Michigan State University

TITLE: Groundwater Contamination Potential of Pesticides and Fertilizers Used on the Golf Course

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This project has three major areas of research: the fate of nitrogen in turf, pesticide leaching under golf course fairway conditions, and the sorption and mobility of phosphorus in high sand content soil mixes. The project was initiated in April of 1991. This report details our research progress to date.

NITROGEN FATE IN TURF

This portion of the project follows the fate of a single application of ^{15}N labeled urea when applied either in the late fall or early spring application window. Each treatment receives five 0.8lbs N/M applications of urea for a yearly application rate 4.0 lbs N/M (196 kg N/ha). Both treatments receive four identical 0.8 lbs N/M applications beginning in late May and continuing every 6 weeks through late September. The early spring treatment receives 0.8 lbs N/M in early April while the late fall treatment receives its application in early November. For the nitrogen fate study the levels of ^{15}N in the water, plant tissue, and soil must be determined by mass spectroscopy. The ^{15}N data will allow a mass balance determination of the fate of nitrogen in a turfgrass ecosystem. Along with the ^{15}N determinations we also measure the levels of all the nitrogen forms within the turf but these can not be used for mass balance purposes since we don't know the source of the N. However, this data provides valuable information on the leaching of nitrogen to groundwater as well as the size of the nitrogen pools within the soil. The data presented in this progress report represents only total nitrogen levels within the soil. Our ^{15}N determinations have not progressed far enough to develop mass balance estimates. We have measured ^{15}N levels of the leachate through 3/7/92 and so far have not detected ^{15}N at levels above background. This indicates that all N detected has come from applications prior to the initiation of this research or possibly represent background levels of N leaching.

The data on the leachate samples for the early spring and late fall applications are shown in tables 1 and 2 and in figures 1-4. The overall tenor of the data is extremely positive. The early spring (ES) treatment has been monitored since April of 1991 with the first collection of leachate occurring on 4/30/91. Our leachate data has been analyzed through 6/17/92 and during that time 38 leachate events have been collected. A total of 2.3 kg/ha of N have been recovered in the leachate during the 14 months of sampling. In that time a total of 245 kg N/ha have been applied so that less than 1% of the applied N has been recovered in the leachate. The average level of N in the leachate over this sampling period is 0.47 PPM N (sum of NO_3 + NH_4). This is a very low value and demonstrates that, at this point in the study, turf is a very effective scavenger of nitrogen. Surprisingly, no NO_3 has been detected since 1/22/92 from this spring treatment. The only contribution to N quantity has come from small amounts of NH_4 (0.015-0.16 PPM) detected in the leachate. We are concerned by the lack of positive NO_3 detections and are checking out the possibility that some NO_3 reduction could take place in our sample collection carboys. However, we are still detecting NO_3 in the late fall (LF) treatment so we believe the data are accurate. The LF treatment is also showing small N leaching losses but the trend in this treatment is not as positive as in the ES treatment (table 2 and figure 4). Figure 4 displays the cumulative losses of nitrogen from both treatments from treatment initiation in April of 1991 to the last date for which we data, 6/17/92. The slope of the two lines is quite different with the LF treatment at a much steeper slope than the ES treatment. The ES treatment appears to have leveled off during the summer of 1992 while the LF treatment is still heading up. Despite the appearance of the curve two points must be kept in mind. First, the amount leached is still quite small with approximately 1.2% of the total applied N in the leachate and with a volumetric mean of 0.76 PPM total N. Second, in my opinion both lysimeters appear to be percolating more N in our early samples than what is appearing later. These losses early on may simply be a reflection of the disturbance of the cores during the construction process. The cores receiving the spring treatment were installed in April of 1990 and equilibrated for a year before receiving the initial treatment in April of 1991. The cores receiving the LF treatment were installed in June of 1991, 5 months prior to receiving the ^{15}N application. Even if the trend displayed in figure 4 is entirely due to the LF treatment, the total amount of N leachate, 0.76 PPM, is quite small and should be good news for the turfgrass industry.

