Mass Balance Assessment of Pesticides and Nutrients Applied to Golf Turf

The Pennsylvania State University
Runoff Studies

1993 Annual Report
To
United States Golf Association

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SURFACE RUNOFF OF PESTICIDES AND NUTRIENTS APPLIED TO GOLF TURF

The Pennsylvania State University

During 1993, eight hydrographs were produced through irrigation while none resulted from any natural precipitation event. The 1993 hydrographs continued to be similar to those in 1992, in that perennial ryegrass slopes produced move runoff at a quicker pace than did creeping bentgrass slopes. On two dates during 1993, runoff peak flow was attained for both species in a very short period of time due to periods of rainfall which fell within hours prior to the irrigation application. Even though these two runoff events produced somewhat atypical hydrographs, the concentration of nitrogen (NO_3-N), phosphorous (PO_4), and MCPP were not elevated compared to other sampling dates.

Typically nitrogen (NO_3-N) and phosphorus (PO_4) concentrations found in both runoff and leachate were consistently low with values below the public drinking water standards for wells. Nitrate -N was usually lower in concentration for both runoff and leachate than the concentration of the irrigation water (source-university well). Concentration of MCPP were found to be low in runoff, even though irrigation was applied at six inches per hour within 24 hours of application. For the most part, MCPP was not detected in runoff produced by irrigation at later dates and was not found for any natural precipitation events.

Isazofos, triadimefon, and trichlorfon were applied during 1993 and analysis of runoff and leachate samples is currently underway at the Penn State Pesticide Anaylses Laboratory.

As part of this research project, experiments were conducted in an attempt to ascertain why perennial ryegrass and creeping bentgrass swards differed in their impact on runoff.

Different growth habits were found to be partially responsible for the runoff and infiltration differences observed on the bentgrass and ryegrass plots. The high-density, thatch-forming creeping bentgrass produced a more tortuous pathway for downward and horizontal movement of water through the turf than perennial ryegrass.

Tortuosity, resistance, and overland flow velocity are all interrelated and characterize any vegetation's hydrologic effect on surface water flow. The more tortuous path of the bentgrass increased resistance (friction) which in turn decreased overland flow velocity. Slower overland flow velocities increased surface residence time which allowed for greater total water infiltration. Greater infiltration decreased the potential for surface transport of nutrients in runoff. Although creeping bentgrass reduced runoff more than ryegrass, both turfs, when maintained as a golf fairway, were effective in reducing transport of NO_3-N, phosphate, and total Kjeldahl.

Runoff Studies at Penn State
1993 Annual Report

Hydrology Summary

During 1993, eight hydrographs were produced for runoff events induced by irrigation at a rate of six inches per hour. No hydrographs could be generated as a result of natural precipitation. Runoff responses for both perennial ryegrass and creeping bentgrass in 1993 were similar to those found in 1992. Perennial ryegrass slopes ran off quicker and with greater total volume than creeping bentgrass slopes. When the runoff facilities received rainfall within 24 hours of an irrigation event, runoff commenced quicker for both species. For instance, on May 12 (Fig. 1) the plots received 0.5 inch of rainfall prior to irrigation, while on May 26 (Fig. 2) no rainfall had fallen for over a week prior to the irrigation. Both species had about a 2x longer time span between the initiation of irrigation and the appearance of runoff when the soils were drier due to lack of rainfall. On June 9, runoff occurred quickly from all slopes (Fig. 3) compared to the same time frame in 1992. In 1992, conditions were dry prior to irrigation while in 1993, 0.4 inch of rain fell on June 8 and 0.5 inch of rain fell on June 9 prior to initiating runoff. Irrigation was necessary to produce runoff for sampling purposes as no runoff occurred as a result of the rainfall. Runoff the remainder of the year (Figs. 5, 6, 7, 8) followed trends similar to those found in 1992. The principle difference between the two years was that the irrigation was left on longer in 1993 than in 1992. Water subsamples for nutrient and pesticide analyses were taken from runoff at a rate of 16 ml/minute for the duration of the runoff period.

