CHEMICAL AND MINERALOGICAL CHARACTERISTICS OF SELECTED
ACID SOILS OF THE STATE OF PARANA, BRAZIL[1] /

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Resumen

Se realizaron experimentos de laboratorio para estudiar las propiedades químicas y mineralógicas de siete suelos ácidos del sur de Brasil. En estos suelos dominó la caolinita como mineral de arcilla y se detectó gibsita y hematita en proporciones menores. No se detectó minerales de arcilla tipo 2:1. Estos suelos meteorizados presentaron CIC permanente bajo que varió de 1.05 me/100 g (Ultisoles) a 2.4 me/100 g (Oxisoles) Al pH de campo (4.0-4.5) la CIC (en KCl) varió de 1.43 me/100 g (Ultisoles) a 5.94 me/100 g (Oxisoles). La CIC a pH 8.2 varió de 5.8 me/100 g (Ultisoles) a 43.80 me/100 g (Oxisoles). La alta CIC propia del pH de estos suelos dependía principalmente de la materia orgánica La CIA a pH 2.0 varió de 3.2 me/100 g (Ultisoles) a 4.4 me/100 g (Oxisoles) mientras que aquello a pH 7.0-7.5 era demasiado baja para medir. El PCZ varió de 2.7 para Oxisoles a 3.5 para Ultisoles. El PCZ más bajo de los horizontes superficiales de los Oxisoles se debía, probablemente, a su mayor contenido de materia orgánica.

Se extrajo mayores cantidades de Al con $CaCl_2$ que con KCl y la diferencia era más pronunciado para los suelos con más materia orgánica. La cantidad de Al extraída con $NH_4 OA_c$ (pH 4.8) era considerablemente mayor que aquélla que se extrajo con soluciones de KCl o $CaCl_2$. El Al no intercambiable y el C orgánico de los suelos indicaron una correlación alta.

Introduction

Although the State of Paraná, Brazil, has extensive areas of acid soils under cultivation for beans (*Phaseolus vulgaris*), coffee (*Coffea arabica*), corn (*Zea mays*), rice (*Oryza sativa*), soybeans (*Soya max*), and wheat (*Triticum* spp), little information is available on the chemical and mineralogical properties of these soils. These soils require lime and complete fertilizers for maximum production. The liming practice is, in general, based upon soil pH rather than upon mineralogical-chemical properties.

The authors initiated a study of the liming requirements of soils collected from the major cultivated areas of Southern Brazil. The focus of this study was upon available Al, i.e., KCl extractable, % Al saturation, and soil solution Al species as affected by application of $CaCO_3$, $MgCO_3$, and $CaSO_4$ with reference to the coffee plant. Results of this phase of the study have been published by Pavan *et al.* (14). In order to evaluate more completely the effects of the amendment treatments, were characterized the chemical-mineralogical properties of these soils, particularly the properties influencing Al chemistry and charge characteristics. The results of this chemical-mineralogical characterization are discussed in this paper.

Materials and methods

Seven highly acid soils were selected from the 0 to 30 cm horizon of uncultivated sites from potential agricultural areas throughout the State of Paraná, Brazil for laboratory study. Figure 1 shows the location of State of Paraná. The specific locations of the sites sampled are given in Table 1. Bulk lots of the soils were air dried and passed through a 2.0 mm screen preparatory for chemical and mineralogical analysis.

Chemical analysis

Extraction of exchangeable cations (Ca, Mg, and Al) was carried out with a N KCl solution following the technique described by Lin and Coleman (6). Extraction with N CaCl₂ solution was also carried out to obtain a measurement of exchangeable Al (1). In addition, a N NH₄OAc solution (pH 4.8) was used to extract Al (15). For the present discussion, Al extracted with buffered solution (NH₄OAc at pH 4.8) is referred to as "exchangeable plus non-exchangeable Al" and that extracted with unbuffered solutions (KCl or CaCl₂) will be referred to as "exchangeable Al". The difference between the two fractions is referred to as "non-exchangeable Al".

