NUTRIENT LEACHING AND RUNOFF IN THE MEDITERRANEAN DAIRY SHEEP FARMING SYSTEMS

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ABSTRACT
Three years of research were carried out in Sardinia (Italy) to evaluate the environmental impact on the soil and water from intensification of the dairy sheep farming systems. An extensive rainfed system based on permanent pasture was compared with an intensive irrigated system based on a three year rotation (double cropping/lucerne). Runoff, soil erosion and nutrient losses were negligible. Nutrient losses by leaching had more important results with clear differences between forage crops. In terms of system losses, the differences were less marked.

KEYWORDS
Erosion, runoff, leaching, N-P-K, intensification

INTRODUCTION
The dairy sheep farming system is very important in Mediterranean countries; 73.2% of world production of ewes' milk is concentrated in these countries (FAO, 1990). Sardinia represents this reality very well with about 3,500,000 dairy sheep.

In the last years the area of dairy sheep farming system in the island has increased in a considerable way for the progressive utilization of most favourite areas in the lowlands.

At the same time, in the lowlands, irrigation projects were developed on a large scale. As consequence, the rainfed forage systems, traditionally based on the use of short term forage crops and winter cereals (Sulas et al., 1995), evolved toward irrigated systems based on double cropping (summer cereal in succession with short term forage crops) characterized by high costs and high fertilizer inputs (Roggero et al., 1995).

The objective of this research was to evaluate the environmental impact from intensification of the farming systems. In the present paper are reported aspects concerning soil erosion and nutrient losses by runoff and leaching in the main forage crops of the studied area.

METHODS
The experiment was developed at the Bonassai Research Station of the Istituto Zootecnico e Caseario per la Sardegna (NW Sardinia). The climate is typical of the central Mediterranean area with an average total annual rainfall of 547 mm, mainly concentrated in autumn.

The experiment was carried out during a three year period (1993-1995) on a clay loam alluvial soil; the total nitrogen and available phosphorus content was 0.14% (Kjeldahl) and 14.9 ppm (Olsen) respectively.

Two forage systems (2 ha each) at different intensification levels were compared:
ES: Extensive rainfed system, based on permanent pasture (PP) (35N-90P_2O_5 kg ha^{-1} $year^{-1}$) constituted by annual self-reseeding species.

IS: Intensive irrigated system based on a three year rotation, with double cropping (DC) of Italian ryegrass (70N-90P_2O_5 kg ha^{-1} $year^{-1}$) and corn (300N-92P_2O_5 kg ha^{-1} $year^{-1}$) on 50% of the surface and a lucerne meadow (M) (150P_2O_5 kg ha^{-1} in the seeding year and 90P_2O_5 kg ha^{-1} $year^{-1}$ as top dressing in the following year) on the other 50%. The two forage systems fed two flocks of Sardinian dairy sheep with a stocking rate of 8 and 16 sheep ha^{-1} in ES and IS respectively. The flock grazed rotationally in the first system while it was always stabled in the second one. In every field crop was realized an isolated plot from external surface runoff (0.5% slope, 150 x 15 m in size). A ditch received runoff and conveyed it to an automatic device for its quantification (triangular overflow -ISO 1438/1, 1980) and sampling (automatic sample extractors). Rainfall events were classified according to the definitions of Wishmeier & Smith (1978) and the maximum rain intensity in 30' (I_{30}max) was also calculated. Physical-chemical analysis quantifying erosion and nutrient losses were also performed.

Leaching volumes and the nutrient losses were determined using for each crop a lysimeter (3 m wide x 2.8 m large x 1 m deep) realized near to the main plots.

Total P_2O_5 was determined using an atomic absorption spectrophotometer, NO^-_3 by a molecular absorption spectrophotometer and K_2O by a flame photometer.

RESULTS AND DISCUSSION
The three years were characterized by a decreasing rainfall trend: 561 mm, 475 mm and 427 mm in 1993, 1994 and 1995 respectively. Rain events greater than 12.5 mm (Wishmeier and Smith, 1978) ranged from 11 in 1994 to 15 in 1993. The most intense rain event during the trial (I30max = 102 mm h-1) was recorded in August, 1995.

Runoff (tab. 1) coefficient was always very low; only in one case did it exceed 1% (1.7 % on PP in 1995).

Runoff turbidity resulted higher in DC than PP and M because the few rain events that originated runoff occurred in the autumnal season when the covering rate was very low for the DC.