The last point is of academic interest and relates to the leachate collected from the LF and ES treatments. Figure 2 shows N loss and leachate collected from each lysimeter from November of 1991 through May of 1992. The data is expressed as cumulative N losses from the beginning of the experiment but the leachate collected is set at 0 for both treatments. Notice that considerably more leachate is collected from the ES treatment than the LF treatment. This separation begins around 12/15/91 and continues throughout the winter, reaching a difference of 5 cm of leachate by the end of February. This implies that the LF treatments are transpiring significantly greater amounts of water during the winter months that the ES treatments. This is an interesting occurence and one that was aided by the exceptionally mild winter. Our normal snow cover and frozen soil conditions would surely eliminate this from occuring in normal years but in more southernly climates this probably occurs regularly.

FATE OF PESTICIDES

This portion of our research project is aimed at studying the leaching characteristics of commonly used turfgrass pesticides. A portion of the water from each leaching event is stored for analysis of pesticide levels in the water. Pesticides applied include 2,4-D, dicamba, isazophos, chlorthalonil, triademefon, metalaxyl, and propiconazole. Most of these pesticides are fungicides which have received little investigation concerning their leaching potential. The analysis of these water samples is being conducted in the laboratory of Dr. Matt Zabik at the Pesticide Research Center at MSU. At the present time, samples have been analyzed for two pesticides, chlorothalonil and isazophos. All the samples collected to date have been analyzed for chlorothalonil and as yet no positive detections have been made. Only a small portion (12) of the samples have been analyzed for isazophos, but at present no positive detections have been found. Thus at this early stage of the project, no occurrences of these pesticides have been detected in any of the samples tested.

Due to the sheer number of analyses to be performed, Dr. Zabik has decided to hire another technician which will help his laboratory keep up with the tremendous number of samples needed to be analyzed.

PHOSPHOROUS MOBILITY AND SORPTION IN SOILS

The potential for contamination of surface waters by phosphorus fertilizers is one of the areas of great concern facing the golf industry and agriculture as a whole. This topic takes on increased importance when construction of a new course in an environmentally sensitive area is proposed. Because of low clay content, the ability of a sand-based greens mix to adsorb phosphorous may be limited. Two experiments were initiated in 1991 to investigate the potential for vertical movement of fertilizer phosphorus in sand-based putting greens. Two areas at the HTRC putting green which have been maintained as phosphorus deficient for a number of years were used for these studies. For the first experiment, initial soil samples were taken in three inch depth increments to a total depth of 12 inches, then eight rates of fertilizer phosphorus were applied to 1.5 x 2 m plots. The first four rates of application were 0, 0.5, 1.0 and 2.0 lbs. P_2O_5 per 1000 sq. ft. Two additional rates were based on soil test results, one according to Bray-Kurtz P1 extractable P and the other based upon Olsen extractable P (two different soil extraction methods). The Bray-Kurtz method is routinely used by the MSU Soil Testing Lab. Olsen is the preferred method for soils with pH measurements in the range of 7.8 or higher. The rate of application for the first year according to both methods was 4.0 lbs./1000 sq. ft. The six treatments described above were made with surface applied P. The final two treatments were at the rates of 1.0 and 4.0 (soil test recommendation) lbs. P_2O_5 per 1000 sq. ft. using a prototype of the HydroJect aerifier to inject the fertilizer to a depth of 5 inches. Soil will be sampled on an annual basis as described above to assess the phosphorus status. The fertilization treatments based on soil test recommendations will be adjusted appropriately with treatments re-applied yearly.

The second experiment is being conducted on an adjacent P-deficient area of the green constructed with Purr-Wick drainage.

There are two regions of this plot which drain into separate collection basins. Phosphorus was applied to the two plots at the rates of 1.0 and 4.0 lbs. P_2O_5 per 1000 sq. ft. per year. Drainage water is collected periodically and analyzed for phosphorus content.

