Role of Winter Cover Crops in Reduction of Nitrate Leaching

W.L. Hargrove, J.W. Johnson, J.E. Box, Jr., and P.L. Raymer[1]

INTRODUCTION

The preeminent challenge facing agriculture today is the development of tillage and cropping strategies to protect vital surface and groundwater supplies. Nitrate is of particular concern because relatively low concentrations (10 ppm NO_3-N) render water unfit for human consumption, and because many shallow groundwater supplies exceed recommended NO_3-N drinking standards (US EPA, 1990). The overall objectives of this research are to evaluate several winter annuals for rooting depth and residual N recovery, and measure the influence of a cover crop on the amount of NO_3 leaching during fall, winter and spring months.

MATERIALS *AND* METHODS

Research was initiated in 1990 at the University of Georgia Bledsoe Farm near Griffin and the USDA-ARS Soil and Water Conservation Laboratory at Watkinsville, GA. The first phase of this research included the preliminary evaluation of 16 winter annual selections from 9 species: wheat (3 cultivars), oats (2 cultivars), rye, barley, triticale (2 cultivars), ryegrass, canola (3 cultivars), hairy vetch, crimson clover and forage turnip. Cover crops were planted in the fall, 1990 following corn harvest. Dry matter production, N concentration and total N uptake were measured by collecting above-ground dry matter samples. In the second phase, root growth of selected winter annual species was evaluated using a minirhizotron technique, as described by Box and Johnson (1987). Eight minirhizotrons (transparent polycarbonate tubes) were installed per plot and root counts recorded at 0.1 m intervals to a soil depth of 1.0 m.

The third phase of this project, begun in 1992, consists of an evaluation of the effectiveness of rye winter cover crops in reducing NO_3-N movement through the soil profile by measuring NO_3-N in effluent from drain tile. Drain tile was installed on plots at the Soil and Water Conservation Laboratory at Watkinsville at a depth of 1 m in 1981 (Box, 1986). A rye winter annual cover crop or no winter cover crop was planted following corn on each of six 7.58 m square drained blocks individually surrounded by a 0.3 mm thick plastic sheet extended to a depth of 0.9 m. Plastic drain tiles 0.10 m diameter, with a 0.10 m thick encasement of 0.01 m diameter gravel and spaced 2.52 m apart at a depth of 0.6 m, were placed along the 7.58 m border on the drained block. Drain tile effluent was collected from each block using a tipping bucket in combination with an ISCO pumping sampler. The tipping bucket and pumping sampler provides hydrograph data and stores samples in a refrigerated chamber until N analyses can be performed.

RESULTS AND DISCUSSION

The winter annuals with the greatest amount of early biomass production (9 February, 1990) included 'Wrens Abruzzi' rye, 'Stan 1' and 'Morrison' triticale, and 'Wysor' barley (Table 1). By the 17 May, 1990 sampling date, 'Coker 716' and 'Simpson' oats also had accumulated large amount of biomass, and, along with 'Crystal' rapeseed, appear to show promise for uptake of N from the soil during the winter and spring months. These results indicate that oats warrant further study as an alternative cover crop to prevent nitrate leaching.

Rye, crimson clover, canola and fallow (weeds) were evaluated in Phase 2 for root growth and soil nitrate concentrations in 1991.

[1]University *of* Georgia and USDA-ARS.

Table 1. Winter annual cover crop dry weight, N concentration and N content.

