Automated Suction Lysimeter

for nitrate leaching measurement in rye cover crop

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Introduction

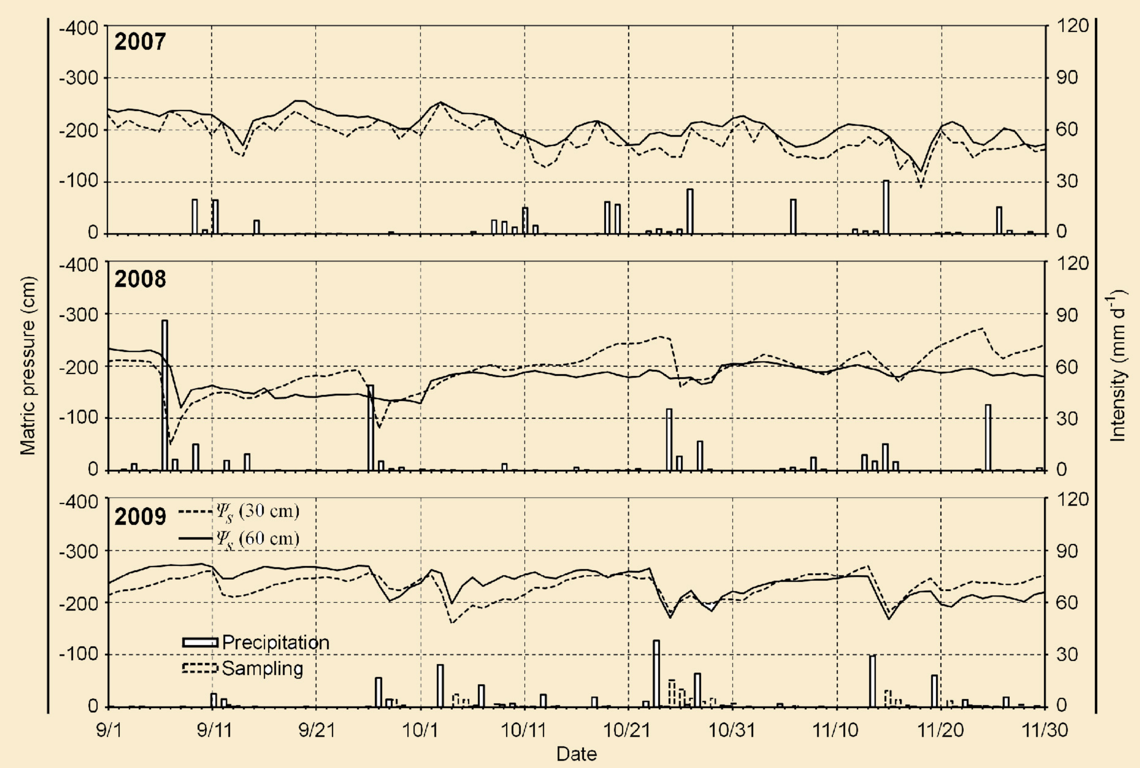
Fall and winter losses of N leaching in corn fields are avoidable and can be reduced or prevented if cover crops are planted early enough to be effective.

Planting date of cover crops has a critical effect on its nutrient recovery efficiency.

Determining the amount of after-harvest nitrate leaching requires an accurate leachate sampling method.

Automated suction lysimeters have recently been introduced to address these problems.

Our goal was to develop an automated lysimeter system and assess it under field conditions and use it for determining the amount of nitrate leachate from cover crop treatments.



daily average of soil matric pressure (30 and 60 cm), precipitation and water sampling during the sampling periods in years 2007 to 2009.

Materials and Methods

Winter rye cover crop was planted from early September to October at biweekly intervals in Deerfield, Massachusetts in 2008 and 2009. A randomized complete block design with four replications was used.

