INFLUENCE OF PUMICE MULCH ON SOIL INFILTRATION RATE

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Abstract
In arid and semiarid regions with scarce rainfall and frequent erosion processes a variety of farming practices have been devised to conserve soil and water. One of these consists of the use of organic and inorganic materials as surface mulch. The use of volcanic materials for this purpose is commonplace in arid parts of the Canary Islands (Spain). In the south and south-east of Tenerife extensive surface coverings of salic volcanic materials (outcrops and pyroclasts) from Pliocene-Quaternary eruptions have propitiated the development of a peculiar farming practice known as 'jable'. The technique involves the placing of a layer of salic pyroclasts to facilitate soil and water conservation. Cultivation takes place in the underlying soil. The pyroclast mulch is of variable thickness (20-50 cm) and the degree of mixing with the soil also varies greatly, depending on the age of the system. In some parts, where the pyroclasts have suffered some weathering, cultivation is possible directly on them. Potatoes are the most frequently-grown crop in this dry farming system.

The present paper studies the effect of this traditional practice on soil water infiltration capacity. A number of sites, situated at heights between 300 and 1200 m.a.s.l. and with different soils (Aridisol, Vertisol, Inceptisol), were chosen. Each site contained plots covered with a (35-45 cm) layer of salic pyroclasts and other plots which were left uncovered. Infiltration rate was measured using a double ring infiltrometer, with three replications in each case. The results show the importance of this traditional practice in arid and semi-arid regions. Irrespective of the type of underlying soil, the infiltration rate improved considerably (to the extent that the infiltration class was modified by at least one category) and runoff was reduced.

Additional Keywords: Arid and semi-arid regions, soil erosion, salic materials, Canary Islands, Tenerife, land use

Introduction
In arid and semiarid regions with scarce and torrential rainfall, lithic mulch is often used as part of a farming system to conserve soil water and enhance crop yield. Many studies have examined the reduced moisture loss produced by the action of the mulch. However, the application of these inorganic coverings has noteworthy effects on erosion processes also. Opinions differ as to their effect: some authors have reported significant increases in the infiltration rate, with the consequent reduction in erosion in soils covered with rock fragments (Box 1981; Collinet and Valentin 1984; Tejedor *et al.* 2003), while others have found the opposite results (Wilcox *et al*. 1988; Rawls and Brakensiek 1989; Abrahams and Parsons 1991; Casenave and Valentín 1992; Poesen and Lavee 1994).

Certain arid parts of the Canary Islands have seen the development of a number of farming systems for soil and water conservation, including some based on the use of volcanic materials as mulch on the soil surface. Traditional systems of this type include '*jables*' in Tenerife, where the soil is covered with pumice materials.

The objective of the present paper is to examine the influence of the salic pyroclasts on the basic infiltration rate by comparing mulched and unmulched adjacent soils.

Materials and Methods
Selection and description of the field plots
Six sites situated at 300-1,200 metres altitude on the southern side of Tenerife (Canary Islands, Spain) which are used for the peculiar farming system described above were selected for the study. On each site, plots which had been covered with 35-45 cm of pumice and adjacent uncovered plots with natural vegetation were chosen, the latter as control plots.

<u>Sites 1, 2 and 3</u>. (300-500 m.a.s.l.). The soils are Aridisols (Fernández Caldas *et al.* 1982) and the plots have been put to different uses. Plot 1 is used for growing potatoes, Plot 2 is currently abandoned and has never been used for cropping, while Plot 3, also abandoned at present, was used to grow potatoes for many years. In all three cases, the natural vegetation on the uncovered plots is *Euphorbia sp.*, *Launaea arborecens*, *Opuntia ficus-indica.*

Site 4 (600 m.a.s.l.).- The soils here are Vertisols and the covered plots are currently used for growing potatoes and grapes. Natural vegetation includes, primarily, *Euphorbia sp.*, together with other species such as *Rumex lunaria* and *Opuntia ficus-indica* also present.
Site 5 (800 m.a.s.l.).- These are Inceptisols and grapes are grown on the mulched plots. Vegetation in uncovered parts consists of *Rumex lunaria,. Papaver somniferum* and *Opuntia ficus-indica.*
Site 6 (1100 m.a.s.l.).- Inceptisols; like the previous site, grapes are grown on the covered plots. The uncovered parts are occupied by species such as *Rumex lunaria* and *Pinus canariensis.*

Analysis
For the determination of the infiltration rate the classic double-ring method was used (Bouwer 1986) with three replications. The infiltration rate (mm/h) was measured at different times until the steady state was reached. Measurements were taken in the mulched soil and in the soil without mulch. The classification for infiltration classes defined by Landon (1991) was followed.

Bulk density was determined in triplicate using an undisturbed sample and cylinders of known volume. The soil samples were taken from the first 30 cm of the mulched and unmulched soils. Samples for physical analysis were air-dried and sieved to 2 mm. Wet sieving was used to determine the percentage of coarse elements. Particle-size distribution was determined by the Bouyoucos hydrometer method. Results were analysed statistically using the SPSS package, version 11.0.1 (SPSS Inc. 2001).

