Grasses as catch crops to reduce N leaching in orchards

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Introduction

Climate, soil and water are the main factors determining the choice of soil management methods in orchards and vineyards. Soils are usually managed in 3 main systems i.e. i) mechanical operations and/or chemical operations to weed; ii) temporal grass cover and mechanical operations in spring; iii) permanent grass cover. Permanent grass cover with natural or artificial species may be used on the whole surface or only on inter-rows, weeding planting-rows. Legumes are used as a green manure, soil cover and living mulch to improve soil properties and to enrich the soil through their rhizobial N fixation ability (PARENTE and FRAME, 1993). Pure-sown grasses fulfil several functions as soil cover and catch crop in different types of orchards and vineyards, although irrigation is needed in many cases during drought periods to avoid sward-tree competition for water. Sowing specific grasses of reduced size can result in many advantages, namely, soil cover, reduced sward-tree competition for water, weed growth inhibition, possibility to make pesticide treatments in every climatic condition, enhanced sward bearing, increased organic matter soil content, increased nutrient availability and reduced soil surface temperature in summer. Conversely, disadvantages may occur, namely, high seed costs, a heaven for certain pests, increased risks for radiation frost, significant sward-tree competition for water. While grasses may cause a yield decrease, fruit quality can be improved and ground water quality may be preserved in Environmentally Sensitive Areas (ESAs) characterised by shallow soils (VENERUS et al., 1996).

Materials and Methods

The trial was carried out at Spilimbergo (102 m a. s. l.) in an ESA area of North-eastern Italy (46° 6' 13'' N, 12° 54' 48'' E) on shallow and gravely soil, during a 4-year period (09 March 1994 - 16 February 1998).

An apple-orchard (cvs. Golden and Granny Smith on M9) was planted in 1990, at a plant distance of 4 x 1.20 m, and supplied with spray irrigation system. Because of the soil type, special field lysimeters (ceramic porous plates, 30 cm of diameter) were inserted into the soil in February 1992, at different depths in order to measure leaching (LORD and SHEPHERD, 1993; WEBSTER et al., 1993) under planting-rows and inter-rows of the apple-orchard. In this paper only N leaching values, measured at the depth of 140 cm in 3 management systems i.e. bare soil (A), completely grass covered soil (B) and partially grass covered soil (C), are reported. A sheep's fescue (Festuca ovina L.)/ryegrass (Lolium perenne L.) mixture (30 + 30 kg ha^{-1}) was sown in 1993, after having ploughed the inter-rows covered by weeds and spontaneous grasses. This association was chosen according to the results of previous researches (BOZZO and PARENTE, 1992) carried out in this area. Grass was cut 3 times per year and left on soil as mulch.

In the first 4-year period (1990-93), after trees planting (1990), the apple-orchard was fertilised by N (150 kg ha^{-1} year^{-1}) according to the practises used by farmers in this area. During the 4-year period of the trial (1994-98), only 60 kg ha^{-1} year^{-1} of N (30 kg on inter-rows and 30 kg on planting-rows) were distributed, according to regional regulation and the EU regulation No. 2078/92.

4 spray irrigations (20 mm each) were made in average per year.

Water samples were taken every week and NO_3^- concentration was determined by spectrophotometry (220 mm).

The amount of the leached N ha^{-1} was calculated considering the diameter of the ceramic plates. These values were corrected considering both the real measured quantity of leached water (mm) and the values calculated according to a protocol (MACDONALD and WEBSTER, 1996) verified *in loco* by different trials (PARENTE et al., 1994). The amount of leached water in bare soils of orchards in this area is approximately 50% of the total available water (rainfall + irrigation).

Results and discussion

The values of available water (rainfall + irrigation), leached water (mm) and kg ha^{-1} of N leaching are reported in *Table 1*. It can be noticed that the values of N leaching were very high in the first year and that these values were decreasing during the 4-year period of the trial. This fact maybe explained both because of disturbances induced by placing the ceramic plates into the soil and because there was a residual effect of the previous high fertilisation levels. In the treatment where the apple-orchard was managed by system A, the values of N leached were decreasing from 137 to 25 kg ha^{-1} with an average value of 74 kg ha^{-1}, higher than the amount of N applied per year. Nevertheless, the positive effect of grass soil cover is evident even in the first year, both in B (23 kg ha^{-1}) and in C (45 kg ha^{-1}) systems. Moreover, system B is the most efficient in catching N, considering the lowest (5) and highest (23) values of kg ha^{-1} year^{-1} of N leached during the period of the trial. Good results are obtained also by system C that shows the lowest value of 17 kg ha^{-1} in the 4th year and the highest value of 45 kg ha^{-1} in the 1st year.