Available K and P were measured by the extraction procedure originally developed by Nelson *et al* (10) and subsequently modified by Vettori (22). This procedure uses a solution of 0.05 N HCl and 0.025 N H_2SO_4 as the extractant. The organic C in soil was determined by the procedure described originally by Walkley (23). The CEC at soil pH was determined by using unbuffered solutions of N KCl and N CaCl₂ following the technique described by
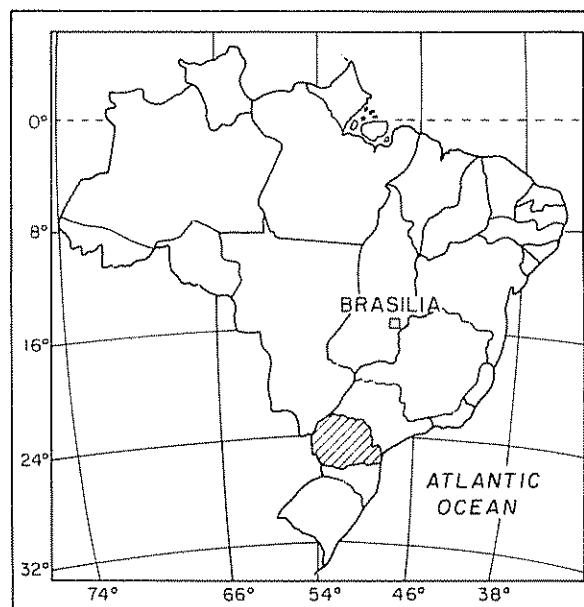
Fiskell (3). The CEC was measured also at pH 4.0, 5.0, 6.0, 7.0, and 8.2 with buffered solution of Ba(OAc)₂ – TEA technique described by Pratt (16).

The pH-dependent CEC of soils was calculated as the difference between CEC measured at pH 8.2 and 4.0. The contribution of clay to the pH-dependent CEC was measured by removing the organic matter from soils by repeated treatments with H_2O_2 of a soil suspension heated on a steam plate. After the organic matter had been removed, a buffered Ba-saturating solution was used to determine the CEC of the clay

Table 1. Soil types according to soil taxonomy, associated location, and particle size.

| Soil No. | Classification | Location | | Particle size | | |
		Longitude West Greenwich	Latitude South	Clay	Silt %	Sand
1	Haplusthox	51° 28'	23° 34'	75	15	10
2	Eutrorthox	51° 28'	24° 00'	56	16	28
3	Tropudults	51° 22'	22° 62'	16	2	82
4	Haplusthox	51° 08'	23° 20'	81	15	4
5	Tropudults	48° 50'	25° 30'	28	23	49
6	Eutrorthox	50° 40'	23° 40'	50	11	39
7	Organic	49° 02'	25° 30'	70[1]	19[1]	11[1]

1 Particle size class of mineral fraction after destruction of organic matter with H_2O_2 at low heat.

fraction at pH values from 4.0 to 8.2 (16). The contribution of organic matter to the pH-dependent CEC of soil was calculated as the difference between pH-dependent CEC of soil and the value obtained from the contribution of clay to pH-dependent CEC of soil. Any interactions between clay and organic matter is ignored in these calculations of pH-dependent CEC.

The permanent charge CEC of soil was determined by equilibrating the soil with 0.02 $\underline{N}$ HCl, removing excess HCl with deionized water, replacing the H+ plus Al^{3+} with $\underline{N}$ KCl solution, and titrating the acidity of the KCl extract (18).

The method used to determine the distribution of electric charge of soil is based upon the procedure developed by Schofield (20). The positive and negative charge of soils were determined by measuring the absorption of both anion and cation from 0.2 $\underline{N}$ KCl solution as a function of suspension pH. The pH of the suspensions were adjusted to 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, and 8.0 with HCl or KOH. The adsorbed K and Cl and entrapped KCl were replaced with $\underline{N}$ Na_2SO_4. The technique used for determining entrapped KCl was essentially that described by Morais *et al.* (9) in which the tare weight of the soil plus container was known and the container plus soil plus entrapped solution was determined after equilibration with a solution of known KCl concentration. The volume times concentration gives the amount of entrapped KCl.

Aluminum, Ca, Mg, and Ba were determined by atomic absorption spectrophotometry (AAS). How-ever, the AAS procedure for Ca and Mg entailed the use of lanthanum to eliminate interferences (24). Potassium was determined by a flame photometric method while chloride was determined colorimetrically (12).

Mineralogical analysis

Mineral components of $\leqslant 2$ μm fraction of the soils were qualitatively identified by Whitting's (25) method with the modification of not removing iron oxides, carbonates, and organic matter as originally specified. X-ray difractograms were obtanied with an X-ray unit equipped with a copper tube and a nickel filter. X-rays were generated from a copper element tube at 35 KV and 15 mA. The samples were scanned from $2°$ to $60°$.