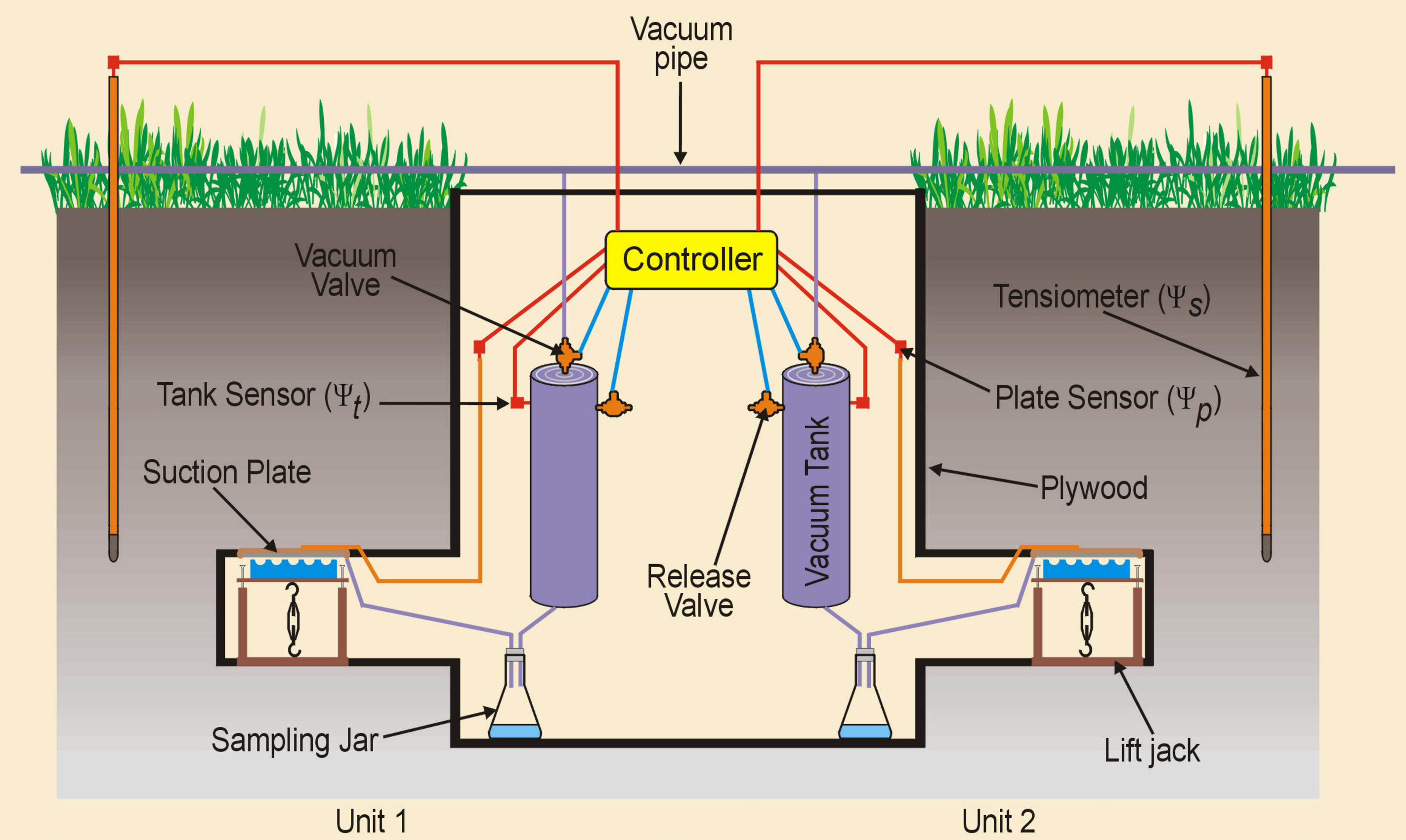
Hourly soil-water tension data and daily soil-water samples (volume and concentration) were collected using automated lysimeters installed in each plot (16 automated lysimeters in total). Tissue and soil samples were taken during fall, winter and next spring.