Nutrient Analyses

Fertilizer was applied on three dates in 1993 (May 25, Sept. 7, and Oct. 5). Scotts 32-3-10 with 50% of the nitrogen from methylene ureas was the fertilizer source and 1.0 pound actual nitrogen per 1000 ft^2 was the rate used. Most of the time, NO_3-N was lower in both leachate and runoff than in the irrigation water. Although water was collected immediately upon exiting the turf, forced with six inches per hour of irrigation, concentrations were below the public drinking water standard for wells (Fig. 9, Table 1 and 2). Results found for phosphate (Fig. 10, Table 3 and 4) were similarly low and the concentration data do not show a significant change as a result of fertilizer applications.

Total Kjeldahl N analyses were conducted on 1992 samples to determine whether there were any substantial amounts of the fertilizer nitrogen that had not yet been converted to NO_3-N. Because total Kjeldahl N concentrations were very low, it was assumed that most of the fertilizer N applied was in the soil above the sub-surface sampler and/or did not become soluble and remained on the soil surface. To a lessor extent the fertilizer may have been converted to NO_3-N and absorbed by foliage and roots and utilized for growth, or may have been lost to NH_3 volatilization.

Pesticide Analyses

During 1993, the following pesticides were applied; MCPP (June 8), Isazofos (June 29), Triadimefon (August 17), and Trichlorfon (September 20). This report also includes the analytical data for 1992 with respect to MCPP which was applied on June 9 and was analyzed on six occasions during the year.

Mean MCPP concentrations were not found to be greater than one part per million on any sampling date (Table 5). With the exception of the sampling 24 hours after application, the concentration of MCPP was usually less than 100 parts per billion or not detectable at all. No clear trend in MCPP concentration was found with respect to grass species. A rainfall event on June 19, 1992 (10 days after treatment) produced some runoff which did not contain a detectable amount of MCPP.

Mean Isazophos concentrations were less than one part per million with no clear trend between the two grass species. Samples taken approximately six weeks after application were not found to have detectable levels of Isazophos (Table 6).