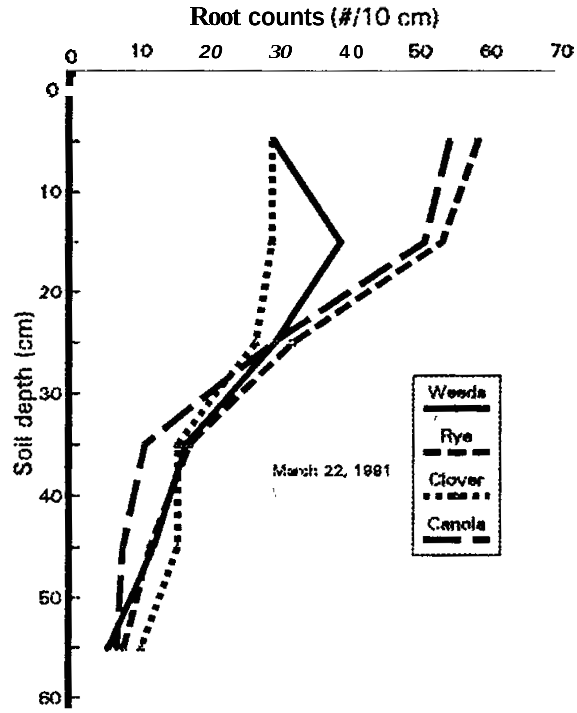
		9 February, 1990			17 May, 1990		
Cover crop	Cultivar	Dry wt	N conc.	N content	Dry wt	N conc.	N content
		kg ha^{-1}	%	kg ha^{-1}	kg ha^{-1}	%	kg ha^{-1}
Ryegrass	Common	165	3.54	5.2	5109	0.81	40.9
Wheat	Stacy	264	3.50	9.0	6314	0.71	43.8
	C 9766	292	4.15	11.4	5957	0.75	44.4
	GA 100	267	3.78	10.1	4644	0.93	41.5
Triticale	Stan 1	455	3.73	16.9	5587	0.92	50.9
	Morrison	389	3.41	13.1	8520	0.79	66.2
Rye	Wrens Abruzzi	521	3.85	19.7	9273	0.64	58.2
Oat	C 716	258	4.06	10.3	6718	1.05	70.7
	Simpson	245	3.93	8.7	7397	1.15	85.0
Barley	Wysor	344	3.76	12.5	5106	0.79	39.2
H. Vetch	Common	100	4.24	4.3	3362	3.14	109.0
C. clover	Tibbee	31	3.43	1.1	4866	1.30	60.8
Rapeseed	Delta	122	2.53	1.5	1814	2.31	37.3
	Crystal	19	4.43	0.8	3189	1.85	58.0
	Per				424	2.29	8.5
LSD		185	0.87	6.3	1793	0.39	26.7

Results for root counts on February 21 show that rye has greater root growth early in the season, but results from March 22 show no difference between rye and canola (Fig. 1) Both fallow (weeds) and crimson clover had reduced root growth at both sampling dates compared to rye and canola.

Results for root counts were consistent with measured soil nitrate-N concentrations (Fig. 2). Soil nitrate-N concentrations on February 4 show that both rye and canola were very effective in recovering soil nitrate. Concentration of soil nitrate-N for fallow (weeds) treatment was approximately 35 ppm at a depth of about 60 cm, as compared to a 5 ppm nitrate-N concentration as observed in the canola and rye treatments. Crimson clover was intermediate in its effectiveness in recovering soil nitrate, with a nitrate-N concentration of approximately 17 ppm at a depth of 60 cm. On the second sampling date, May 3, the residual nitrate in the fallow and crimson clover treatments moved below the depth of sampling, while soil profile concentrations for the rye and canola treatments remained low (<7 ppm).

Drainage from tiles was first measured in January, 1992 (Fig. 3). Drainage started after approximately 100 mm of rainfall on the fallow treatment, compared to 150 mm of rainfall received prior to drainage on the rye