Plots were tested in September of 1991 to determine initial P levels. Results showed Bray P1 levels of 6.1, 4.4, and 4 lbs P_2O_5 for the 0-3, 3-6, 6-9 inch layers, respectively. The individual plot areas were sampled in July of 1992 after P treatments had been applied. Results (Table 3) showed that the applied phosphorus was confined mainly to the thatch layer and that the Bray P1 test was showing little to no P movement. The 3.0 lbs P_2O_5/M injected treatment did show some movement of P as would be expected. The Olsen test indicated that some P is moving downward after 3.0 lbs P_2O_5/M had been applied. These results indicate that the Bray P1 test will underestimate levels of P in greens with high soil pH's. The second part of the field study portion of this project involves the collection of leachate from greens constructed using the Purr-wick method of construction. At this time we have have collected and analyzed leachate samples from 5/6 through 8/12/92 and have had only one positive detection of P on 5/18 at the 1.0 lbs P_2O_5/M application rate but at a level of 0.1 PPM. Thus, for practical purposes we have not seen any P leaching at this time.

The other aspects of this study involve a survey of P levels in the profiles of golf course greens in Michigan and the determination of P adsorption isotherms for greens mixes from around the United States. The golf courses in Michigan were identified last fall and samples cores collected to determine initial P levels. Samples for 1992 will be collected in the month of November and P levels determined.

We had hoped the USGA Green Section Agronomists would help with the collection of greens mix samples from around the US to use for the determination of P adsorption isotherms. However, at this time we have not received any samples for this portion of the study and would request that the Agronomists be prodded once again for these samples.

Table 1. Individual Event data for Nitrogen leaching from a Spring N application

Sample #	JULIAN DAY	PPM NO_3	PPM NH_4	TOTAL PPM	LEACHATE (CM)	LEACHATE CUM (CM)	KG N/HA	CUM KG N/HA
1	121 (1991)	3.09	0.07	3.16	0.86	0.86	0.27	0.27
2	137	3.12	0.06	3.18	0.58	1.44	0.18	0.45
3	163	2.97	0.05	3.02	0.85	2.29	0.26	0.71
4	203	2.66	0.07	2.73	0.36	2.65	0.10	0.81
5	229	1.29	0.11	1.4	0.62	3.27	0.09	0.90
6	235	1.31	0.2	1.51	0.4	3.67	0.06	0.96
7	241	1.62	0.21	1.83	1.15	4.82	0.21	1.17
8	242	1.45	0.19	1.64	0.59	5.41	0.10	1.26
9	246	1.15	0.18	1.33	3.16	8.57	0.42	1.68
10	259	0.23	0.21	0.44	0.55	9.12	0.02	1.71
11	295	0	0.36	0.36	0.48	9.6	0.02	1.73
12	299	0.25	0.2	0.45	0.2	9.8	0.01	1.73
13	300	0.29	0.17	0.46	0.92	10.72	0.04	1.78
14	303	0.13	0.2	0.33	0.77	11.49	0.03	1.80
15	312	0.11	0.14	0.25	0.87	12.36	0.02	1.82
16	324	0.24	0.11	0.35	1.2	13.56	0.04	1.87
17	327	0.19	0.11	0.3	1.33	14.89	0.04	1.91
18	337	0.14	0.11	0.25	3.7	18.59	0.09	2.00

