This article was downloaded by: [New York University]
On: 01 February 2015, At: 14:22
Publisher: Taylor & Francis
Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK

Communications in Soil Science and Plant Analysis
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/lcss20

Grazing as a cause of lime precipitation in a natraqualf

Raul S. Lavado [a] , Gerardo Rubio [a] & Margarita Alconada [b]

[a] Departamento de Suelos, Facultad de Agronomia , Universidad de Buenos Aires , Avenida San Martin 4453, Buenos Aires, 1417, Argentina

[b] Departamento de Suelos , Ministerio de Asuntos Agrarios de la Pcia. de Bs. As. , Av. 32 No. 949, La Plata, Argentina

Published online: 11 Nov 2008.

To cite this article: Raul S. Lavado , Gerardo Rubio & Margarita Alconada (1993) Grazing as a cause of lime precipitation in a natraqualf, Communications in Soil Science and Plant Analysis, 24:11-12, 1389-1396, DOI: 10.1080/00103629309368884

To link to this article: http://dx.doi.org/10.1080/00103629309368884

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the “Content”) contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms & Conditions of access and use can be found at http://www.tandfonline.com/page/terms-and-conditions

Downloaded by [New York University] at 14:22 01 February 2015

COMMUN. SOIL SCI. PLANT ANAL., 24(11&12), 1389-1396 (1993)

GRAZING AS A CAUSE OF LIME PRECIPITATION IN A NATRAQUALF

Raul S. Lavado and Gerardo Rubio
Departamento de Suelos, Facultad de Agronomia, Universidad de Buenos Aires. Avenida San Martin 4453, 1417 Buenos Aires, Argentina

Margarita Alconada
Departamento de Suelos, Ministerio de Asuntos Agrarios de la Pcia. de Bs. As. Av. 32 No. 949, La Plata, Argentina

Downloaded by [New York University] at 14:22 01 February 2015

ABSTRACT: The movement of water from the watertable to the atmosphere is one of the most common causes for $CaCO_3$ accumulation on top of the soil. In the Flooding Pampa, the increase in water evaporation due mainly to the reduction of soil cover as a result of grazing has given place to pulses of topsoil salinization. We investigated the influence of this process on lime precipitation in the upper horizon. Data from continuous grazed and ungrazed areas were considered. The relative ion concentrations in the upper horizon of the ungrazed area and in the phreatic water were very similar. Under grazing, absolute ion concentration was larger than in the water table. The anionic constituents did not increase directly and linearly. Chlorides and sulfates showed increments. The carbonate proportion did not change, but bicarbonates showed a relative decrease. This latter reduction could be related to the precipitation of CaCOs in the uppper horizon of the soil. In agreement, the Ion Activity Product (IAP) of the calcite of the soil solution indicated conditions for saturation of $CaCO_3$ in the grazed area. Conversely, the IAP showed $CaCO_3$ undersaturation in the ungrazed area. In spite of the evidence for the ocurrence of lime precipitation, the top horizon did not show measurable lime under grazing. This fact could be explained by considering both the usual time taken by $CaCO_3$ precipitation, and the recent and episodic process of top soil salinization in this region after the introduction of livestock.

Copyright © 1993 by Marcel Dekker, Inc.

INTRODUCTION

The presence of lime in soils is a very important feature in terms of soil classification, management, or fertilization. There are different pathways for calcium carbonate ($CaCO_3$) accumulation in soils. The precipitation of lime during the passage of water from the water table to the atmosphere is the most common reason of lime precipitation in soils with a shallow water table (1,2). The precipitation of different minerals depends on their solubility. As saline groundwater moves upwards minerals with low solubility such as calcite and gypsum precipitate within the profile (3), whereas more soluble Na-Mg salts eventually precipitate over the surface of the soil as efflorescence (4). There is extensive literature describing the chemical evolution of such soil solutions. According to the Hardie-Eugster model, as saturation with respect to a specific mineral is reached, further concentration results in precipitation and changes in the solution composition, which will depend upon the initially ions present in the solution. Evapotranspiration is generally considered to be the main mechanism of concentration which results in the precipitation of evaporite minerals (5). The time spent for the $CaCO_3$ deposit is estimated in some thousands years (6).

