COMPARATIVE STUDIES OF THE EFFICIENCY OF LIME REFUSE FROM SUGAR BEET FACTORIES AS AN AGRICULTURAL LIMING MATERIAL

P. González-Fernández[1], R. Espejo-Serrano[2], R. Ordóñez-Fernández[1], F. Peregrina-Alonso[2]
[1] *C.I.F.A. "Alameda del Obispo". Apartado 3092, 14080 Córdoba.*
pedro.gonzalez.fernández@juntadeandalucia.es
[2] *E.T.S.I.Agrónomos. Univ. Politécnica. Ciudad Universitaria. 28040 Madrid.*

ABSTRACT

Lime refuse from several sugar beet extraction factories was used in a field assay to study its behaviour as an amendment material for an acid soil (plinthic Palexerult). A finely pulverized dolomitic lime was used as a reference. A total of 6.3 t/ha of dolomitic lime and 7.4 t/ha of sugar factory lime scum were employed. Two years after its incorporation into the soil the effects of the lime scum on the change cations were similar to those caused by the dolomitic lime. Throughout six years and six crops it was observed how, in the plots amended with lime refuse, a slightly higher pH was maintained than that measured in the plots without lime, and with fewer fluctuations. Once the maximum pH value was reached in the treated plots, the rate of the pH decline was similar to the acidification process undergone by the soil in the control plots and fitted the regression:

$$pHw = - 0.000435 * daa + 6.93$$

where daa are the days after the application of the amendment.

The recycling of sugar beet factory lime refuse as a liming material for acid soils was seen to be a valuable and efficient alternative to traditional limes and dolomites.

INTRODUCTION

The correction of the excessive acidity of soils by using lime is a very old agricultural practice. Limestone ($CaCO_3$) is the liming material most used although there are many other sources of neutralizing and correcting materials for the yield limiting effects of soil acidity. Those prominent among them are: dolomites ($Ca\ CO_3*MgCO_3$), burnt lime (CaO), hydrated lime ($Ca(OH)_2$), burnt magnesite (MgO), pulverized magnesite ($MgCO_3$) and their different mixtures.

The above materials are sometimes not available to farmers or their price is prohibitive for their use in agriculture. It is therefore important to seek other local sources of acidity correcting materials such as: mollusc shells, paper industry residues, ash, basic steel industry refuse, etc.

In our case we have studied the efficacy as a liming material of sugar factory refuse lime (SFRL). This sugar foam waste results from the purification-flocculation of colloid matter from the liquor extracted from sugar beet. In this process, slaked lime and carbon dioxide are used to purify the liquors. The composition varies in accordance with that of the limestone used in the manufacture of slaked lime. SFRL is the residue of these materials together with notable amounts of organic matter and micronutrients.

MATERIALS AND METHODS

The study was carried out in a trial field established on mid-final Pliocene *raña* (Espejo, 1978) located on the boundaries of Cañamero (Cáceres) and Valdecaballeros (Badajoz) in the west of Spain.

The highly weathered raña soils are classified as Plinthic Palexerult and have a profile of Ap, AB, Bt. The ochric epipedon shows a high content in organic matter, 3.9%, extractable Aluminium, 0.93 cmol c/Kg and 28.3 % of coarse elements, a low pH of 5.07 and a sparse clay content of 5.8%. In contrast, the argillic horizon with a massive structure is rich in clay, 32.4%, and extractable aluminium, 2.07 cmolc/Kg.

The climate is a mild Mediterranean one and the average rainfall in the period studied was 945 mm, with a maximum of 1287 in the agricultural year 2000-2001 and a minimum of 585 mm in the period from 1998-1999.

The plots with the different treatments were of a random block design with four repetitions. The basic plots measured 5 x 7 m^2. Throughout the duration of the data collection the plots received a total of 647 KG/ha of N, 121 Kg/ha of phosphorous (P) and 231 Kg/ha of potassium K through the inorganic fertilizers used without any calcium or magnesium contribution.

