Na and Cl content in banana plants of Canary Islands.

J.M. HERNÁNDEZ ABREU, J. MACARELL,
S. DUARTE and A.R. SOCORRO*

TENEUR EN Na ET Cl DE BANANIERS DES ILES CANARIES.
J.M. HERNANDEZ-ABREU, J. MASCARELL, S. DUARTE et A.R. SOCORRO.
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RESUME - Données préliminaires d'une enquête sur la salinité et l'alcalinité, recherchant les corrélations des taux de Na et de Cl dans le limbe central ou marginal et dans les racines, avec Na et Cl dans les sols et dans les eaux d'irrigation, compte tenu également des bicarbonates.
Les racines présentent les meilleures corrélations mais ne sont probablement pas assez sensibles dans tous les cas. Les taux de Cl dans le limbe central et de Na dans le limbe marginal sont de bons indicateurs pour des plants adultes, Ca et Mg dans le limbe central étant tout aussi valables pour des plants jeunes.

INTRODUCTION

This paper is a preliminary and partial report of data from a prospective study on salinity and alkalinity of banana plantations in the Canary Islands. It shows the data corresponding to Tenerife Island (Fig. 1). In this island the surface under banana is about 6 000 ha.

MATERIALS AND METHODS

A randomized sample was made, selecting one farm for every 50 ha. The same farm was sampled twice : the first time between May and August 1980 (Set 1) and the second between November 1980 and February 1981 (Set 2). So the interval between taking the samples was, on an average, 5 months. The plants of Set 1 were in active vegetative growth, and those of Set 2 were at flowering stage.

* - Instituto Nacional de Investigaciones Agrarias - España.

Communication présentée au 3e Séminaire du Groupe international sur la Nutrition minérale du Bananier, Nelspruit 1982.

For each farm a representative area was selected in which samples of soil, leaf, and roots from three separate plants were taken. As symptoms normally associated with Na toxicity begin in the margin of the older leaves, leaf IV was sampled. In this leaf, for both Sets, and for most plants sampled, the symptoms were just begining to show. Central (C) and marginal (M) zones of the leaf were analized separetely (Fig. 2), as suggested by P. MARTIN-PREVEL (personal communication). In Set 2, leaf III was additionally sampled in accordance with the International Method of Reference, but the data are still being computed.

RESULTS

Table 1 shows the means, coefficients of variation (CV%), and significance level (s.l.) for differences between means, in the 38 variables studied. The left column compares Sets 1 and 2 ; the right column compares, in Set 2, well and gallery (*) waters. In this case, farms which used water

* - A gallery is a mine perforated in the mountain, to tap water of confined aquifers. In the island of Tenerife the contribution of the galleries to the total water resources is about 80%.