Results and discussion

CEC relations

Data pertaining to exchangeable cations and their summation (Al+Ca+Mg+K) are reported in Table 2. Only a small proportion of the exchange capacity was balanced by basic metals. Aluminum was the dominant cation in the cation exchange complex. The effective CEC at native soil pH as calculated by the sum of cations is compared in Table 2 with CEC measured by unbuffered salt solutions (KCl and $CaCl_2$) and buffered salt solution $Ba(OAc)_2$-TEA at pH 8.2. The sum of the exchangeable cations was related more closely to the KCl-CEC values than to the $CaCl_2$-CEC values. The CEC values measured

Table 2. Chemical properties of the soils: exchangeable cations (Al, Ca, Mg, and K), CEC, and permanent charge-CEC.

Soil No.	pH(H$_2$O) 1:1	Exchangeable cations				CEC				Permanent Charge-CEC
		Al	Ca	Mg	K	Σ Cations	KCl	CaCl$_2$	Ba(OAc)$_2$ -TEA pH 8.2	
						me/100 g				
1	4.2	2.31	1.77	0.40	0.38	4.86	4.82	5.19	24.40	1.60
2	4.0	2.86	0.60	0.22	0.19	3.87	4.31	5.59	43.80	1.72
3	4.3	0.55	0.60	0.20	0.34	1.69	1.43	2.11	5.80	1.05
4	4.3	1.77	1.76	0.47	0.34	4.34	4.73	5.15	23.90	2.00
5	4.1	2.00	0.90	0.50	0.19	3.59	3.82	4.49	14.55	2.02
6	4.2	4.11	0.96	0.35	0.22	5.64	5.94	7.55	30.90	2.24
7	4.5	7.36	0.80	0.36	0.23	8.75	14.60	15.18	88.50	4.94

with buffered BA(OAc)$_2$-TEA at pH 8.2 showed that a large proportion of the exchange sites of these soils were pH-dependent

For soil 1 to 6, inclusive, the sums of exchangeable cations agree quite well with the CEC values measured by KCl and they are only slightly smaller than the CEC values measured by CaCl$_2$ However, for soil 7 the sum of cations is much smaller than these CEC values One explanation for this difference for soil 7 is that it might have contained exchangeable H$^+$ The analytical procedures did not involve a determination of exchangeable H$^+$ because the large accumulation of information on soil acidity during the past three decades shows that essentially all of the exchangeable acidity in mineral soils is exchangeable Al But, soil 7 is an organic soil for which the main component of the CEC was undoubtedly from humus The CEC-pH curve (Figure 2) and the absolute values for CEC support the conclusion that a large fraction of the CEC in soil 7 is contributed by the organic colloids which possibly favor adsorbed H$^+$ as compared to adsorbed Al^{3+}

Table 2 also shows the values for permanent charge CEC of soils Coleman et $al.$ (2) pointed out that there is a relationship between permanent charge or soils and clay type minerals. viz, low values are indicative of kaolinite Kaolinite is the dominant mineral in the clay fraction of these soils

The effect of pH on soil CEC-Ba(OAc)$_2$-TEA is shown in Figure 2. These data show a relationship between pH of the buffered solution and CEC. There are three distinct pH-CEC regions of the curves: (i) There is a small increase per unit of CEC from pH 4.0 to 5.0; (ii) a greater increase in CEC from pH 5.0 to

6.0; and (iii) a marked increase in CEC between pH 6.0 to 8.2. The latter increase in CEC was evidently associated with organic matter since the soils which attained the highest CEC values were the soils richest in organic matter. Soils 2, 6, and 7 which had the highest levels of organic matter showed a greater increase in CEC above pH 5.0, whereas soil 3, which has the lowest level of organic matter and clay, showed the smallest increase in CEC with pH. Such a relationship between CEC and organic matter has been reported by Schofield (20), Pratt (16), Kamprath and Welch (5), and McLean and Owen (7)