The electronic system was designed to monitor soil tension every second with accuracy of 1 mbar and to apply the equal amount of suction to the sampling media (suction cup or plate).

A regular suction cup was installed in each plot as the control treatment.
A Leakage detection module (LDM) was designed for protecting vacuum pump against unexpected major vacuum leakage events.

LDM shuts down the leaking unit, yet continues sampling data from vacuum sensors. LDM checks the leaking unit every hour. When no major leakage is detected, the system resumes working automatically.

Each unit has a separate LDM. Therefor leakage of a unit does not have any effect on the other one. Also main tank has a LDM for protecting the vacuum pump against major leakages.



Automated lysimeter system configuration. Each lysimeter can have up to 3 sensors and 2 relays. Tensiometer, soil-water sampler, sampling jar, vacuum tank, electronic valves and controller are the main parts of an automatic lysimeter. A main vacuum tank supplies vacuum for all the units.

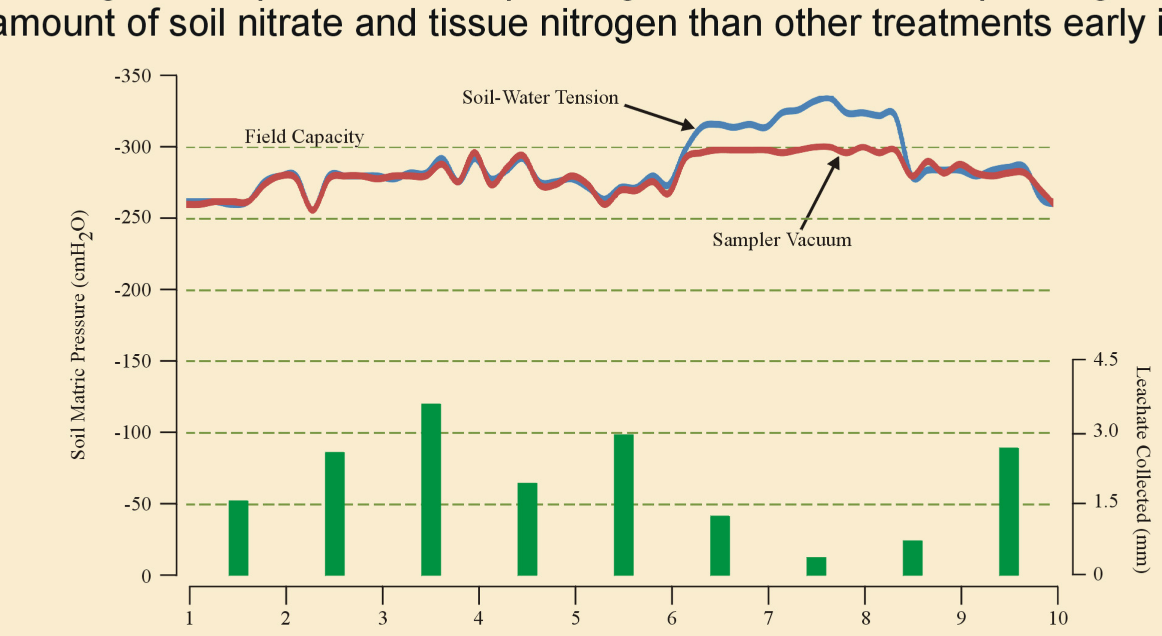
Results and discussion

Automated lysimeter had a very good performance in field conditions. The system managed to keep the tank vacuum level within the desired range.