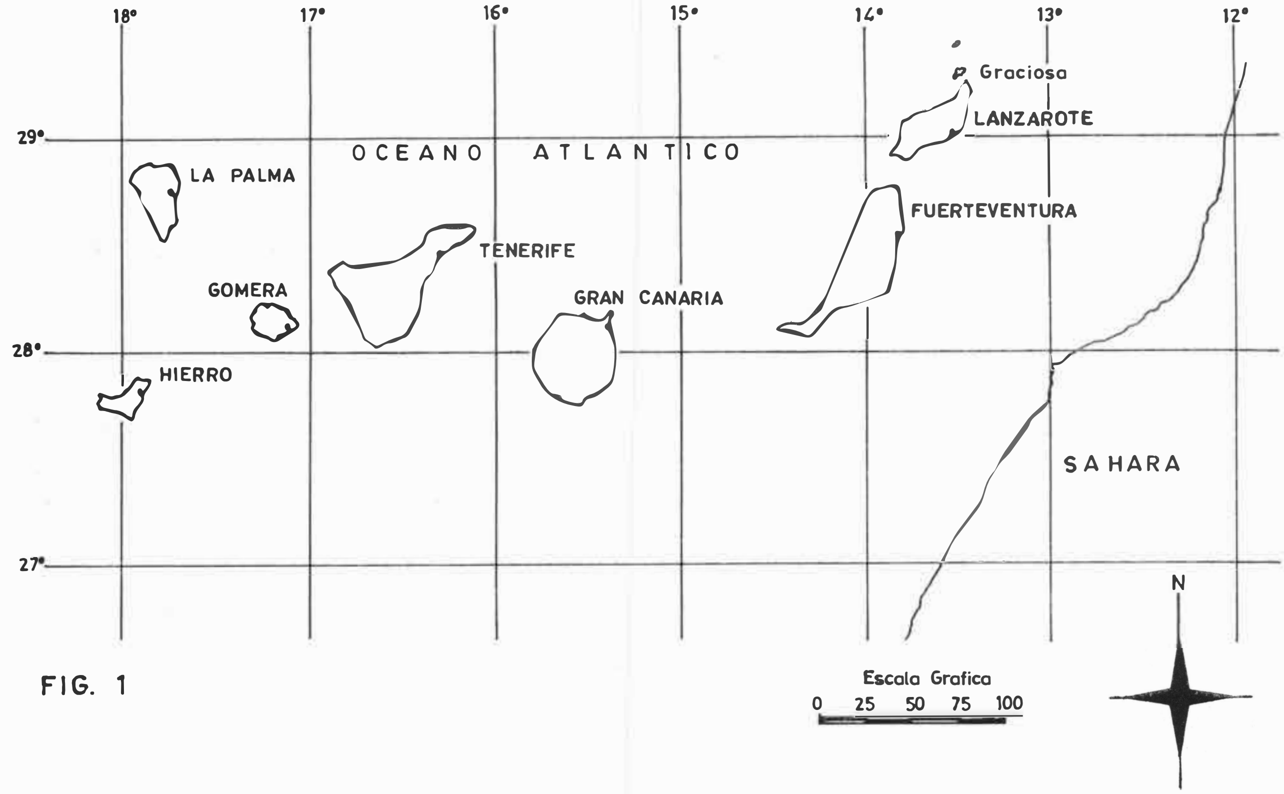

FIG. 1

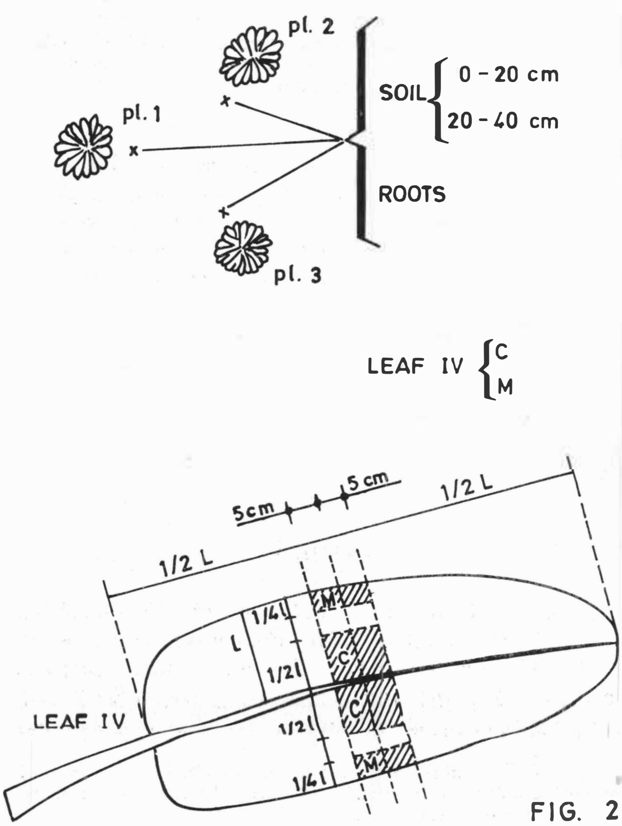

FIG. 2

from both origins were not included. Hence, the number of farms is 109 vs. 132 in the whole of Set 2.

Table 2, 3 and 4 present the coefficients of linear correlation.

DISCUSSION

As high correlations between Na and Cl plant indicators have not been found, both will be discussed separately.

Sodium.

The comparison of both Sets (Table 1) shows the increase in Na concentration in soil and plants over a period of 5 months. In the plant, the maximum concentration is found in the roots and the minimum in the leaf-C. This zone of the leaf does not seem sensitive enough to detect the increase in Na, as opposed to the roots and leaf-M where the concentrations of Na increase with time.

In leaf-C the sum of cations remains constant with the passing of time, but not in leaf-M (Table 1).

In Table 2, for plants at flowering stage (Set 2), the roots show the best correlations with soil and water indicators, followed by leaf-M and leaf-C. The correlation for Na between root and leaf-M is not very high but it is

TABLE 1 - Analytical results.