19	346	0.1	0.12	0.22	4.41	23	0.10	2.10
20	352	0.07	0.11	0.18	1.32	24.32	0.02	2.12
21	3 (1992)	0.07	0.13	0.2	1.66	25.98	0.03	2.15
22	22	0	0.16	0.16	1.41	27.39	0.02	2.18
23	52	0	0.15	0.15	2.89	30.28	0.04	2.22
24	58	0	0.16	0.16	1.16	31.44	0.02	2.24
25	67	0	0.2	0.2	0.56	32	0.01	2.25
26	78	0	0.035	0.035	2.54	34.54	0.01	2.26
27	85	0	0.05	0.05	0.99	35.53	0.00	2.26
28	87	0	0.04	0.04	0.84	36.37	0.00	2.27
29	95	0	0.07	0.07	1.09	37.46	0.01	2.27
30	101	0	0.015	0.015	1.25	38.71	0.00	2.27
31	107	0	0	0	0.875	39.585	0.00	2.27
32	112	0	0.03	0.03	1.245	40.83	0.00	2.28
33	115	0	0.02	0.02	1.705	42.535	0.00	2.28
34	116	0	0	0	1.29	43.825	0.00	2.28
35	118	0	0.025	0.025	1.395	45.22	0.00	2.29
36	127	0	0.015	0.015	1.185	46.405	0.00	2.29
37	160	0	0.05	0.05	2.015	48.42	0.01	2.30
38	169	0	0.03	0.03	0.7	49.12	0.00	2.30

Table 2. Individual Event data for nitrogen leaching from lysimeters receiving a late fall N application.

Sample #	JULIAN DAY	PPM NO_3	PPM NH_4	TOTAL PPM	LEACHATE (CM)	KG N/HA	LEACHATE CUM (CM)	CUM KG N/HA
15	312	1.46	0.17	1.62	1.03	0.17	1.03	0.17
16	324	1.43	0.16	1.59	0.92	0.15	1.95	0.31
17	327	1.28	0.11	1.39	1.59	0.22	3.54	0.53
18	337	1.04	0.11	1.14	2.57	0.29	6.11	0.83
19	346	0.86	0.12	0.98	1.51	0.15	7.62	0.97
20	352	0.76	0.10	0.85	1.29	0.11	8.91	1.08
21	3 (1992)	0.74	0.18	0.91	1.26	0.11	10.17	1.20
22	22	0.43	0.18	0.61	1.55	0.09	11.72	1.29
23	52	0.50	0.17	0.67	1.11	0.07	12.83	1.37
24	58	0.43	0.16	0.59	0.96	0.06	13.79	1.42
25	67	0.40	0.18	0.58	0.61	0.04	14.40	1.46
26	78	0.17	0.09	0.26	2.08	0.05	16.48	1.51
27	85	0.16	0.07	0.23	1.23	0.03	17.71	1.54
28	87	0.30	0.08	0.37	0.55	0.02	18.26	1.56
29	95	0.19	0.07	0.26	1.06	0.03	19.31	1.59
30	101	0.29	0.03	0.32	0.61	0.02	19.92	1.61
31	107	0.17	0.00	0.17	0.61	0.01	20.53	1.62

32	112	0.25	0.03	0.28	1.00	0.03	21.53	1.64
33	115	0.19	0.02	0.21	1.23	0.03	22.76	1.67
34	116	0.20	0.06	0.26	1.28	0.03	24.04	1.70
35	118	0.19	0.03	0.22	1.54	0.03	25.58	1.73
36	127	0.14	0.76	0.90	1.44	0.13	27.01	1.86
37	160	1.12	0.66	1.78	2.11	0.37	29.12	2.24
38	169	0.61	0.07	0.68	1.07	0.07	30.18	2.31

Table 3. Soil phosphorus levels, sampled July 1992.				
TREATMENT ($\#P_2O_{05}/M$)	DEPTH (inches)			
	Thatch	5/8 - 3	3 - 6	6 - 9
Check	7.5	< 4	< 4	< 4
0.5	19.5	< 4	< 4	< 4
1.0	34.0	< 4	< 4	< 4
2.0	90.5	< 4	< 4	< 4
1.0 (Inject)	13.7	< 4	< 4	< 4
3.0 (Inject)	34.1	4.4	6.1	4.0
3.0 (Bray P1)	105.7	11.2	< 4	< 4
3.0 (Olsen)		33.1	14.0	17.4
LSD	13.2	7.0	3.1	6.9

Soil test P levels are in pounds P/A.
LSD = least significant difference, P = 0.05.