In *Table 2*, NO_3^- concentration (mg l^{-1}) values in leached water are reported for the same 4-year period. In the 1st year

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Table 1: **Available water (R+I), leached water (mm) and kg ha^{-1} of N leached**

	9/3/94-27/2/95		27/2/95-12/2/96		12/2/96-10/2/97		10/2/97-16/2/98		Average	
R+I (mm)	1380		1647		1996		1125		1537	
	mm	kg ha-1	mm	kg ha-1	mm	kg ha-1	mm	kg ha-1	mm	kg ha-1
System A	690	137	824	85	998	50	562	25	768	74
System B	694	23	725	14	588	5	132	10	535	13
System C	781	45	804	39	680	21	234	17	625	30

Table 2: **NO_3- concentration (mg l-1) values in leached water**

	9/3/94-27/2/95	27/2/95-12/2/96	12/2/96-10/2/97	10/2/97-16/2/98	Average
	NO_3^- mg l^{-1}	NO_3^- mg l^{-1}	NO_3^- mg l^{-1}	NO_3^- mg l^{-1}	NO_3^- mg l^{-1}
System A	88	45	23	20	44
System B	23	8,3	3,1	8,2	11
System C	28	22	9,8	16	19

of the trial, the values for system A are very high (88) decreasing to more acceptable levels in the 4th year (20). Systems B and C show to be very efficient, because water was with very low NO_3^- concentration values. System B has values between 3.1 and 23 mg l^{-1} and system C between 9.8 and 28 mg l^{-1} .

In *Table 3* are reported the percentages of N leached per year, considering only the rates of N applied (60 kg ha^{-1} year^{-1}). The system A shows a very high percentage (228 %) of N leached in the 1st year. This value includes N applied and residual effect of soil N. Nevertheless, during the 4th year of the trial, when the negative effects of the soil disturbances should not have influenced the systems, system A shows very high percentages of N leached (42 %) according to the relatively low quantity of N applied. In the same year, only 17 % and 28 % of N applied is leached respectively in systems B and C.

Conclusions

The trial carried out in an ESA area, characterised by shallow and gravel soil, shows the opportunity of using grasses as catch crops in orchards and vineyards, in order to reduce N leaching and preserve water quality. This is the case even when using low N fertiliser levels according to local and EU regulations. Shallow and gravely soils in bare condition are a risk both for water quality and for economically aspect because very high percentages of N may be leached. Completely grass-covered soil is the most environmentally friendly system in orchards of these fragile areas and it should be strongly suggested in similar pedoclimatic conditions. Nevertheless, orchards managed with grass covered inter-rows and weeded planting-rows may also be convenient because of acceptable percentages of N leached and quite low concentration values. These values are always lower than the present limits of EU regulations (50 mg l^{-1} NO_3^-).

Also in grass covered orchards and vineyards, farmers must be very careful when grass restoration is needed because mechanical operations may cause disturbances and N leaching. In these circumstances, grass renovation may be practised by sod-seeding or direct drilling techniques.

Table 3: **Percentage (%) on N leached**

	1year	2year	3year	4year	Average
System A	228	142	83	42	124
System B	38	23	8	17	22
System C	75	65	35	28	51

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Summary

In an Environmentally Sensitive Area (ESA) of North-eastern Italy, a 4-year field-lysimeter trial was carried out in order to measure N leaching in an apple -orchard planted on a shallow and gravely soil.

The use of cover crops, especially of grasses as catch crops, in orchards and vineyards is becoming more and more important because of the role in regulating soil water content and in retaining nutrients applied by mineral fertilisers. Field lysimeters were placed at a depth of 140 cm in an orchard soil managed by 3 different treatments i.e. bare soil (A), completely grass covered soil (B) and partially grass covered soil (C). A sheep's fescue (Festuca ovina L.)/ryegrass (Lolium perenne L.) mixture was used as catch crop.

During the C and A Grasses used as catch crops in orchards proved to be an important tool in reducing N leaching and in enhancing N efficiency.

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