Figure 1. Average Hydrographs for May 12, 1993

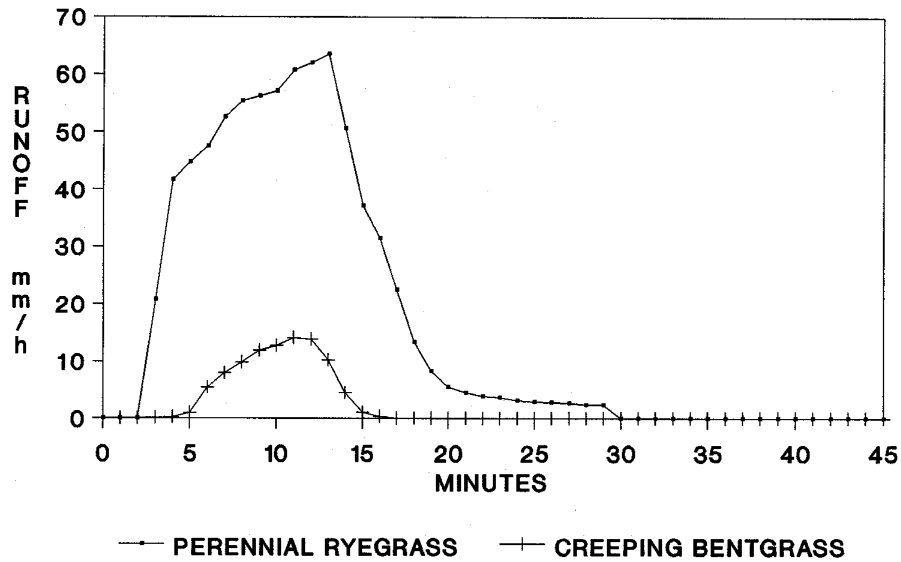


Figure 2. Average Hydrographs for May 26, 1993

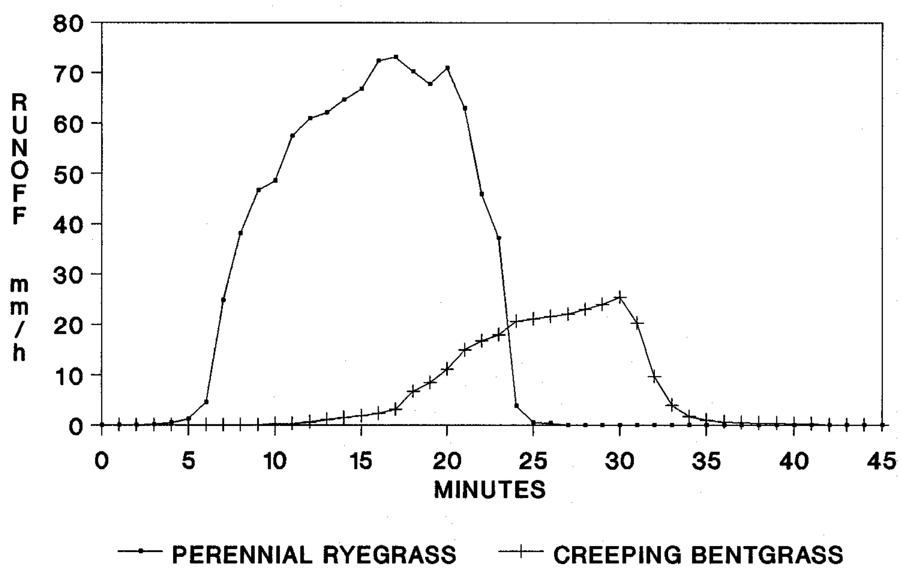


Figure 3. Average Hydrographs for June 9, 1993 & June 10, 1992

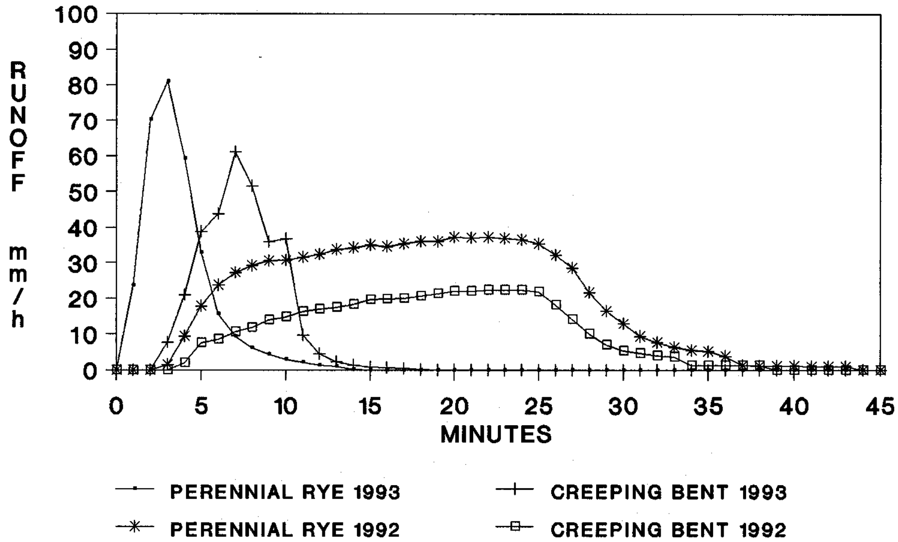


