pool CHANGE      330.85     (lb/ac)                         ¤
¤                                                                               ¤
¤         Inorganic N in profile      44.20     (lb/ac)                         ¤
¤                                                                               ¤
¤                  Ok    É           Quit  É                                    ¤
¤                ÔÔÔÔÔÔÔÔ            ÔÔÔÔÔÔ                                     ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¾
 Alt-X Exit
```

```
  Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South [illegible]                  Rainfall        ¤
¤                                       N Form                ( ) Dry          ¤
¤                       C:N Ratio       ( ) Ammon. Nitrate    () Average       ¤
¤ Crop                  ( ) Grass  - 20:1  ( ) Urea           ( ) Wet          ¤
¤ () Corn               () Leaves - 40:1  ( ) Liquid Nitrogen                  ¤
¤ ( ) Future            ( ) Leaves - 70:1  () Anhydrous Ammon  Air-temp        ¤
¤ ( ) Future            ( ) Wood   - 150:1 ( ) Ammon. Sulfate  ( ) Hot         ¤
¤                                                             () Average       ¤
¤ Plant on  APR 28     Apply on  APR 2     Apply on    MAY 30  ( ) Cold        ¤
¤                                                                              ¤
¤ SeedRate   30700     Rate Ton/Ac  40     NRate (lb/ac) 200   Soil Type       ¤
¤                                                             ( ) Sand         ¤
¤ Harvest   OCT 12     Incorporation       Apply Method       () Loam          ¤
¤                      ( ) None            ( ) Surface        ( ) Clay         ¤
¤                      ( ) Shallow [0-6"]  () Shallow [0-6"]                   ¤
¤                      () Deep [0-12"]     ( ) Deep [0-12"]   % total N   99   ¤
¤                                                                              ¤
¤                                                             N init ppm 99    ¤
¤                                                                              ¤
¤                                                                              ¤
¤                                                                              ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë    Ok    Éëëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

```
  Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                       ¤
¤   Amount N left in the residue   [illegible]    (lb/ac)                ¤
¤                                                                       ¤
¤         Inorganic N leached       .01          (lb/ac)                ¤
¤                                                                       ¤
¤  Net immobil(-)/mineralizat(+)    [illegible]74.91  (lb/ac)           ¤
¤                                                                       ¤
¤            Denitrification        [illegible].51    (lb/ac)           ¤
¤                                                                       ¤
¤         Top mass @ 15.5 H2O       [illegible].87    (lb/ac)           ¤
¤                                                                       ¤
¤     Moisture deficit in crop      .99          (inches)               ¤
¤                                                                       ¤
¤     Nitrogen deficit in crop      .74          (lb/ac)                ¤
¤                                                                       ¤
¤  Organic Nitrogen pool CHANGE     [illegible]   (lb/ac)                ¤
¤                                                                       ¤
¤       Inorganic N in profile      [illegible].72    (lb/ac)           ¤
¤                                                                       ¤
¤               Ok   É                                                  ¤
¤             ÒÒÒÒÒÒÒ                                                   ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¹
 Alt-X Exit
```

```
  Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëë Simulation ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤ Name  Farmer Tom   Field  South                             Rainfall         ¤
¤                                       N Form                ( ) Dry          ¤
¤                       C:N Ratio       ( ) Ammon. Nitrate    () Average       ¤
¤ Crop                  ( ) Grass  - 20:1  ( ) Urea           ( ) Wet          ¤
¤ () Corn               () Leaves - 40:1  ( ) Liquid Nitrogen                  ¤
¤ ( ) Future            ( ) Leaves - 70:1  () Anhydrous Ammon  Air-temp        ¤
¤ ( ) Future            ( ) Wood   - 150:1 ( ) Ammon. Sulfate  ( ) Hot         ¤
¤                                                             () Average       ¤
¤ Plant on  APR 28     Apply on  APR 2     Apply on    MAY 30  ( ) Cold        ¤
¤                                                                              ¤
¤ SeedRate   30700     Rate Ton/Ac  80     NRate (lb/ac) 200   Soil Type       ¤
¤                                                             ( ) Sand         ¤
¤ Harvest   OCT 12     Incorporation       Apply Method       () Loam          ¤
¤                      ( ) None            ( ) Surface        ( ) Clay         ¤
¤                      ( ) Shallow [0-6"]  () Shallow [0-6"]                   ¤
¤                      () Deep [0-12"]     ( ) Deep [0-12"]   % total N   99   ¤
¤                                                                              ¤
¤                                                             N init ppm 99    ¤
¤                                                                              ¤
¤                                                                              ¤
¤                                                                              ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë    Ok    Éëëëëëëëëëëëëëëëëëëëëëëëë¥
 Alt-X Exit
```

```
  Menu
èë[±]ëëëëëëëëëëëëëëëëëëëëëëëëëëë 0 ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë[]ë£
¤                                                                       ¤
¤   Amount N left in the residue    291.65       (lb/ac)                ¤
¤                                                                       ¤
¤         Inorganic N leached       .01          (lb/ac)                ¤
¤                                                                       ¤
¤  Net immobil(-)/mineralizat(+)    -8[illegible].83  (lb/ac)           ¤
¤                                                                       ¤
¤            Denitrification        1[illegible].50   (lb/ac)           ¤
¤                                                                       ¤
¤         Top mass @ 15.5 H2O       [illegible].13    (lb/ac)           ¤
¤                                                                       ¤
¤     Moisture deficit in crop      .00          (inches)               ¤
¤                                                                       ¤
¤     Nitrogen deficit in crop      10[illegible].06  (lb/ac)           ¤
¤                                                                       ¤
¤  Organic Nitrogen pool CHANGE     120[illegible].[illegible]6  (lb/ac) ¤
¤                                                                       ¤
¤       Inorganic N in profile      7[illegible].[illegible]1   (lb/ac) ¤
¤                                                                       ¤
¤               Ok   É          Quit                                    ¤
¤             ÒÒÒÒÒÒÒ                                                   ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¹
 Alt-X Exit
```