Figure 1. Root Counts



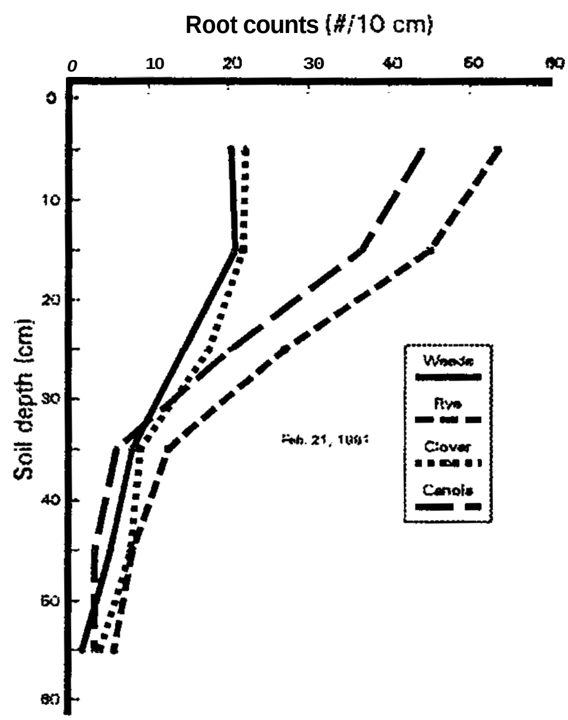
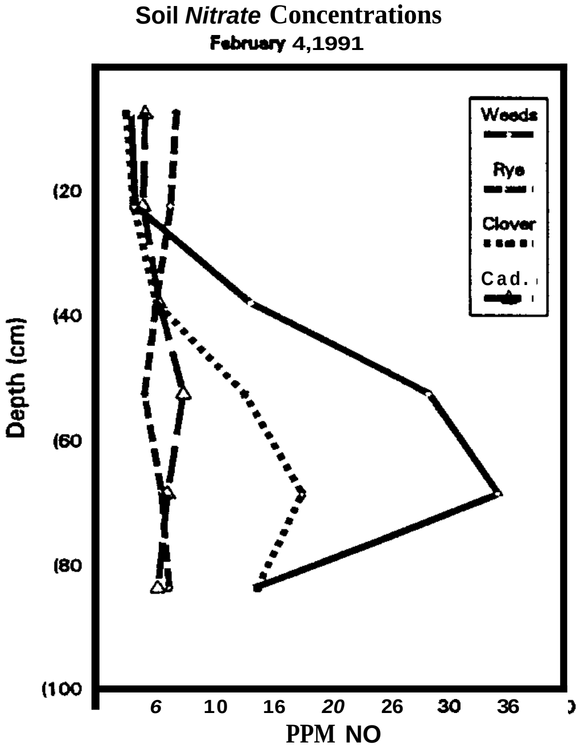