	Set of samples				Water origin (Set 2)			
	1	2	CV %	s.l.	Well	Gallery	CV %	s.l.
SAMPLE SIZE	132	132			25	84		
WATER								
pH	8.73	8.67	5-5	N.S.	8.69	8.74	5-4	N.S.
EC (mmhos/cm at 25°C)	0.94	1.00	44-83	N.S.	1.99	1.00	55-47	N.S.
CO_3H^- (meq/l)	4.83	5.63	67-63	*	4.14	6.89	66-51	***
Cl^- (meq/l)	2.25	1.53	114-149	**	2.89	0.75	97-63	***
SAR	5.49	4.76	43-48	**	5.03	4.94	35-49	N.S.
Adj. SAR	10.80	9.76	52-57	N.S.	9.76	10.60	51-54	N.S.
SOIL 0-20 cm								
pH	6.6	6.6	13-18	N.S.	6.50	6.80	15-15	N.S.
EC (mmhos/cm at 25°C)	1.70	1.57	57-59	N.S.	1.88	1.44	51-53	*
Cl (meq/l)	2.23	2.39	117-124	N.S.	3.76	1.50	90-95	***
Exch. Na (p. 100)	7.91	9.23	43-43	***	9.4	9.8	46-41	N.S.
SAR	4.07	5.28	45-55	***	5.50	5.62	52-56	N.S.
SOIL 20-40 cm								
pH	6.8	6.8	12-14	N.S.	6.74	6.96	17-13	N.S.
EC (mmhos/cm at 25°C)	1.38	1.35	51-53	N.S.	1.59	1.25	41-45	*
Cl (meq/l)	2.00	2.07	100-120	N.S.	3.0	1.34	70-96	***
Exch. Na (p. 100)	8.9	10.0	43-40	**	10.35	10.54	37-40	N.S.
SAR	4.62	5.78	57-56	***	6.45	6.11	50-56	N S.
LEAF (IV-C)								
Ca (meq/100 g)	53.8	70.1	25-32	***	78.3	69.1	23-36	*
Mg (meq/100 g)	43.7	38.3	21-28	***	40.8	37.9	25-26	N.S.
Na (meq/100 g)	0.9	0.9	48-69	N.S.	0.8	1.0	107-59	N S.
K (meq/100 g)	88.1	75.9	14-24	***	68.2	79.6	25-23	**
Σ cations (meq/100 g)	186.6	185.3	9-14	N.S.	188.1	188.0	9-15	N.S.
Ca (p. 100 Σ)	28.7	37.3	21-22	***	41.4	36.1	16-25	**
Mg (p. 100 Σ)	23.5	20.8	20-26	***	21.7	20.3	24-25	N.S.
Na (p. 100 Σ)	0.5	0.5	48-68	N.S.	0.4	0.5	105-63	N.S.
K (p. 100 Σ)	47.3	41.3	12-23	***	36.5	42.8	26-22	**
Cl (%)	1.05	0.99	44-57	N.S.	1.25	0.80	44-52	***
LEAF (IV-M)								
Ca (meq/100 g)	44.9	47.0	28-29	N.S.	52.9	44.7	32-29	*
Mg (meq/100 g)	41.2	34.2	21-23	***	35.6	34.0	22-22	N S.
Na (meq/100 g)	1.6	3.6	83-148	***	1.66	4.09	131-80	***
K (meq/100 g)	66.2	47.3	21-31	***	45.7	48.1	33-31	N.S.
Σ cations (meq/100 g)	153.3	132.2	14-13	***	136.0	131.3	15-13	N.S.
Ca (p. 100 Σ)	29.1	35.1	21-21	***	38.3	33.7	21-22	**
Mg (p. 100 Σ)	27.6	26.2	23-23	*	26.7	26.2	25-22	N.S.
Na (p. 100 Σ)	1.0	2.5	89-137	***	1.2	3.1	120-125	***
K (p. 100 Σ)	42.6	35.9	19-31	***	33.9	36.6	32-30	N.S.
Cl (%)	0.64	0.30	53-134	***	0.34	0.21	103-152	N.S.
ROOT								
Na (meq/100 g)	15.8	21.8	52-52	***	23.7	22.9	56-48	N.S.
Cl (%)	1.25	0.93	42-66	***	1.28	0.68	42-59	*

* : < 5 % ** : < 1 % *** : < 0.1 %

TABLE 2 - Coefficients of correlation for sodium.