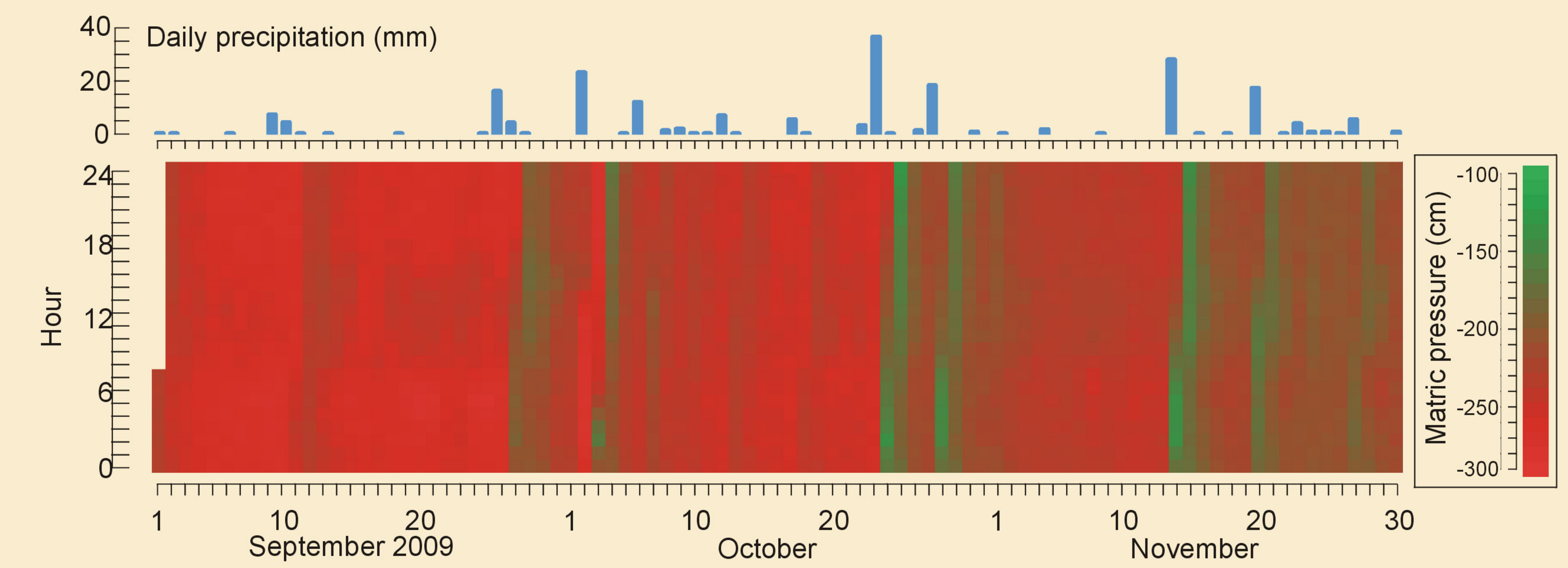
The volume of water collected from samplers in field condition was not very much consistent among the treatments. One possible reason can be horizontal water movement in soil profile. It can be preventable by pushing steal cylinders into the soil profile and above the water samplers.

LDM showed a very reliable performance. The ability of automatic resuming of this module can save a lot of time and effort since there is no need to restart each unit separately.

By the end of fall, plots planted in September 1st had significantly lower amounts of soil nitrate-N and soil-water nitrate concentration. Also cover crops in these plots contained highest amount of tissue nitrogen compared to other planting dates. First date of planting also had significantly higher amount of soil nitrate and tissue nitrogen than other treatments early in the next spring.



Daily precipitation, Soil-water tension and vacuum applied to a sampler in a soil column experiment. Automated lysimeter managed to follow the soil tension during the experiment. Controller was programed not to apply more than field capacity (< -300 cmH_2O) to water sampler.



Hourly soil-water tension and daily precipitation during the sampling period (Sept., Oct. and Nov. of 2009).Change in color after each rain incidence represents a drop in soil-water tension. Also gradual shift in color from Sept. to Nov. suggests a continuing decline in soil-water tension which is due to more intense rain events at the end of sampling period.