The Flooding Pampa is a wide region, located in eastern Argentina with predominance of halohydromorphic soils subjected to the effect of a high water table (7). In those salt-affected soils, the lime accumulation in the profile is also produced during the passage of water from the water table to the atmosphere (8). In most profiles, lime is located in deep horizons, around the upper limit of the water table (8,9).

Most of the Flooding Pampa is covered by grasslands devoted to the production of beef cattle (10). Compared with ungrazed conditions, in areas subjected to continuous grazing fluxes of water and salts from the water table were observed. The salt content of the top soil showed episodical increases, while that of deep horizons is independent of land use and related to the phreatic water. Grazing resulted in the salinization of the surface horizon mainly through the reduction in litter and standing dead material, and the consequent increase in water evaporation by one order of magnitude (9,11). It has been stated that this process started or intensified after the introduction of domestic herbivores in the region in the last century (9,12).

Downloaded by [New York University] at 14:22 01 February 2015

Table 1. Characteristics of the soil.

Horizon Depth (cm)	Ap 00-16	B1 16-23	B21 23-36	B22 36-69	B31 69-115	B32 115-
pH[a]	8.5	9.3	9.3	9.2	8.8	7.8
Organic[b] carbon (%)	0.95	0.44	-	-	-	-
Clay[c] (%)	24.1	42.9	61.9	49.4	39.0	33.2
Silt (%)	65.2	51.4	32.4	41.0	50.3	52.4
Sand (%)	10.7	5.7	6.6	0.0	9.0	14.4
Lime[d] (%)	0	0	0	0	[illegible]	2.5
C.E.C.[e] (me/100g)	20.1	36.6	45.0	32.6	25.9	22.4

a) pH in paste (13).
b) Organic carbon by Walkley and Black method (13).
c) Particle size analysis by pipette method (10).
d) Lime by Allison method (13).
e) Cation exchange capacity by ammonium acetate method (13).

In this work, we studied the influence of grazing on $CaCO_3$ precipitation in the superficial horizons of a Natraqualf. We hypothetized that under actual grazing conditions the shallow groundwater passing throughout the soil profile becomes more concentrated and the least soluble salt, $CaCO_3$, precipitates on the upper horizon.

MATERIALS AND METHODS

The study was carried out in Veronica, located to the Northeast of the Flooding Pampa. The soil is a Typic Natraqualf with some vertic characteristics. The annual rainfall (80 year average) is 950 mm.

The observations were carried out on two contrasting areas: a) grazed area, a degraded tall wheatgrass (*Elytrigia elongata*) pasture subjected to continuous

Downloaded by [New York University] at 14:22 01 February 2015

grazing by cattle, and b) an ungrazed enclosure built two years before in the continuously grazed field. One soil pit in each treatment was studied. Some properties of the soil profile, located in the grazed area, and the methods used are shown in Table 1. Five soil samples were taken in each area in December 1987. During the same summer, we observed that under grazing conditions the salt content was significantly higher ($P < 0.05$) than in non grazed adjacent areas (12). The depth of the water table was recorded in two observation wells and water samples were extracted.

The soil samples from each area and the water samples were analyzed for paste pH, and electrical conductivity (EC) in a soil saturation extract and in the groundwater samples. Also, soluble cations were determined by atomic absorption spectrophotometry and soluble anions by titrimetry. In addition, the Sodium Adsorption Ratio (SAR) was calculated (13). The logarithmic form of the Ion Activity Product of the calcite (pIAP) was calculated using the corresponding equations (14).