The SFRL ,Lime scum or lime refuse has a liming capacity (CCE) per t equivalent to 0.85 t of pure lime. The dosage needed to reach a pHw of 6.3 in the first 20 cm of soil was calculated, based on the CCE, humidity and the soil neutralization curve. The soils treated with SFRL received 7.4 t/ha of refuse lime from sugar beet factories equivalent to the 6.3 t/ha of dolomitic material added to the soils treated with limestone necessary to raise the pH of the soil to 6.3.

The following are the characteristics of the SFRL used:

			g/kg			
Material	OCa	SO_4^{2-}	SiO_2	F^-	P_2O_5	Al_2O_3
SFRL	437	5.1	26.5	nd	8.1	8.1
			g/kg			
Material	Na_2O	K_2O	Fe_3O_4	MnO	MgO	Org. M.
SFRL	1.05	1.95	1.9	<0.1	47.3	8.67

The control plots did not receive any amendment and only the NPK fertilizers in common with the rest of the treatments.

The Ap horizon was analyzed periodically by means of compound samples from at least 2 points per plot. Once dried and sieved, the samples were analyzed in duplicate. The pH was measured electrochemically with a CRISON pHmeter and a glass membrane combined electrode in suspensions of 1:2.5 in water.

RESULTS AND DISCUSSION

The intensive cultivation of acid soils in the land of Cañamero, with no contribution of base cations with fertilizers, has augmented the natural acidification processes (Helyar and Porter, 1989) as can be seen in the evolution of the mean pH values in the control plots (Figure 1), which did not receive any amendment.

The mean values in the control plots fluctuated in a range of 1.29 units of pH with a coefficient of variation of 9%. The plots limed SFRL maintained acidity values within a narrower interval of 0.88 units of pH with a coefficient of variation of 5%.

The effectiveness of sugar factory refuse lime (SFRL) as a soil acidity corrector has been witnessed by means of the pH evolution measured throughout the period studied (Figure 1). When SFRL was applied in amounts equivalent to traditional liming with dolomitic lime (DL), the pH rose similarly. Both lime materials require over two years to arrive at a maximum value. Once the highest pH was reached, a gradual pH decline began.

The plots treated with SFRL maintained a higher pHw on their most superficial horizon (Ap) than the control plots in all the measurements, in spite of their higher decline rate. This trait was expected as they began with higher initial pH values (Creagan et al., 1989; Conyers et al., 2003).

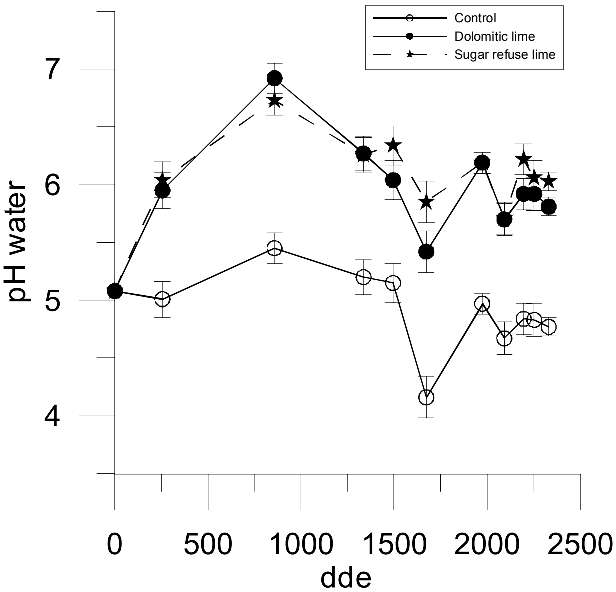

Figure 1. *pH Evolution with time in the plowed layer (Ap) of a Plinthic Palexerult cultivated soil. Soils untreated (control) or amendment with SFRL or DL incorporated. Each point is the mean of 4 plots. Vertical bars are l.s.d. at p= 0.05.*

The effects of SFRL last for a long time. Fitting a regression line to the pHw values measured from the beginning of the decline the following equation is obtained:

$$pHw = -0.000435*daa+6.93$$

Where daa represents days after amendment.