The contribution of clay and organic matter to the soil CEC is reported in Table 3. The contribution of organic C to the pH-dependent CEC of soil was on
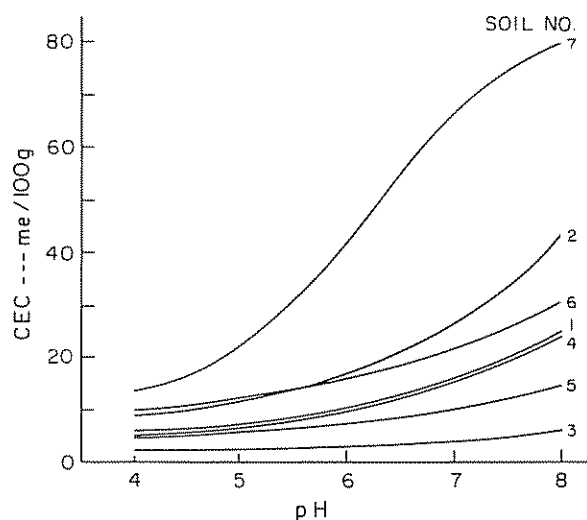

Fig. 2   CEC values of soils in relation to soil pH

Table 3. The pH-dependent CEC of soils, and the contribution of organic C and clay to pH-dependent CEC of soils.

Soil No.	pH-dep. CEC	Clay pH-dep. CEC	Org. C pH-dep. CEC	Clay %	pH-dep. CEC of clay me/100 g	Org. C %	pH-dep. CEC of org. C me/100 g
		me/100 g					
1	19.25	5.00	14.25	75	6.70	1.71	833
2	35.85	3.68	32.17	56	6.57	4.46	721
3	3.70	0.45	3.25	16	2.81	0.44	739
4	18.40	4.38	14.02	81	5.40	1.84	762
5	9.95	2.75	7.20	28	9.82	1.46	492
6	21.90	1.17	20.73	50	2.34	2.42	857
7	68.00	8.00	60.00	70	11.40	18.59	323

an averaged basis 83% of the CEC values for the seven soils studied. The pH-dependent CEC of clay was lower than the pH-dependent CEC of organic C Although these Oxisols contain high clay contents, these soils manifested a low pH-dependent CEC for the clay fraction, possibly because these soils have a "low activity" clay. Evidently the pH-dependent CEC of these soils was primarily associated with organic matter.

Al relationships

Table 4 contains values for KCl-and $CaCl_2$-Al and NH_4OAc (pH 4.8)-extractable Al The amount of Al extracted with $CaCl_2$ was greater than that extracted with KCl, the difference being more pronounced for soils containing relatively large amounts of organic matter. Pionke and Corey (15) reported that the addition of a salt solution increased the concentration of Al in the soil solution, altering the equilibrium in favor of the formation of Al organic matter complexes They found that organic exchange sites in unlimed soils were less affective for adsorbing K from KCl than Ca from $CaCl_2$. Thus, less Al would be extracted with KCl than with $CaCl_2$ in soils containing Al bound with organic matter.

The amount of Al extracted with NH_4OAc (at pH 4.8) was approximately three times greater than that extracted with either KCl or $CaCl_2$ solutions. Pratt and Bair (17), McLean *et al.* (8), and Igue and Fuentes (4), found that NH_4OAc at pH 4.8 released more Al than KCl for soils containing similar amounts of organic matter. The difference between Al extracted with NH_4OAc (pH 4.8) and KCl solution, referred to as the non-exchangeable fraction, correlated closely

with organic C content of soils (R=0.90**). These data indicate that the Al complexed with organic matter was virtually non-exchangeable with KCl, but somewhat extractable with N NH_4OAc at pH 4.8 and hence was included in the non-exchangeable Al fraction. Similar relationship between non-exchangeable Al and organic C content of Brazilian soils has been reported by Pavan (13).

Distribution of charges

The effect of pH on distribution of positive and negative charges of soils as measured by adsorption of K^+ and Cl^- ions from 0.2 N KCl is shown in Table 5. These soils were separated into Oxisols and Ultisols. For all soils used in this study, the positive charge tended to decrease and the negative charge tended to increase as the pH was raised. The marked increase of negative charge with pH was a reflection of the pH-dependent CEC of these surface soils. The zero point of charge (ZPC) of these soils was obtained by plotting the net charge against pH. The value of the soil solution at which there was no net charge is reported in Table 5. The ZPC values obtained varied from 2.7 (Oxisol) to 3.5 (Ultisol) which are within the range of ZPC values expected for kaolinite. Parks (11) reported ZPC values for kaolinite to be pH 3.5. The lower ZPC value obtained for the Oxisols may be due to the soils's higher content of organic matter and higher permanent-CEC charge. According to Van Raij and Peech (21) and Parks (11), organic matter lowers the ZPC of soils. The results of the present study are in accord with observations of Brazilian soils by Van Raij and Peech (21) and Morais *et al.* (9). The CEC values measured with buffered $Ba(OAc)_2$-TEA were consistently higher than those measured at

Table 4. Amount of exchangeable Al (KCl and $CaCl_2$), extractable Al (NH_4OAc at pH 4.8), and nonexchangeable Al (NH_4OAc at pH 4.8 — KCl) of soils.