Figure 4. Average Hydrographs for June 30, 1993

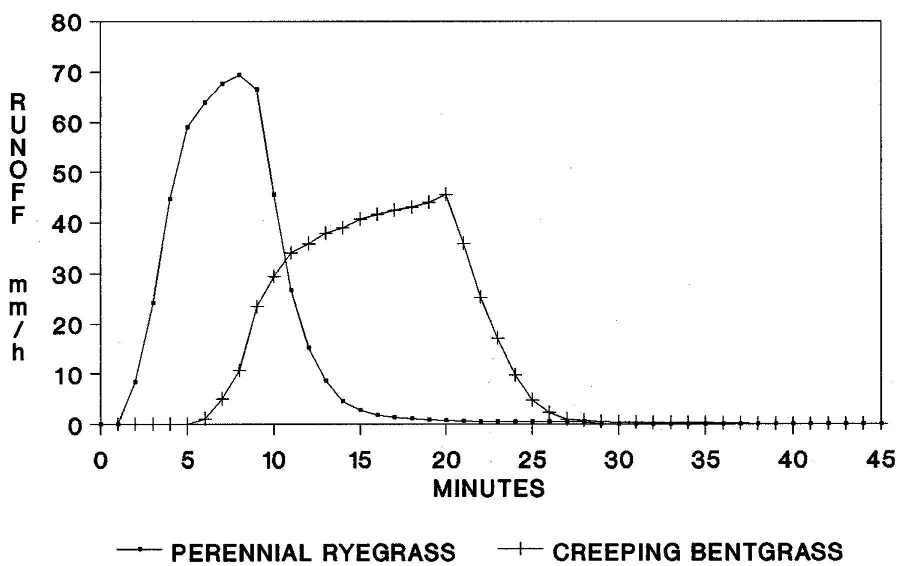


Figure 5. Average Hydrographs for
AUGUST 18, 1993

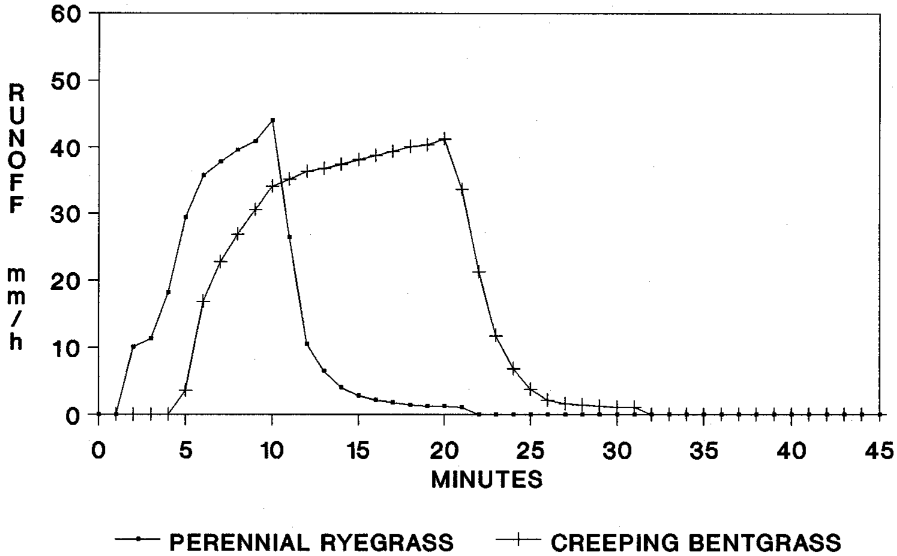


Figure 6. Average Hydrographs for
SEPTEMBER 8, 1993