The maximum total erosion amount was recorded in 1995 on PP with 86 kg ha^{-1}. On lucerne and double cropping, soil losses ranged between 5/29 and 20/30 kg ha^{-1} $year^{-1}$ respectively.

Runoff nutrient losses were determined by a few important events (1/3 $year^{-1}$).

The N-NO^-_3 losses were always below 300 g ha^{-1} $year^{-1}$ (tab. 2), while the phosphorous losses were negligible: only 4.2 g ha^{-1} per mm of runoff on the general average, with few differences between crops. The peak of potassium losses was recorded on PP in 1995 with 2.2 kg ha^{-1}.

On the whole, runoff effect (erosion and nutrient losses), even at a high fertilizing level (DC), may be considered negligible in accord to Pagliai & Sequi (1981) and to the results obtained by Acutis *et al*. (1992b) in a similar experiment in a wetter environment (Piemonte region, NW Italy).

The leaching volume (Table 1) and nutrient loss results were gener-

ally more important if compared with runoff losses (Table 2). On the average were leached 36.4, 10.1 and 2.6 kg ha^{-1} $year^{-1}$ of $N\text{-}NO^{-}_{3}$ on DC, PP and M respectively. About 38% of N losses in DC occurred during summer under irrigation in the 1st year.

The higher leaching values for phosphorus were recorded on M (0.6 kg ha^{-1} $year^{-1}$) and for potassium (3.6 kg ha^{-1} $year^{-1}$) on DC.
As far as the leaching nutrient losses are concerned the results showed clear differences between crops.

In term of system losses (rainfed *vs*. irrigated) the differences were less marked.

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REFERENCES

Acutis, M., C. Grignani and **A. Reyneri.** 1992. Perdita di suolo e qualita delle acque ruscellate da terreni sistemati a spianata e coltivati a mais. Riv. di Agron. 1992, 26, 4 suppl., pp 648-654.

FAO, 1990. Trade and Production Year Books. Vol. 43 (1989 statistics).

Pagliai, M. and **Sequi, P.** 1981. The influence of applications of slurries on soil properties related to runoff. Nitrogen losses and surface run-off from landspreading of manures. J. C. Brogan editor, p. 47.

Roggero, P.P., G.A. Re and **C. Porqueddu.** 1995. Seed production of European white clover varieties in the Mediterranean sheep grazing system. *Proc. of 3rd International Herbage Seed Conference*, Halle (Saale), Germany, 18-23 giugno, 246-250.

Sulas, L., C. Porqueddu, P.P. Roggero, S. Caredda and **S. Ligios.** 1995. Validita agronomica e sostenibilita di un pascolo migliorato con specie autoriseminanti in alternativa all'erbaio autunno-vernino nei sistemi foraggeri asciutti mediterranei. Riv. di Agron. XXIX, suppl. al n. 3, luglio-settembre 1995, pp 468-475.

Wishmeier,W.H. and **D.D. Smith.** 1978. Predicting rainfall-erosion losses from cropland east of the Rocky Mountain. USDA Agricultural Handbook n. 537.

Table 1
Relationships between soil cover and annual surface runoff (R) and leaching (L) in mm

	Permanent pasture		Lucerne		Double cropping	
	R	L	R	L	R	L
1993	1.7	40.8	3.1	119.8	0.1	147.1
1994	0.2	0.0	0.3	137.3	0.1	82.6
1995	7.0	0.0	< 0.1	1.1	< 0.1	23.6

Table 2
Relationships between soil cover and runoff nutrient losses RL) and leaching nutrient losses (LL) in kg ha^{-1}

		Permanent pasture		Lucerne		Double cropping	
		RL	LL	RL	LL	RL	LL
$N\text{-}NO^{-}_{3}$	1993	0.1	30.3	0.3	2.3	< 0.1	68.2
	1994	< 0.1	0.0	< 0.1	5.5	< 0.1	14.9
	1995	< 0.1	0.0	< 0.1	< 0.1	< 0.1	26.1
P_2O_5	1993	< 0.1	0.1	< 0.1	0.8	< 0.1	1.2
	1994	< 0.1	0.0	< 0.1	1.1	< 0.1	0.4
	1995	< 0.1	0.0	< 0.1	< 0.1	< 0.1	0.2
K_2O	1993	< 0.1	3.4	0.1	3.9	< 0.1	5.4
	1994	< 0.1	0.0	< 0.1	2.6	< 0.1	2.1
	1995	2.2	0.0	< 0.1	< 0.1	< 0.1	3.5