Soil No.	Exchangeable Al		Extractable Al	Nonexchangeable Al
	KCl (2)	$CaCl_2$ (3)	NH_4OAc pH 4.8 (4)	4 – 2 (5)
			me/100 g	
1	2.31	2.38	8.40	6.09
2	2.86	3.70	12.63	9.77
3	0.55	0.59	1.68	1.13
4	1.77	1.81	6.30	4.53
5	2.00	2.20	4.18	2.18
6	4.11	4.31	12.76	8.65
7	7.36	9.80	34.35	26.99

Table 5. Negative and positive charges, and zero point of charge (ZPC) for surface soils at different pH values.

| Soil | pH | Charges in 0.2 N KCl | | | ZPC |
| | | Neg. | Pos. | Net | |
			me/100 g		
Ultisol	2.0	1.8	3.2	+ 1.4	
	3.1	2.0	2.8	+ 0.8	
	4.1	4.6	2.5	− 2.1	
	5.0	5.8	2.1	− 3.7	3.5
	5.8	7.5	1.9	− 5.6	
	6.4	8.8	1.1	− 7.7	
	7.9	12.6	0.8	− 11.8	
Oxisol	2.0	2.2	4.4	+ 2.2	
	3.2	3.6	2.8	− 0.8	
	4.2	9.2	2.4	− 6.8	
	4.9	10.6	0.9	− 9.7	2.7
	5.7	14.8	0.8	− 14.0	
	6.3	18.0	0.5	− 17.5	
	7.5	26.8	0.2	− 26.6	

low solution electrolyte (0.2 N KCl). This aspect of electrolyte solution effect on CEC measurement of tropical soil has been discussed by Van Raij and Peech (21).

Mineralogy

Qualitative mineralogy for the ≤ 2 μm soil fraction is shown in Table 6. Kaolinite was the only clay mineral present in all soils. Hematite, gibbsite, and quartz were present in smaller amounts. The hematite peaks were more evident in Oxisols than in Ultisols. Hematite was almost absent in soil 5 (Ultisol). The presence of gibbsite minerals were more evident in soils 2 and 6 (Oxisol) and least in other soils. Quartz was identified in soils 3 and 5 (Ultisols) only. The presence of these mineral compounds suggest that these soils have undergone strong chemical weathering. Clay minerals of the 2:1 type were not detected for these soils. Similar mineralogical characteristics for Brazilian soils have been reported by Pratt et al. (19).

Soil management implications

Oxisols are the principal soils in many parts of Brazil. There are extensive agricultural areas in the State of Paraná that have Oxisols. The selected soils used in the present study showed highly acid, low CEC, high % Al saturation, and low base saturation

in the surface horizons. Hydrous oxides and kaolinite are the main minerals in the clay fraction in these soils.

The low CEC values in association with heavy rainfall results in the removal of macro- and micronutrients. The high levels of Al saturation also creates an unfavorable soil condition for most crop species. Consequently, special management techniques must be used in an attempt to neutralize Al and to supply basic cations for the nutritional needs of most crops.

Table 6. Dominant minerals in the ≤ 2 μm soil fraction.

Soil No	Minerals[1]
1	Kaolinite, hematite, and gibbsite[2]
2	Kaolinite, gibbsite, and hematite[2]
3	Kaolinite, hematite, quartz, and gibbsite[2]
4	Kaolinite, hematite, gibbsite[2]
5	Kaolinite, quartz, gibbsite, and hematite[2]
6	Kaolinite and gibbsite

1 Minerals are listed in order of peak intensities

2 Trace

Liming these soils appears to be a routine practice to neutralize the soil acidity, to supply adequately nutrients (Ca and Mg), and to increase the availability of other nutrients as well

Properties, such as content of organic matter, CEC, degree of Al saturation, and rainfall characteristics control to varying degrees the effectiveness of lime and fertilizer applications. Although these factors are interrelated, the content of organic matter undoubtedly exerts an influence on the physical and chemical properties of Oxisols