The regression line indicates that in this situation of a rapid reacidification, the plots treated with SFRL will maintain an agriculturally safe pH for at least 9 years.

The mean difference between the pHw of control plots and that of those limed with SFRL was 1.24 units while the mean difference between the pH of the control plots and that of the plots amended with DL was 1.12 units.

The longevity of the treatments with SFRL was greater than that of the traditionally amended ones. Figure 2 shows that the pHw values in plots into which SFRL was incorporated were higher than those amended with DL.

Figure 1 shows how, from 1335 daa onwards, the mean pHw values in the plots treated with SFRL turn out to be significantly higher than the pHw found in plots limed with DL.

It can be noted from Figure 2 how this difference grows with time and this trend is reflected in the regression line fitted to these differences:

$$Dif.pPHw = 9.10\text{-}5*days\text{-}0,017$$

Although the correlation was a poor one given the variability of the data, the equation can supply a reliable prediction of the tendency. It can be seen that 180 days after observing the maximum value, the differences were positive and increased with time.

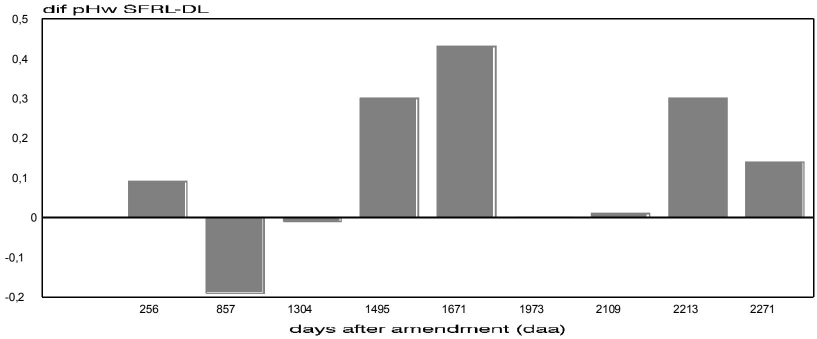

Figure 2. *Seasonal Soil pHw differences between measurements in SFRL and DL treated plots.*

From the above it is deduced that the efficiency of SFRL in correcting soil acidity is similar to DL and that its effects last longer.

CONCLUSIONS

Sugar factory refuse lime SFRL used in the correction of acid Plinthic Palexerult soils in the *raña* of Cañamero has shown itself to be an effective liming material, whose beneficial effects last for at least 9 years.

The persistence of the effects of SFRL is greater than that shown by traditional liming materials such as DL and its physical and chemical properties make it a valuable and efficient substitute for those other liming materials.

REFERENCES

Espejo, R. 1978. Estudio del Perfil Edáfico y Caracterización de las superficies tipo Raña del Sector Cañamero-Horcajo de los Montes. Tesis doctoral. Universidad Politécnica de Madrid. ETSIA.

Espejo, R., Peregrina, F., Santano, J., González, P., Ordóñez, R. 2004. A comparative analysis of the agronomic implications of the use of lime and gypsum bye-products as acid soil amendments. Application to Palexerult in W. Spain. Soil Sci. (Submitted).

Creagan, P.D., Hirth, J.R., Conyers, M.K. 1989. Amelioration of soil acidity by liming and other amendments. In: Robson A.D. (Ed.). *Soil Acidity and Plant Growth*. Academic Press. Marrickville. pp. 205-264.

Conyers, M.K., Mullen, C.L., Scott, B.J., Poile, G.J., Braysher, B.D. 2003. Long-term benefits of limestone applications to soil properties and to cereal crop yields in southern and central New South Wales. Austr. J. Exp. Agric., 43: 71-78.

Helyar, K.R., Porter, W.M. 1989. Soil acidification, its measurement and the processes involved. In: Robson, A.D. (Ed.). *Soil Acidity and Plant Growth*. Marrickville. Academic Press, pp. 61-101.