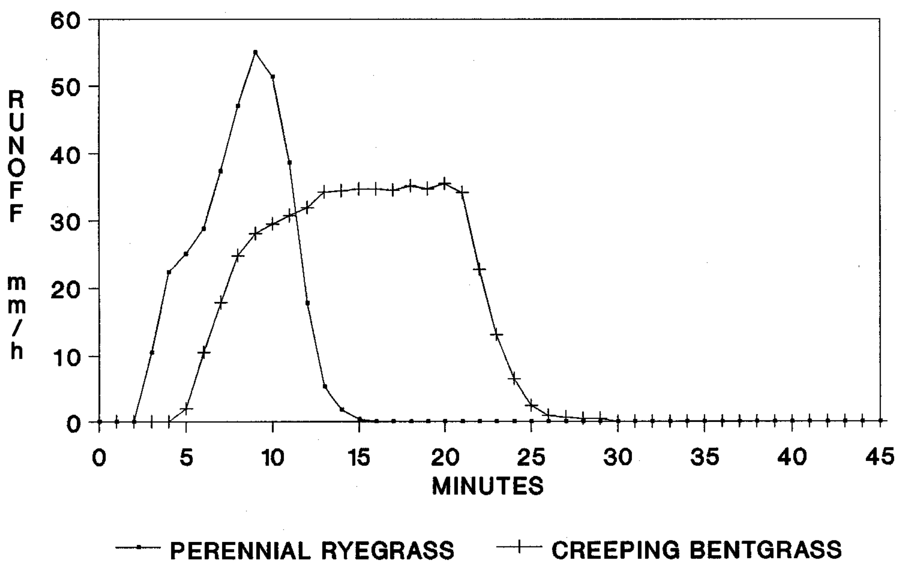


Figure 7. Average Hydrographs for SEPTEMBER 21, 1993

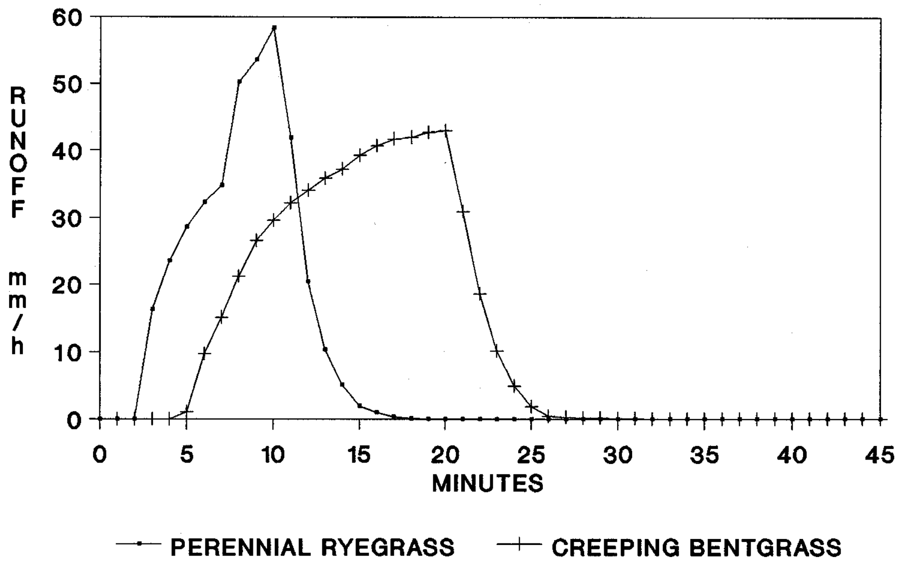


Figure 8. Average Hydrographs for OCTOBER 6, 1993

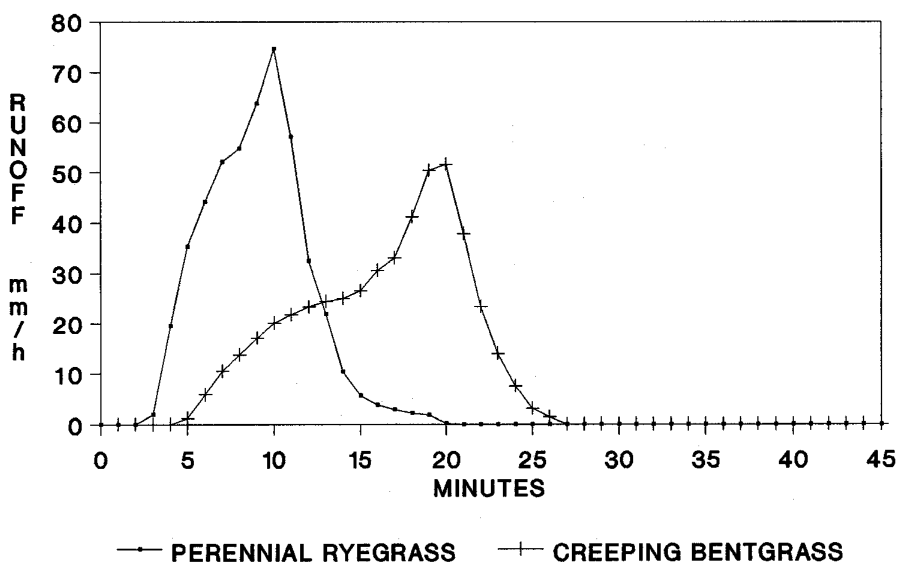
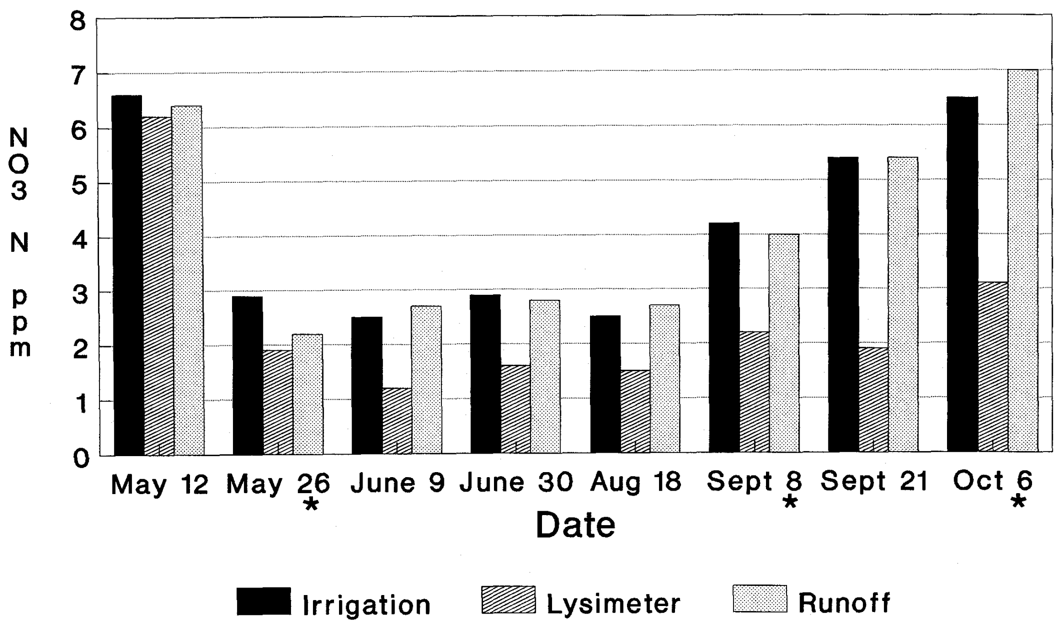