The high rainfall (1 600 mm per year) creates problems of soil erosion and conservation In fact, annual crops require special management to prevent losses of soil, organic matter (by erosion itself or by acceleration of mineralization) and nutrients Also perennial crops require soil erosion control, specially during the earlier stages of growth The inter rows of coffee plantation, for example, are maintained under continuous vegetation during the rainfall season

Regarding fertilizer management, the high rainfall and low CEC of these soils make it necessary to use split applications of nitrogen and potassium to minimize losses by leaching The presence of hydrous oxide contents suggest high phosphate fixation capacity for these soils Dolomitic lime is expected to be effective for these soils. More specifically, dolomitic lime combined with gypsum might be the best amendments for these soils Dolomitic lime effects (decrease exchangeable Al, increase pH, CEC, and exchangeable Ca and Mg) are limited to the topsoil while the gypsum effects (decrease exchangeable Al, increase exchangeable Ca, no change — pH or CEC, and improve sulfate status in soil) are manifested throughout the soil profile

Conclusion

The inorganic fraction of these Oxisols and Ultisols was dominated by 1:1 layer silicates (kaolinite) Hematite, gibbsite, and quartz were present in smaller amounts There was a relationship between permanent charge CEC of soils and clay type minerals These soils exhibited a low permanent charge CEC which is to be expected because of their kaolinitic character However, the CEC of these soils increased as the pH was increased The high pH-dependent CEC was primarily associated with organic matter The non-exchangeable Al and organic matter content of soils were highly correlated

The ZPC values for these surface soils fall within the range expected for kaolinite, averaging 2 7 for the Oxisols and 3 5 for the Ultisols The higher ZPC of

Oxisols was probably due to its higher content of organic matter In general, the organic matter content of Oxisols exceeded that in Ultisols

Summary

Laboratory experiments were conducted to study chemical and mineralogical characteristics of seven acid soils from southern Brazil Kaolinite was the dominant clay mineral present in these soils Gibbsite and hematite were detected in smaller proportion Clay minerals of the 2:1 type were not detected These weathered soils showed a low permanent CEC varying from 1 05 me/100 g (Ultisol) to 2 24 me/100 g (Oxisol) At the field pH (4 0 to 4 5) the CEC (KCl) varied from 1 43 me/100 g (Ultisol) to 5 94 me/100 g (Oxisol). The CEC at pH 8 2 varied from 5.8 me/100 g (Ultisol) to 43.80 me/100 g (Oxisol) The high pH-dependent CEC of these soils was associated with organic matter mainly. The AEC at pH 2 0 varied from 3 2 me/100 g (Ultisol) to 4 4 me/100 g (Oxisol) while that at pH 7 0 — 7 5 was immeasurably small The ZPC varied from 2 7 for Oxisols to 3 5 for Ultisols The lower ZPC for the surface horizon of Oxisols was probably due to their higher amount of organic matter

The amount of Al extracted with $CaCl_2$ was greater than that extracted with KCl and this difference was more pronounced for soils containing larger amounts of organic matter The amount of Al extracted with NH_4OAc (pH 4.8) was considerably greater than that extracted with KCl or $CaCl_2$ solutions The non-exchangeable Al and organic C of soils were highly correlated

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Reseña de libros

STAPLES, R C and TOENNIESSEN, G H Salinity tolerance in plants John Wiley & Sons. 1984 443 p

Tradicionalmente la agricultura moderna se ha desenvuelto en dos campos: el técnico y el científico La interacción entre estos tiende a ser cada vez más fuerte porque las necesidades de alimentos y de materias primas de origen vegetal son más apremiantes cada día y los problemas agrícolas se agudizan rápidamente "Salinity Tolerance in Plants —Strategies for Crop Improvement"— es un libro que ilustra perfectamente el anterior aserto, ya que nos presenta una visión amplia y actualizada del conocimiento científico sobre los mecanismos que utiliza la planta para acomodarse a situaciones de alta salinidad en el suelo y el agua También se analizan en él las nuevas estrategias desarrolladas por un conjunto de genetistas y fisiólogos vegetales, quienes se han propuesto modificar la capacidad hereditaria de ciertas especies glicófilas de alto valor económico (arroz, trigo, cebada), para que eventualmente se adapten a condiciones salinas y posiblemente a otras situaciones ambientales adversas, como alta temperatura, sequía, etc