		Water CO_3H^-	Water Adj. SAR	Soil 0-20 cm ESP	Soil 20-40 cm ESP	Soil 0-20 cm SAR	Soil 20-40 cm SAR	Leaf-C (p. 100 Σ) Ca	Leaf-C (p. 100 Σ) Mg	Leaf-C (p. 100 Σ) Na	Leaf-C (p. 100 Σ) K	Leaf-M (p. 100 Σ) Ca	Leaf-M (p. 100 Σ) Mg	Leaf-M (p. 100 Σ) Na	Leaf-M (p. 100 Σ) K	Root Na
Set 1 (n = 132)																
LEAF-C (p. 100 Σ)	Ca	-.50 ***	-.43***	-.32***	-.24**	-.31***	-.33***	1.00								
	Mg	.41***	.35***	.37***	.26**	.24**	.34***	-.41***	1.00							
	Na	.01	-.06	.01	.01	.05	.06	-.17*	-.08	1.00						
	K	.20*	.17	.04	.05	.14	.07	-.71***	-.35***	.20*	1.00					
LEAF-M (p.100 Σ)	Ca	-.34***	-.32***	-.21*	-.22*	-.28**	-.30***	.67***	-.24**	-.20*	-.49***	1.00				
	Mg	.25**	.18*	.20*	.10	.11	.11	-.26**	.44***	-.13	-.07	.06	1.00			
	Na	.20*	.20*	.15	.15	.15	.35***	-.21*	.04	.50***	.17*	-.16	-.17*	1.00		
	K	.07	.06	-.01	.06	.07	.07	-.28**	-.14	.17	.39***	-.69***	-.69***	.17*	1.00	
ROOT :	Na	.39***	.49***	.63***	.57***	.57***	.58***	-.27**	.40***	.02	-.03	-.28**	.11	.32***	.05	1.00
Set 2 (n = 132)																
LEAF-C (p.100 Σ)	Ca	-.28**	-.18*	-.11	-.08	-.08	.01	1.00								
	Mg	.19*	.08	.23**	.18*	.14	.20*	-.08	1.00							
	Ka	.35***	.19*	.23**	.26**	.16	.18*	-.33***	.38***	1.00						
	K	.12	.10	-.04	-.04	-.01	-.12	-.78***	-.54***	-.01	1.00					
LEAF-M (p.100 Σ)	Ca	-.30***	-.29***	-.09	-.13	-.13	-.07	.64***	.17*	-.10	-.66***	1.00				
	Mg	.30***	.12	.20*	.16	.14	.17*	-.04	.69***	.30***	-.38***	.14	1.00			
	Na	.38***	.24**	.27**	.20*	.26**	.26**	-.04	.15	.42***	-.06	-.04	.17*	1.00		
	K	-.12	.03	-.15	-.07	-.09	-.15	-.39***	-.53***	-.22*	.67***	-.73***	-.68***	-.38***	1.00	
ROOT :	Na	.65***	.60***	.60***	.55***	.57***	.61***	-.04	.27**	.17*	-.12	-.22*	.28**	.31***	-.13	1.00

* : < 5 % ** : < 1 % *** : < 0.1 %

TABLE 3 - Coefficients of correlation for sodium.

		Water CO_3H^-	Water Adj. SAR	Soil 0-20 cm ESP	Soil 20-40 cm ESP	Soil 0-20 cm SAR	Soil 20-40 cm SAR	Leaf-C (p. 100 Σ) Ca	Leaf-C (p. 100 Σ) Mg	Leaf-C (p. 100 Σ) Na	Leaf-C (p. 100 Σ) K	Leaf-M (p. 100 Σ) Ca	Leaf-M (p. 100 Σ) Mg	Leaf-M (p. 100 Σ) Na	Leaf-M (p. 100 Σ) K	Root Na
Well Water (Set 2 ; n = 25)																
LEAF-C (p. 100 Σ)	Ca	-.08	-.05	.18	.22	.03	.24	1.00								
	Mg	.33	.32	.49*	.37	.29	.34	.23	1.00							
	Na	.22	.15	.31	.22	.06	.05	-.38	.33	1.00						
	K	-.13	-.14	-.41*	-.38	-.19	-.36	-.83***	-.73***	.05	1.00					
LEAF-M (p.100Σ)	Ca	.18	-.17	.13	.11	-.18	.08	.53**	.22	-.04	-.50*	1.00				
	Mg	.40*	.35	.29	.25	.16	.26	.32	.65***	-.10	-.58**	.15	1.00			
	Na	.22	.19	.44*	.24	.28	.17	-.17	.25	.56**	-.04	-.10	-.16	1.00		
	K	-.15	-.12	-.33	-.27	.01	-.24	.56**	-.59**	.02	.72***	-.80***	-.70***	.04	1.00	
ROOT :	Na	.69***	.68***	.64***	.61**	.68***	.66***	.17	.43*	-.11	-.35	-.05	.43*	.18	-.25	1.00

* : < 5 % ** : < 1 % *** : < 0.1 %

TABLE 4 - Coefficients of correlation for chloride.