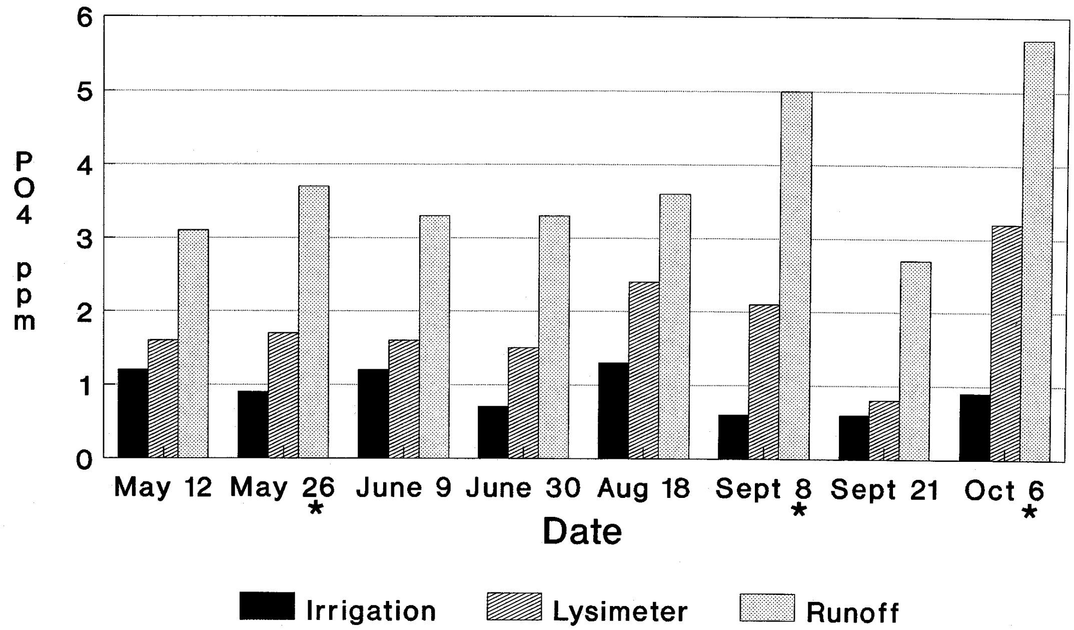
Figure 9. Concentration of Nitrate N
(1993)



* 49 kg N/ha applied

00335

Figure 10. Concentration of Phosphate P
(1993)



* 5 kg P2O5/ha applied

00336

Table 1. Surface movement of nitrate N resulting from application of fertilizer* to sloped turfgrass plots.