Figure 1. WATER AND NITROGEN LEACHED
MAY 1992 - OCTOBER 1992

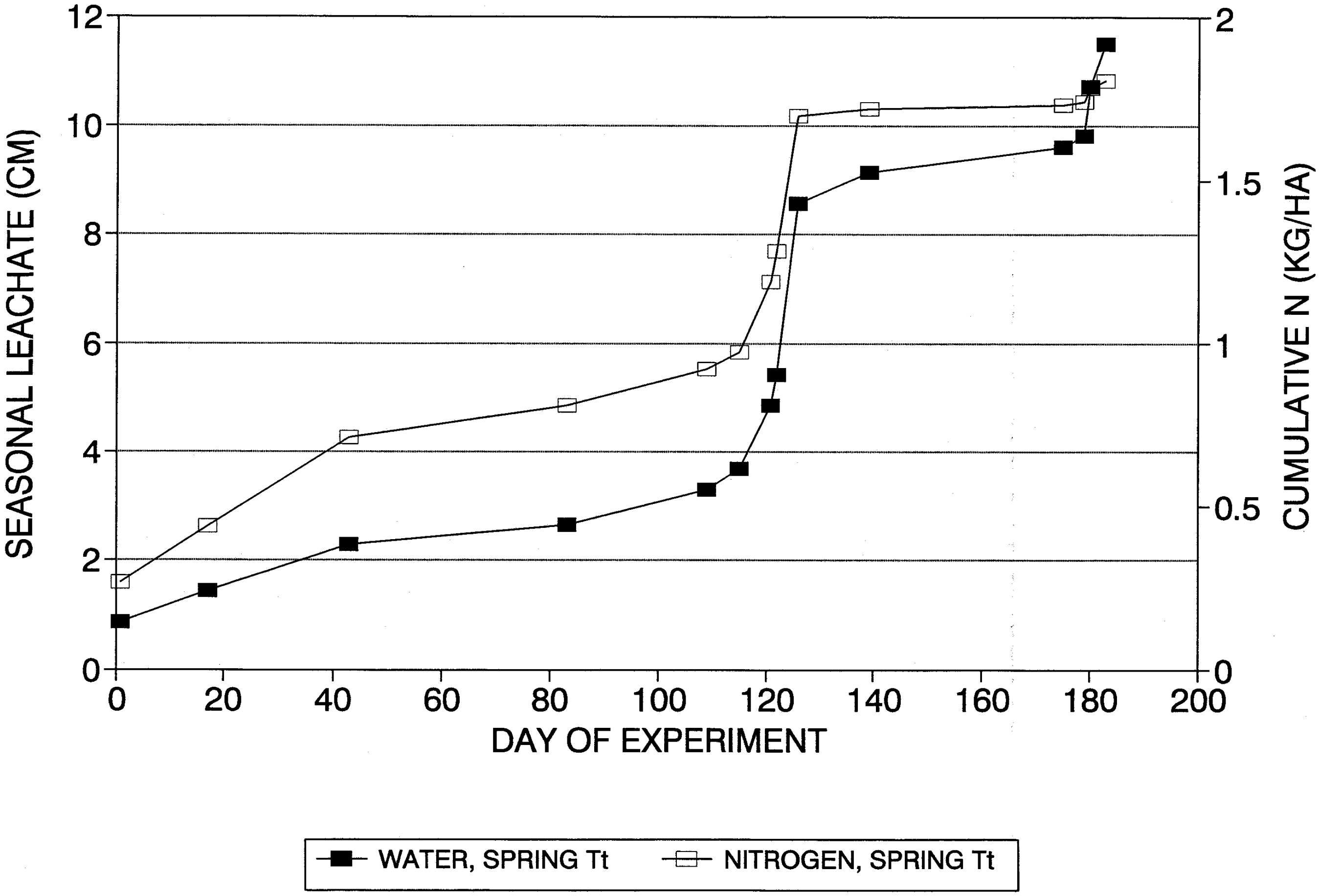

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Figure 2. WATER AND NITROGEN LEACHED