Downloaded by [New York University] at 14:22 01 February 2015

RESULTS AND DISCUSSION

The average chemical composition of the water table and soil surface horizons under both treatments is shown in Table 2. The water table was located at the 1.15 m depth, very close to the historical average (12). This ground water was dominated by sodium bicarbonate. In the ungrazed enclosure, where topsoil salinization did not occur, few differences in relative ion concentrations between the surface horizon solution and the water table were found. These differences were the lack of soluble carbonates (sodium carbonate) and the higher proportion of chlorides in the upper horizon. The anionic composition tended to resemble that of local rainfall (15), while cation status were more related to the shallow groundwater.

Under continuous grazing, the absolute ion concentration was higher in the Ap horizon than in the water table (Table 2). When water table was progressively concentrated, the anionic constituents did not increase directly or linearly. The anion composition of the upper horizon showed important differences, compared to the water table – chlorides and sulfates showed marked relative increments, carbonate proportion did not change but bicarbonates showed a relative decrease.

Table 2. Average chemical composition of the water table and the saturation extract of the surface horizon (meq/L).

Components	Phreatic Water meq/L	%	Ap Horizon Salt Level grazed meq/L	%	ungrazed meq/L	%
Anions						
Cl^-	0.76	4.3	13.15	23.0	4.75	21.2
HCO_3^-	14.79	04.4	22.00	39.3	15.95	71.1
$CO_3^=$	0.84	4.7	2.45	4.3	0.0	0.0
$SO_4^=$	1.16	6.6	10.27	32.7	1.75	7.0
Cations						
Ca^{++}	0.10	0.6	0.23	0.4	0.28	1.3
Mg^{++}	0.22	1.3	0.50	1.0	0.44	2.0
Na^+	16.26	96.9	55.12	98.2	21.10	95.8
K^+	0.20	1.2	0.25	0.4	0.21	1.0
SAR	52.8		73.3		32.6	
E.C. (dS/m)	1.03		4.94		1.79	
pH	0.5		0.0		7.8	

Downloaded by [New York University] at 14:22 01 February 2015

The relative composition of cations of the Al horizon solution in the grazed area (Table 2) was close to the cation proportion of the water table. Arndt and Richardson (16) found calcite saturation in soil solutions when concentrations were higher than 1 dS/m, but Ca values decreased only after EC increased over 3.7 dS/m. On the other hand, they also found calcite fixed alkalinity when the soil extracts were lime saturated. Bicarbonates were not correlated with solution concentration. Our observations under grazing resemble that picture. The proportional reduction of bicarbonates could be related to the precipitation of $CaCO_3$ in the soil surface horizon, the result of both solution concentration and CO_2 losses.

Downloaded by [New York University] at 14:22 01 February 2015

The IAP in the soil solution is relatively related to the Ksp of the pure mineral, because of several factors, lack of equilibrium, chemisorption, absence of pure minerals in nature, etc. (17). Taking into account these limitations comparative analysis of the pIAP values were performed. In both water table and Al saturation extract under grazing, the pIAP were 7.60 and 7.05, respectively. The pIAP of the calcite is 8.47 (14) or 8.30 (1). It indicates conditions for $CaCO_3$ precipitation in both phreatic water and soil saturation extracts. Conversely, the pIAP of the Al saturation extract in the ungrazed enclosure was 8.60, indicating undersaturation of $CaCO_3$ in that soil solution.

The $CaCO_3$ distribution within the soil profile is not entirely in agreement with the general picture given by the chemical composition and the IAP relations with calcite. The topsoil horizons did not show measurable lime content (Table 1), regardless of the differences in the saturation extracts in each area. Conversely, the deeper soil horizon (B32), in direct contact with water table, contained an important proportion of lime, as can be seen from the characteristics of the water table.

CONCLUSIONS

In the ungrazed area no conditions for $CaCO_3$ precipitation in the Al horizon were found. Conversely, in the grazed area, evidences of $CaCO_3$ precipitation in the Al horizon, in close relation to the ascension of salts were found. This is in accordance with the initial hypothesis. The lack of correlation between this fact and the actual lack of lime in the topsoil could be explained by considering the recent and episodic process of topsoil salinization and the consequent $CaCO_3$ precipitation, and the time normally taken to precipitate measurable lime in the soil profile.