Species	Single N application rate (kg N/ha)	Total annual N rate (kg N/ha)	Date applied	Irrigation (mm)	Nitrate** Concentration in water (mg/L)
Lolium perenne	0		May 93	38	0
	49		May 93	114	0
	0		June 93	38	<1
	0		June 93	38	<1
	0		Aug 93	38	<1
	49		Sept 93	38	<1
	0		Sept 93	38	<1
	49		Oct 93	38	<1
		147			
Agrostis palustris	0		May 93	57	0
	49		May 93	114	0
	0		June 93	38	<1
	0		June 93	76	<1
	0		Aug 93	76	<1
	49		Sept 93	76	0
	0		Sept 93	76	<1
	49		Oct 93	76	<1
		147			

* The Nitrogen sources are NH_4^-N, Methylene Urea, Urea, (Scotts 32-3-10).
** Mean of replications

Table 2. Leaching of nitrate N resulting from application of fertilizer* to sloped turfgrass plots.

Species	Single N application rate (kg N/ha)	Total annual N rate (kg N/ha)	Date applied	Irrigation (mm)	Nitrate** Concentration in water (mg/L)
Lolium perenne	0		May 93	38	<1
	49		May 93	114	0
	0		June 93	38	2
	0		June 93	38	0
	0		Aug 93	38	0
	49		Sept 93	38	0
	0		Sept 93	38	0
	49		Oct 93	38	0
		147			
Agrostis palustris	0		May 93	57	<1
	49		May 93	114	0
	0		June 93	38	2
	0		June 93	76	0
	0		Aug 93	76	0
	49		Sept 93	76	0
	0		Sept 93	76	0
	49		Oct 93	76	0
		147			

* The Nitrogen sources are NH_4^-N, Methylene Urea, Urea, (Scotts 32-3-10).

** Mean of replications

Table 3. Surface movement of phosphate PO_4 resulting from application of fertilizer* to sloped turfgrass plots.

Species	Single Phrosphorus application rate (kg P2O5/ha)	Total annual rate (kg P2O5/ha)	Date applied	Irrigation (mm)	Phosphate** Concentration in water (mg/L)
Lolium perenne	0		May 93	38	2
	5		May 93	114	3
	0		June 93	38	2
	0		June 93	38	2
	0		Aug 93	38	2
	5		Sept 93	38	4
	0		Sept 93	38	2
	5		Oct 93	38	4
		15			
Agrostis palustris	0		May 93	57	2
	5		May 93	114	3
	0		June 93	38	2
	0		June 93	76	3
	0		Aug 93	76	2
	5		Sept 93	76	4
	0		Sept 93	76	2
	5		Oct 93	76	6
		15			

* The Phosphorus source is Monoammonium Phosphate (Scotts 32-3-10).
** Mean of replications.

Table 4. Leaching of phosphate PO_4 resulting from application of fertilizer* to sloped turfgrass plots.

Species	Single Phrosphorus application rate (kg P2O5/ha)	Total annual rate (kg P2O5/ha)	Date applied	Irrigation (mm)	Phosphate** Concentration in water (mg/L)
Lolium perenne	0		May 93	38	<1
	5		May 93	114	<1
	0		June 93	38	<1
	0		June 93	38	<1
	0		Aug 93	38	2
	5		Sept 93	38	2
	0		Sept 93	38	<1
	5		Oct 93	38	2
		15			
Agrostis palustris	0		May 93	57	<1
	5		May 93	114	1
	0		June 93	38	<1
	0		June 93	76	<1
	0		Aug 93	76	<1
	5		Sept 93	76	<1
	0		Sept 93	76	<1
	5		Oct 93	76	3
		15			

* The Phosphorus source is Monoammonium Phosphate (Scotts 32-3-10).
** Mean of replications.

Table 5. Movement of MCPP (ppm) in runoff from sloped plots of creeping bentgrass and perennial ryegrass. MCPP applied 6/9/92 and 6/8/93.

Date	Turf	
	Perennial ryegrass	Creeping bentgrass
6/10/92	0.854*	0.380
6/19/92	0.0	0.0
6/24/92	0.007	0.014
6/26/92	0.037	0.054
9/9/92	0.002	0.0
10/14/92	0.001	0.0
6/9/93	0.169	0.107
6/30/93	0.0	0.0

* mean of three slopes in ppm

Table 6. Movement of isazophos (ppb) in runoff from sloped plots of creeping bentgrass and perennial ryegrass. Isazophos applied 6/29/93.

Date	Turf	
	Perennial ryegrass	Creeping bentgrass
6/30/93	470.1*	514.1
8/18/93	0.0	0.0

* mean of three slopes in ppb