NOVEMBER 1991 - APRIL 1992

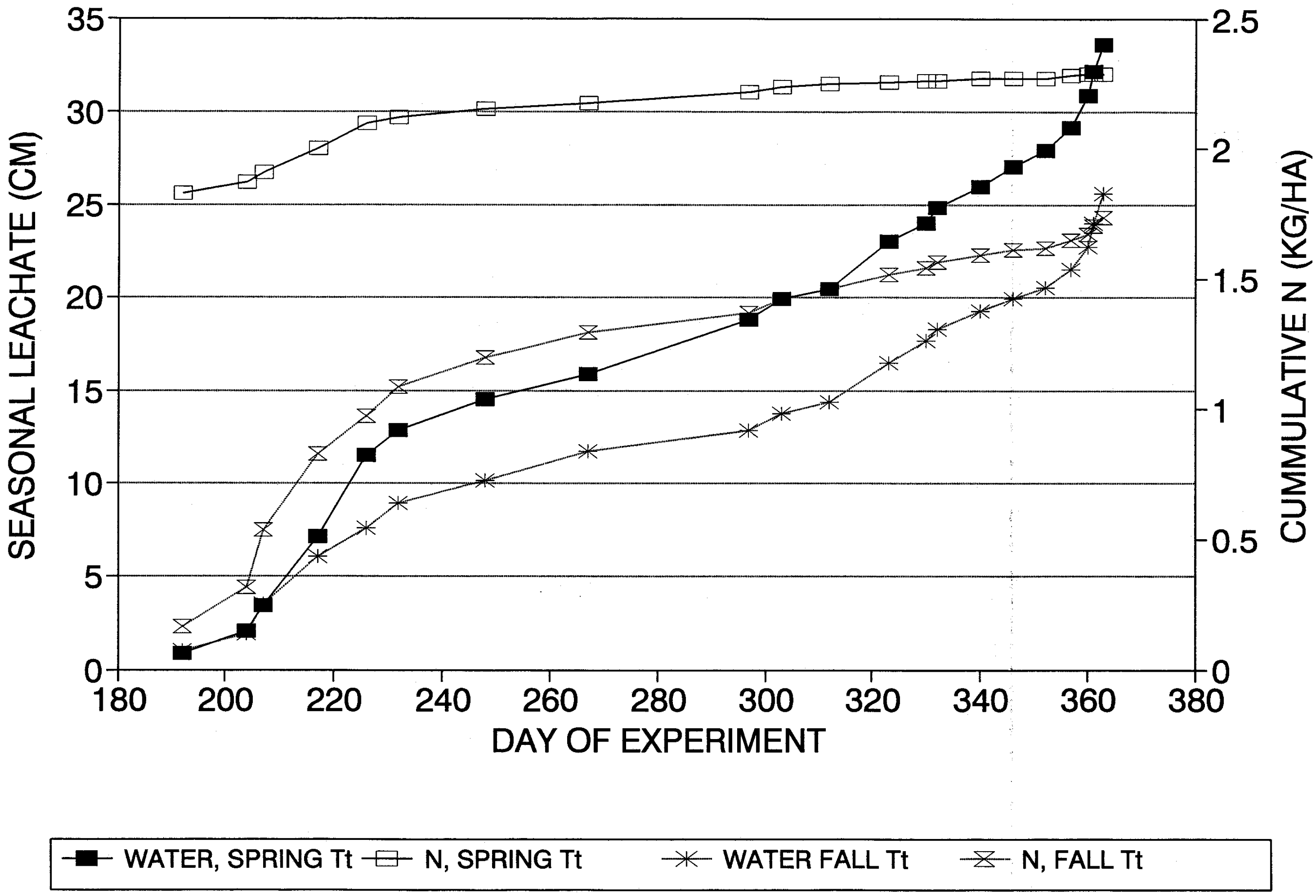

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Figure 3. WATER AND NITROGEN LEACHED
MAY 1992 - OCTOBER 1992