Results and Discussion
Table 1 gives some of the physical properties of the soils related to their infiltration capacity, which varies according to the typology. The infiltration rate and infiltration classes are also shown. The results show a generally higher infiltration rate in soils covered with ‘jable’, with (in some cases) a modification in the basic infiltration class proposed by Landon (1991).

In figure 1, which illustrates the infiltration rates for the covered and uncovered soils at site 1, one can see not only a higher basic velocity in the mulched soils but also that they take longer to reach said velocity. The initial rate is also seen to be much higher in the covered soils. The statistical analysis using the Wilcoxon test reveals significant differences between the mulched and unmulched soils for the sample set studied.

Table 1. Physical characteristics

Site	Land use	clay (%)	fraction > 2 mm (%)	Bulk density (g/cm^3)	Infiltration rate (mm/h)	Infiltration classes (Landon 1991)
Site 1	Mulched soil	30.6	35.2	0.49	116	Moderately fast
	Unmulched soil	19.1	26.5	1.01	45	Moderate
Site 2	Mulched soil	47.3	20.3	1.19	24	Moderate
	Unmulched soil	42.9	21.6	1.31	45	Moderate
Site 3	Mulched soil	38.8	38.2	1.15	60	Moderately fast
	Unmulched soil	46.9	19.3	1.33	36	Moderate
Site 4	Mulched soil	51.7	13.7	1.08	56	Moderate
	Unmulched soil	48.5	19.7	0.87	21	Moderate
Site 5	Mulched soil	25.7	22.8	1.45	65	Moderately fast
	Unmulched soil	30.5	18.2	1.13	46	Moderate
Site 6	Mulched soil	30.4	24.8	1.36	105	Moderately fast
	Unmulched soil	37.4	18.5	1.25	85	Moderately fast

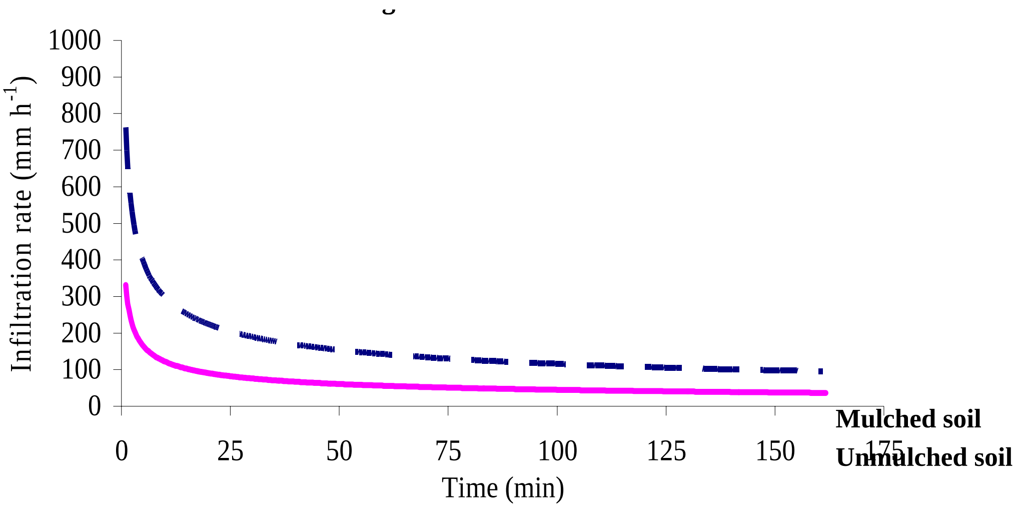

Figure 1. Infiltration curve. Site 1

The relationship between the physical parameters listed in table 1 and the infiltration rate was tested for using a unilateral Spearman correlation, the results of which are given in table 2.

Table 2. Statistical results

Parameter	Bulk density (gr/cm^3)	Fraction > 2mm (%)	Clay (%)
Correlation coefficient	0.140	0.326	-0.515
Significance	0.332	0.151	0.043

As expected, an inverse and significant correlation ($p < 0.05$) is found between the infiltration rate and the clay percentages. In the case of the coarse elements, the correlation is positive, albeit not 95% significant.

The clay content and the coarse fragments of the soils are closely associated with the presence of pumice cover and the use made of the soil. The oldest plots, where the pumice and soil have mixed extensively, show the greatest increases in infiltration rates (sites 1 and 3) in the covered soils, whereas in the youngest plots, where this mix is not present, the increase is lower (sites 5 and 6) and indeed the rate is even seen to fall in one case (site 2), as a result of the higher clay and the lower stone content of the mulched soil.

These findings are in line with those of other authors such as Ravina and Magier (1984), who note that coarse elements (in our case the sands from the degraded ‘jable’) help improve the physical properties of the soils, increasing porosity, hydraulic conductivity and infiltration, as has also been reported by Fernández-Sanjurjo (1999).

Although the statistical tests fail to produce definitive results as regards the relationships, it can be concluded that the use of a pumice covering does propitiate an increase in the infiltration rate. Hence, it is considered a good erosion control system in arid and semiarid parts, while also improving agricultural productivity

Acknowledgements

This research was funded by the Consejo Insular de Aguas de Tenerife (Project: *Caracterización de los suelos de la isla de Tenerife, con especial incidencia en su funcionamiento hídrico*)

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