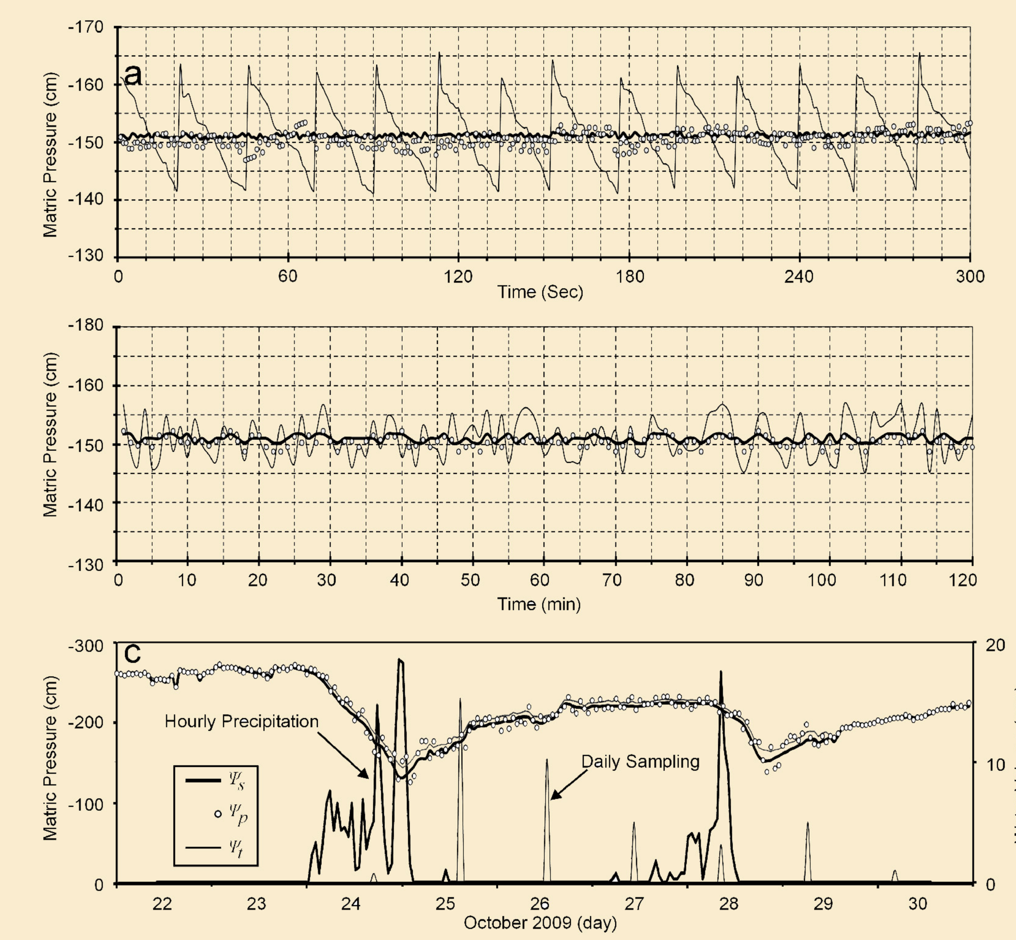
Conclusion

Automated lysimeter is a very accurate soil-water sampling device in vadose zone. It can be used easily for all-year-round sampling and data logging with minimum supervision. Automated lysimeters are more cost effective and accurate in comparison with container lysimeters.

The electronic system showed a very reliable and accurate performance in the field condition.

Although the automated lysimeters seem to be the most accurate soil-water sampling devices, there is a need for an standard laboratory testing system for evaluating their performances.

These cover crop tissue and soil results confirmed the effectiveness of cover crop in N recovery and the importance of planting date of winter rye for maximum nutrient recovery



(a) System performance during 300 seconds of the laboratory experiment (data record per each program cycle). (b) During 120 minutes of laboratory experiment (data record every minute without averaging). (c) Field performance from 22nd to 30th of 2009 (data record every hour without averaging).