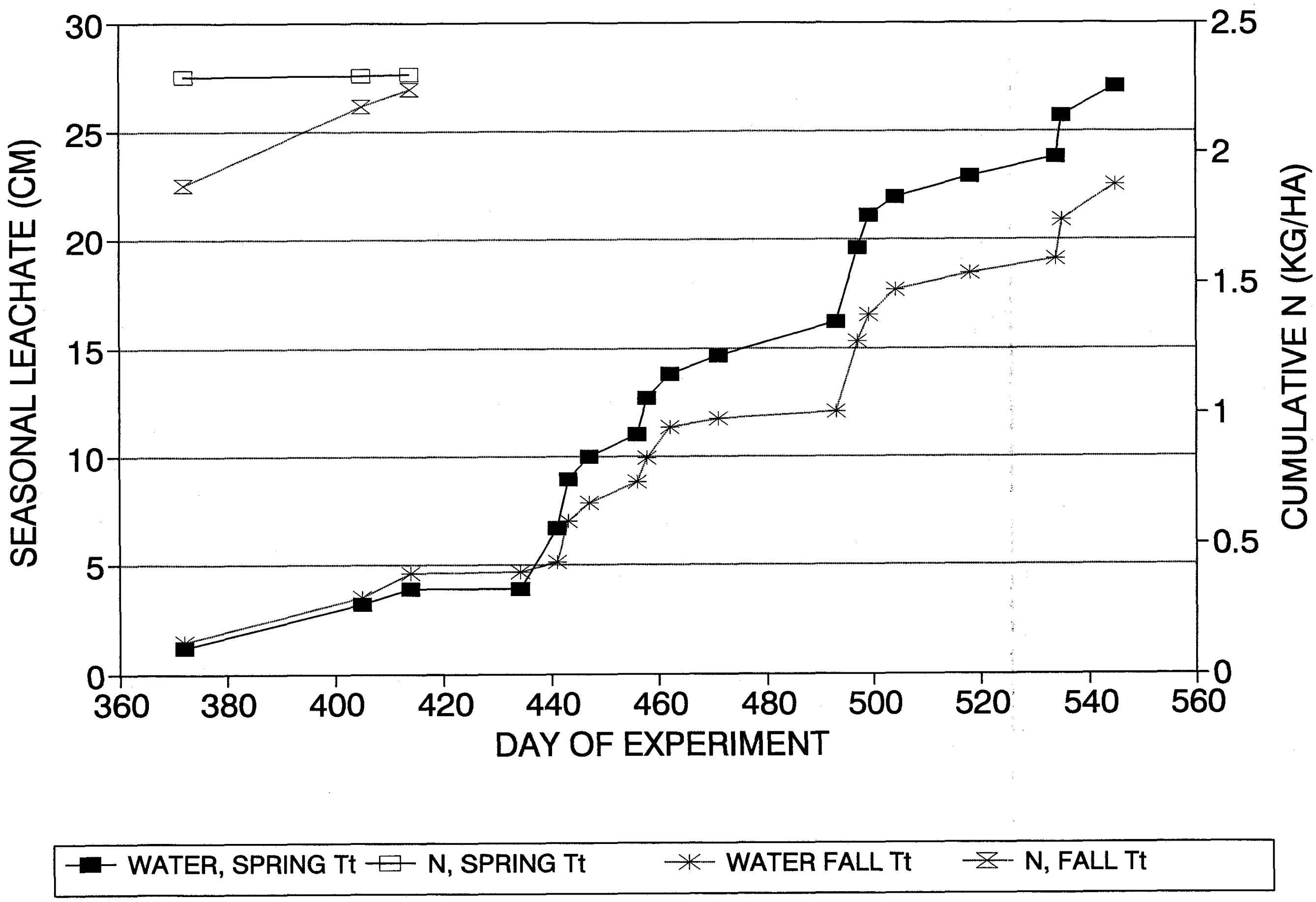

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Figure 4. CUMULATIVE NITROGEN LEACHED
MAY 1991 - JUNE 1992