Figure 2. Soil Nitrate Concentration



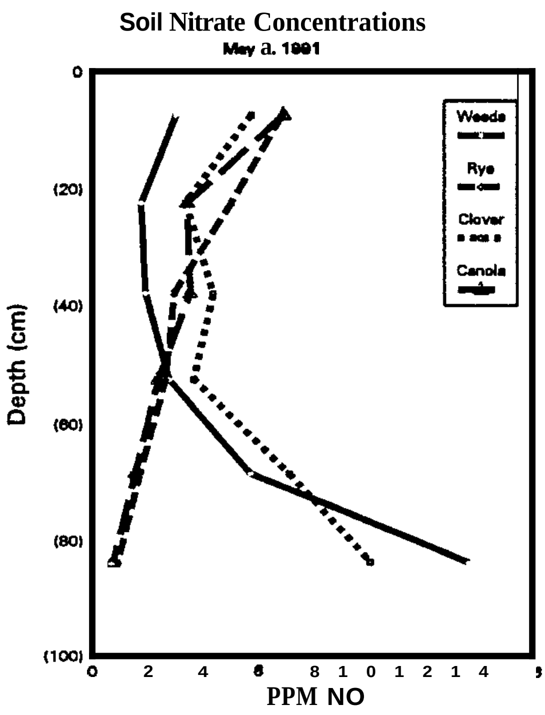
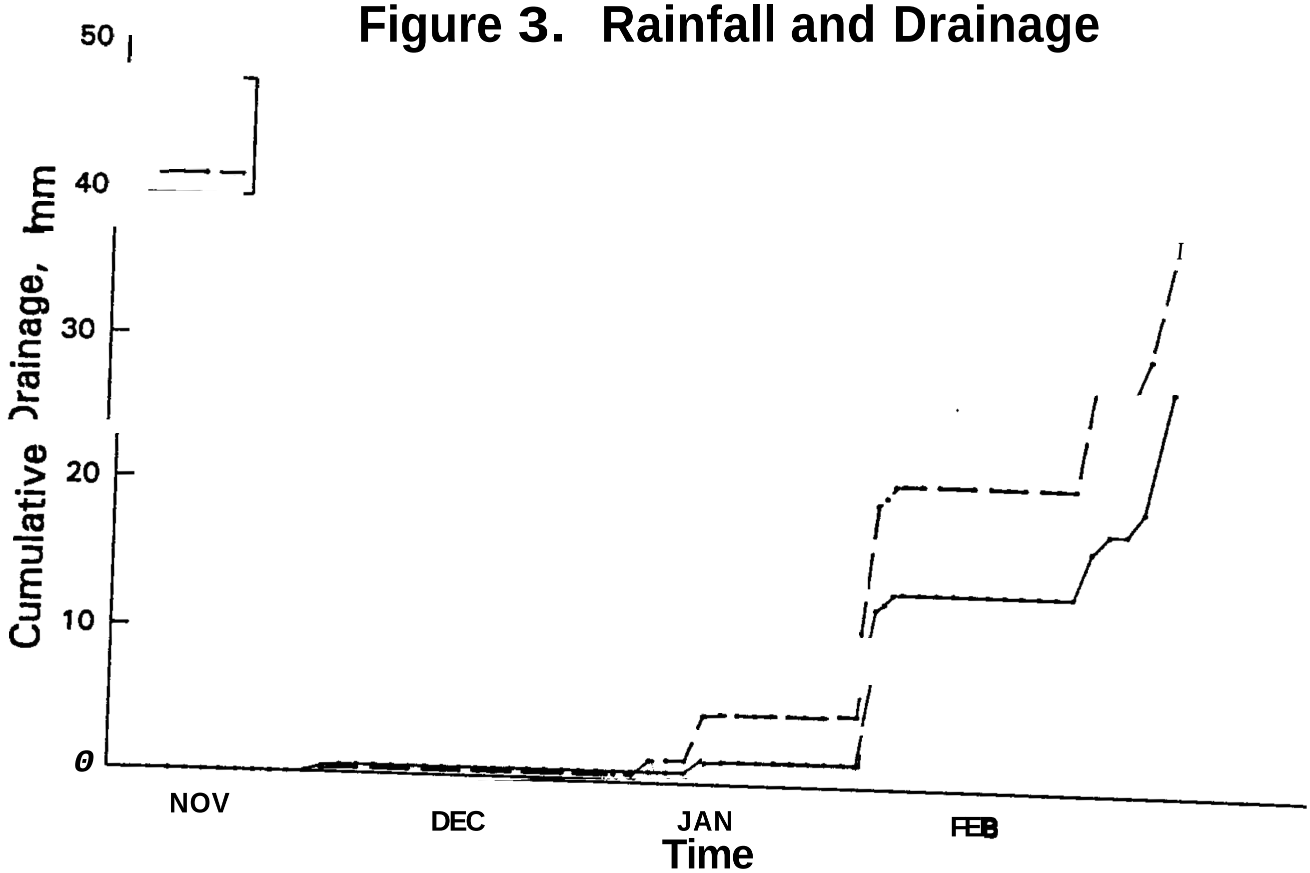
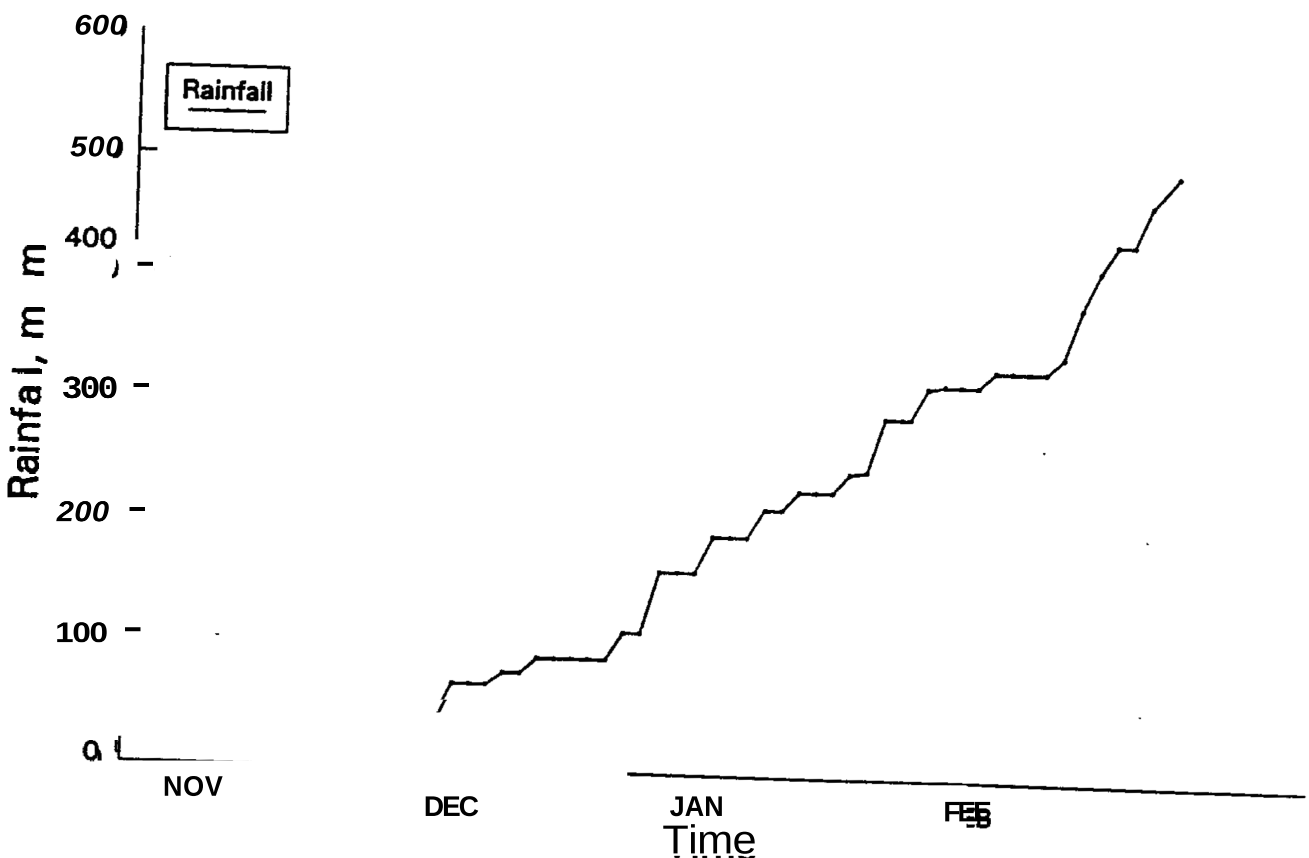


Figure 3. Rainfall and Drainage





treatment. To date, cumulative drainage for the fallow treatment is approximately 40 mm, and only 25 mm for the rye treatment. Nitrate analysis of drainage samples are pending.

CONCLUSIONS

Our preliminary results indicate that rye and canola are very effective in recovering residual nitrate remaining in the soil following corn. Oats and forage turnips also are effective in recovering residual nitrate, and their potential as cover crops to prevent nitrate leaching warrants further study. Non-leguminous cover crops can potentially recover 100 kg N ha^{-1} that would be subject to leaching over the winter months. Results from nitrate analyses of drainage effluent and associated ^{15}N analysis should further elucidate the efficacy of winter cover crops in reducing nitrate leaching.

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