These results suggest that $CaCO_3$ precipitation in soils not only occurs due to geochemical or pedological processes, but also takes into account the influence of land use, *i.e.* grazing.

REFERENCES:

1. Miller, J.J., S. Pawluk, and G.J. Beke. 1989. Evaporite mineralogy, and soil solution and groundwater chemistry of a saline seep from southern Alberta. Can. J. Soil Sci. 69:273-206.

2. Timpson, M.E. and J.L. Richardson. 1986. Ionic composition and distribution in saline seeps of Southwestern North Dakota. Geoderma 37: 295-305.

3. Timpson, M.E., J.L. Richardson. L.P. Keller, and G.J. McCarthy. 1986. Evaporite mineralogy associated with saline seeps in Southwestern North Dakota. Soil Sci. Soc. Am. J. 50:490-493.

4. Keller, L.P., G.J. McCarthy, and J.L. Richardson. 1986. Mineralogy and stability of northern of soil evaporites in North Dakota. Soil Sci. Soc. Amer. J. 50:1069-1071.

5. Arndt, J.L. and J.L. Richardson. 1986. The effects of groundwater hydrology on salinity in a recharge-flowthrough-discharge wet land system in North Dakota, pp. 269-277. IN: Van der Kamp, G. and M. Madunicky (eds.) Proceedings of the Third Canadian Hydrogeology Conference. Saskatoon, Saskachewan, Canada.

6. Knutenson, J.A., J.L. Richardson, D.D. Patterson, and L. Prunty. 1989. Pedogenic carbonates in a calciaquoll associated with a recharge wetland. Soil Sci. Soc. Amer. J. 53:495-499.

7. INTA 1990. Atlas de Suelos de la Republica Argentina I, 83-202. Buenos Aires, Argentina.

8. Lavado, R.S. 1983. Occurrence of magnesium-bearing calcites in pampean soils. Geoderma 29 59-66.

9. Lavado, R.S. and M.A. Taboada. 1988. Water, salt and sodium dynamics in a Natraquoll in Argentina. Catena 15: 577-594.

10. Leon, R.J.C., G.M. Rusch, and M. Oesterheld. 1984. Los pastizales pampeanos, impacto agropecuario. Phytocoenologia 12:201-210.

11. Lavado, R.S. and M.A. Taboada. 1987. Soil salinization fluxes as an effect of grazing in a native grassland soil the Flooding Pampa, Argentina. Soil Use and Manage. 3:143-140.

12. Lavado, R.S., G. Rubio, and M. Alconada. 1990. Changing soil salinity and alkalinity due to grazing. Proceedings XIV International Congress of Soil Science. Kioto, Japan. VII:216-221.

13. Page, A.L., R.H. Miller, and D.R. Keeney (eds.). 1982. Methods of Soil Analysis, Part 1. Agronomy No. 9, 2nd Edition. American Society of Agronomy, Madison, WI.

14. Suarez, D.L. 1977. Ion activity product of calcium carbonate in waters below the root zone. Soil Sci. Soc. Amer. J. 41:310-315.

Downloaded by [New York University] at 14:22 01 February 2015

15. Lavado, R.S. 1983. Evaluacion de la relacion entre la composicion quimica del agua de lluvia y el distinto grado de salinidad y sodicidad de distintos suelos. Rev. Facultad Agronomia 4:135-139.

16. Arndt, J.L. and J.L. Richardson. 1989. Geochemistry of hydric soil salinity in a recharge-throughflow-discharge prairie-pothole wetland system. Soil Sci. Soc. Amer. J. 53:848-855.

17. Yong, F., Bohn, H.L., Brito, J., and J. Prenzel. 1992. Solid activities of aluminum phosphate and hydroxide in acid soils. Soil Sci. Soc. Amer. J. 56: 59-62.

18. Klute, A. (ed.). 1986. Methods of Soil Analysis, Part 1. Agronomy No. 9, 2nd Edition. American Society of Agronomy, Madison, WI.

Downloaded by [New York University] at 14:22 01 February 2015