Tools to reduce N leaching in maize monoculture system

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Introduction

N leaching in intensive agricultural systems is an important problem in Northern Italy because of the high rate of groundwater pollution (PARENTE et al. 1994). According to the EU regulations (Nitrate Directive 676/91), one of the possibilities of preserving groundwater quality is to maintain the soil covered throughout the year (PARENTE et al. 1997). In N-E Italy maize is the main crop because of its high economic value. Maize is fertilised with a high level of N, usually 300-400 kg ha^{-1}. Recent studies demonstrate that N leaching in maize monoculture systems is around 1/3 of the total N input (WEBSTER et al. 1993). In animal farming, maize is commonly used in the crop rotation lucerne-maize-soybean-wheat, whereas in the other farms maize is used as a cash crop, mainly in monoculture, for grain production. In the first case, the impact is mitigated by the crop rotation because the management of soil nutrients is more balanced. In the second case, the absence of cover crop, as catch crop, during winter leads to higher N leaching. Trials carried out in the last years demonstrated the possibility of using ryegrass (*Lolium multiflorum*) as a cover crop between two maize crops (PARENTE and VENERUS, 1997, 1998). SAASD has been active for many years in monitoring N leaching from different agricultural systems by means of a series of lysimeters settled in two experimental farms since 1992. In this study the efficiency of N-leaching reduction in a maize-ryegrass system, with ryegrass as catch crop, was compared with a maize monoculture system in the years 1998-2000. Leaching water was collected and comparative assessments were made on NO_3 concentration and on the total N leaching.

Materials and methods

Experiments were carried out for two years (1999-2000) on maize monoculture (system a) in comparison with maize-ryegrass (system b) in a farm (F. Ricchieri) of the Province of Pordenone (PARENTE and VENERUS 1997, 1998, PARENTE et al. 1997); the farm is located in the Friuli lowlands at 30 m asl. The soil is medium-textured, loamy and basic. The annual average of rainfall is about 1260 mm. Four plots were compared: 2 plots with the system (a) and 2 plots with the system (b). During this period the leached water was collected by some lysimeters. Every plot had 3 lysimeters with a diameter of 30 cm (WEBSTER et al. 1993, LORD and SHEPHERD 1993) in different layers of the soil (70 cm, 110 cm and 140 cm).

Ryegrass (*Lolium multiflorum* CV ASSO) was sown (45 kg ha^{-1}) on 17.11.98 in 2 plots. During the spring of 1999 ryegrass was cut and soil ploughed. Maize (CV DK502 cl 500) was sown in all plots (7.2 plants m^{-2}) on 02.06.99. After maize harvest and soil harrowing, ryegrass (CV ASSO 45 kg ha^{-1}) was sown again (08.10.99) in 2 plots. In the following spring after ryegrass cutting and soil ploughing maize (CV CECILIA cl 500, 7.2 plants m^{-2}) was sown again (28.04.00). After maize harvest and soil harrowing ryegrass (CV ASSO 45 kg/ha) was sown (30.10.00) in 2 plots.

Maize was fertilized every year with 100 kg ha^{-1} of P_2O_5 and 100 kg $ha^{-1}$of K_2O and with a total of 210 kg $ha^{-1}$of N. Nitrogen was applied in 3 times, the first during the sowing and the following at two different growing stages: 4th leaves and 8th leaves. No fertilisers were applied to ryegrass plots. Irrigation was applied for a total of 125 mm in 1999 (5 times) and 75 mm in 2000 (3 times) during the maize growing period. The total rainfall was 992 mm during the 1st cycle (winter 98-99 plus summer 99) and 1290 mm during the 2nd cycle (winter 99-00 plus summer 00).

The leached water was collected periodically from the lysimeter plates and analysed in order to evaluate NO_3 concentration. The total volume of leached water was recorded and estimations were made on NO_3 and N- loss by leaching (kg ha^{-1}).

Results and discussion

The data of the two successive years has been aggregated into vegetative seasons, respectively „summer“ during maize growing and „winter“ with bare soil (system a) or ryegrass cover (system b). Data average has been obtained from all the plates of each plot (6 plates per treatment totally, irrespective of their depth). In each case the results indicate great differences between the maize + cover system and the maize monoculture system (*Figures 1* to *4*). The variation from season to season depends mainly on the different amount of water input in the soil, by rainfall plus irrigation.

The application of a cover during winter resulted in order to reduce the leached water of some 40-70% (*Figure 1*).

The cover treatment reduced NO_3 water concentration of about 50-80% (*Figure 2*), and reduced NO_3 and N leached of about 80-90% (*Figure 3-4*).