	Cl-Water	Cl-Soil 0-20 cm	Cl-Soil 20-40 cm	Cl-Leaf C	Cl-Leaf M	Cl-Root
Set 2 (n = 132)						
Cl-Water	1.00					
Cl-Soil (0-20 cm)	.73 ***	1.00				
Cl-Soil (20-40 cm)	.61***	.75***	1.00			
Cl-Leaf C	.52***	.43***	.45***	1.00		
Cl-Leaf M	.34***	.27**	.40***	.58***	1.00	
Cl-Root	.51***	.54***	.52***	.61***	.43***	1.00
Gallery Water (Set 2 ; n = 25)						
Cl-Water	1.00					
Cl-Soil (0-20 cm)	.21	1.00				
Cl-Soil (20-40 cm)	.25*	.88***	1.00			
Cl-Leaf C	.41***	.23*	.30**	1.00		
Cl-Leaf M	.05	.05	.12	.29**	1.00	
Cl-Root	.35**	.40***	.45***	.43***	.06	1.00

* : < 5 % ** : < 1 % *** : < 0.1 %

highly significant, whereas the correlation between root and leaf-C is poor.

In young plants (Set 1, Table 2) leaf concentrations of Ca and Mg present better correlations with soil and water indicators than Na.

The relationships between Ca/K and Mg/K bring up clearly the antagonism phenomena. In mature plants, (Table 2, Set 2) there are significant correlations between Na and Ca (-) and Mg (+) in leaf-C but not in leaf-M. In young plants the correlation coefficients for leaf Na content are low.

The correlations between Na and K are poor with the exception of the leaf-M in the mature plants, where a high negative coefficient appears. So while the concentration of Na in the margin increases with time, the K concentration decreases (Table 1).

In the right column of Table 1, the data of Set 2 have been split into well and gallery irrigation waters, showing the most important differences between them. Chloride content in well water is higher than in gallery water, and bicarbonate content is lower. Nevertheless, as SAR, Adjusted SAR, and Na concentration values (not included) are similar, the alkalinization capacities of both types of water, on an average, are also similar. As a consequence, the indicators in soil and plants do not show significant differences, with the exception of leaf-M, where the Na concentration in gallery water is higher than in well water. On the other hand, the well water (Table 3) does not present strong negative correlation between Na and K in leaf-M as occurs in gallery water (*). In the former, Na in root is the only plant indicator that shows significant correlations with soil and water, but the number of samples studied to date is too low to draw conclusions.

A clear explanation for this has not been found, but it seems that the plant accumulates Na in the roots and possibly in the corm : the rate of transportation to leaves may differ depending on the concentration of bicarbonate, perhaps not directly but through a mechanism involving Ca. The Ca concentration in leaf-C and M is lower for gallery water than for well water (Table 1). If this is the case, leaf-M would be a more sensitive indicator for Na in the plant.

Chloride.

In both Sets 1 and 2, the roots and leaf-C show the maximum chloride contents (Table 1). In leaf-M the chloride concentration is low. So it seems that bananas do not accumulate chloride at the margin of the leaves.

For the whole Set 2 (Table 4) the coefficients of correlation between plant, soil, and water indicators are highly significant, but they are better for root and leaf-C. Further, the difference between well and gallery waters is not detected in leaf-M (Table 1) and, when waters with low chloride content are being used (Table 4), there is no correlation between leaf-M and soil and water chloride indicators. Therefore, the roots and leaf-C may be good plant chloride indicators but not the leaf-M.

* - Matrix of coefficients of correlation for gallery water have been omitted because they are very similar to those of the whole Set 2 (Table 2), due to high contribution of the gallery waters to this Set.

CONCLUSIONS

The concentrations of Cl and Na in the roots show the best correlations with soil and water. Nevertheless, the roots may not be the best plant indicator for practical purposes in all cases.

For Cl, the concentration in the central zone of the leaf may be a good indicator, without differences between mature and young plants.

For Na and bicarbonate water : in young plants, Ca and Mg concentrations in the central zone of the leaf are better indicators than leaf Na concentration. Mature plants irrigated with high bicarbonate water show higher Na concentration in the leaf margins than those using water with lower bicarbonate and higher chloride concentration. This cannot be explained, but it may indicate that bicarbonate could play some role in the Na transportation to leaves. If this is the case, the Na concentration in the margin of the leaf may be the best indicator.

For well water, roots seem to be the best Na indicator, but the number of samples to date is too low to draw definite conclusions.