La obra es producto del trabajo editorial de Richard C Staples, de la Universidad de Cornell y de Gary H Toenniessen, de la Fundación Rockefeller, EEUU, y reúne las disertaciones de distinguidos hombres de ciencia de varios países, quienes se reunieron en una Conferencia Internacional que se llevó a cabo en Bellagio, Italia, en 1983, bajo los auspicios de la Fundación Rockefeller. Al respecto creemos que es de justicia reconocer públicamente tanto a la Fundación como a la Editorial John Wiley & Sons, el haber hecho posible nuestro acceso a tan valiosa información en un período relativamente corto.

"Salinity Tolerance in Plants —Strategies for Crop Improvement" consta de tres partes. En la primera se enfocan, a través de 12 capítulos, los mecanismos de tolerancia a las sales. A nivel citológico y fisiológico se discuten los fenómenos de absorción, intercambio y exclusión de iones, según ocurren en las raíces y follaje de plantas halófilas y glicófilas, para desembocar en un análisis ecológico de la adaptación, por evolución, a medios salinos Este conocimiento es fundamental para pasar al examen de nuevas vías en el mejoramiento genético de las plantas, lo cual constituye la segunda parte del libro.

Considerando que Latinoamérica tiene cerca del 20% de los suelos mundiales clasificados entre moderada a fuertemente salinos, que en algunas partes de nuestro hemisferio el uso de esas tierras puede ser importante a corto plazo, que la adopción de tal medida obligaría a emplear cultivares (variedades) resistentes o al menos tolerantes al estrés salino y, finalmente, que son muy pocas las especies botánicas —y menos aún los cultivares— que se caracterizan por crecer y producir eficientemente en ambientes ecológicamente limitantes, es fácil comprender el alto valor teórico y práctico de los conocimientos condensados bajo el título: Selección de Cultivos y Mejoramiento Es oportuno señalar que aquí el enfoque se aparta de los métodos seguidos tradicionalmente por el fitomejorador, cuando manipula la composición genética de las plantas con miras a obtener cultivares de mayor producción de alimentos en ambientes favorables desde el punto de vista agrícola Ahora que ha llegado el momento de encarar el problema de tener que utilizar en agricultura tierras marginales y de que es prácticamente imposible o antieconómico pretender cambiar el ambiente en grandes extensiones, como en efecto lo son las afectadas por la acumulación de sales inorgánicas, el reto para los científicos es modificar la constitución genética de la planta para que ésta se ajuste al ambiente hostil Este es el mensaje que se nos comunica por medio de 7 capítulos, in-

teligentemente colocados y desarrollados en la segunda parte del libro. La discusión cubre los aspectos genéticos del cruzamiento y la selección por tolerancia al exceso de sales, en plantas como el arroz, el trigo y la cebada; abarca también el papel de las halófilas en la agricultura bajo regadío y examina la genética fisiológica de la resistencia salina en las llamadas plantas superiores, profundizando hasta los niveles celular y molecular del problema. Se nos presenta una idea clara del progreso hecho en este campo, así como del trabajo que resta por hacer. Aunque todavía no se han producido cultivares tolerantes a las sales, se espera que tal cosa ocurra al finalizar la presente década

En la tercera parte, aunque es relativamente corta y de contenido más heterogéneo que las precedentes, encontramos temas muy importantes, como los tratados en los capítulos 20 y 21, que versan sobre el cultivo de plantas en agua salobre bajo condiciones agrícolas controladas, y sobre un análisis económico de las estrategias de fitomejoramiento para satisfacer condiciones salinas. En el último capítulo se discute

la situación alimentaria a escala mundial, así como el papel que pueden desempeñar las plantas tolerantes al exceso de sales, como un nuevo recurso al servicio de la humanidad.

Definitivamente, "Salinity Tolerance in Plants –Strategies for Crop Improvement" es un libro ejemplar desde muchos puntos de vista. Estimamos que debe ser analizado cuidadosamente tanto por estudiantes como por profesores de agronomía, horticultura y biología. También pueden ser una excelente obra de referencia para los señores políticos, en cuyas manos está la responsabilidad de propiciar el mejoramiento de la enseñanza superior y la investigación científica y tecnológica en que debe sustentarse nuestro desarrollo agrícola y por ende el socio-económico de Latinoamérica.

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