A synthetic estimation of the performances of the two systems is presented in *Table 1*. The average values are referred to one year of growing season. Considering a yearly input of 210 kg ha^{-1} of N, the cover treatment reduces the amount of leaching of about 10 times; in other words the cover has an apparent recovery of 98% vs. 83% of the monoculture. The grain DM yield seems not to be affected by the cover treatment, the production being not significantly different (8.0 t ha^{-1} with cover vs. 8.4 t ha^{-1} in monoculture). This indicates that the systems give the maximal productivity with this level of N fertilization with low leaching rate, and it suggests the opportu-

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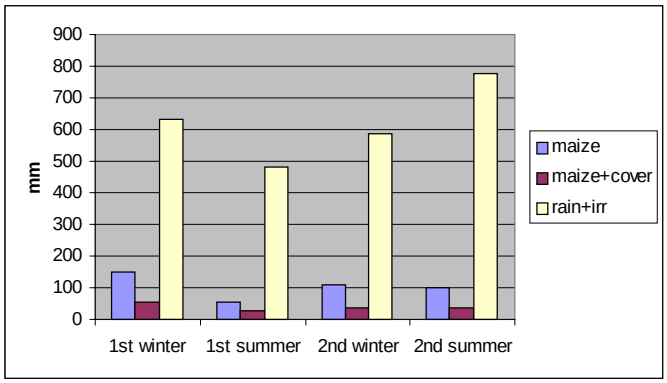

Figure 1: **Amount of leached water and total rainfall plus irrigation**

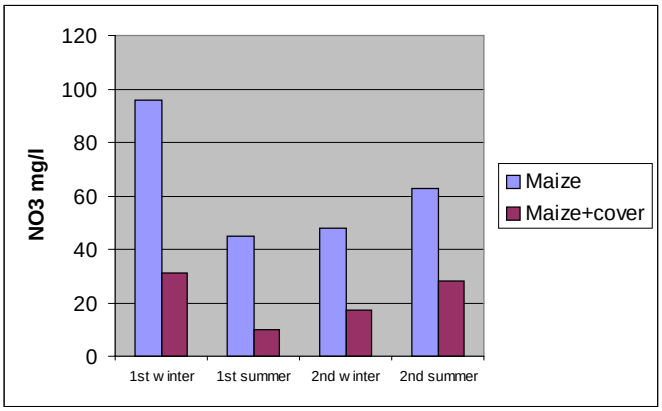

Figure 2: **Concentration of NO_3 in the leached water**

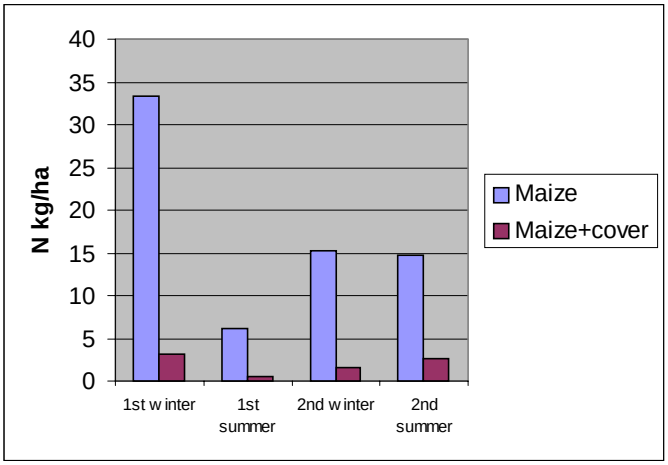

Figure 3: **Amount of NO_3 loss by leaching**

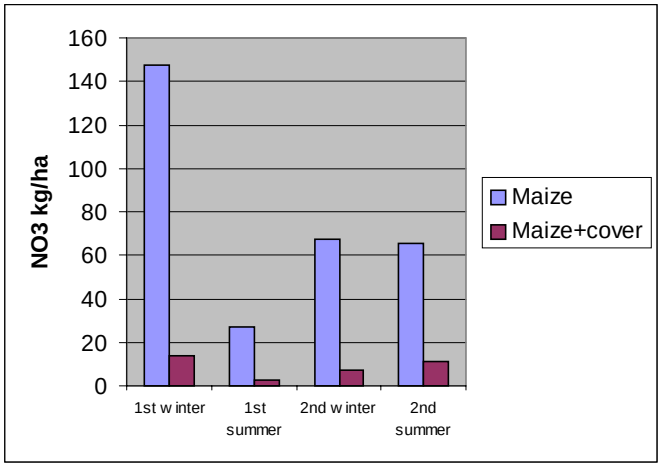

Figure 4: **Amount of N loss by leaching**

Table 1: **Comparison between two agricultural systems: annual average values**

	maize+cover	maize
Leached water (mm)	76.0	336.0
NO_3 concentration (mg l^{-1})	29.4	62.8
NO_3 leached (kg ha^{-1})	17.3	153.9
N leached (kg ha^{-1})	3.9	34.8
Maize grain yield DM (t ha^{-1})	8.0	8.4

nity to investigate the performance of the same systems treated with higher N fertilization rate (300-350 kg ha^{-1}), as usually farmers do in these areas.

The differences between systems are detected in summer periods too, when all plots are uniformly covered with maize and fertilised with the same N rate. This can be explained by the amelioration of the soil texture by means of a cover crop which is incorporated before the maize sowing. These results are particularly important for our areas during winter, when rainy periods can be long and heavy, and absolute amounts of leachate are high. It is possible to conclude that the use of cover crops, especially during winter, is very profitable in our areas with the main aim to reduce strongly the N leaching while maintaining a good productive potential.

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