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Effect of Depth of Lime Application on Yield of Two Corn Hybrids Grown on a Typical Ultisol of Puerto Rico[1,2]

Raúl Pérez-Escolar and M. A. Lugo-López[3]

ABSTRACT

The effects of lime applied at 20, 40, and 60 cm depth, and of calcium nitrate applied in the top 20 cm, in terms of yield of two corn hybrids and on soil acidity factors in Humatas clay (a typical upland Ultisol of Puerto Rico) were determined. The first corn crop (Funk's G-795 W) revealed a significant linear relationship between corn yield and soil pH and exchangeable bases of the top 60 cm. The second crop (G-795 W), the dry stover yield of which was used as a criterion to evaluate treatments, did not reveal significant effects of soil acidity factors on yield. The third crop (Pioneer X-306 B hybrid) showed a highly significant quadratic effect of pH and soil acidity factors of the 0–60 cm zone on corn yield. The fourth crop (X-306 B) revealed a highly significant linear effect of pH and soil acidity factors on yield. The application of calcium nitrate resulted in low yields approximating those of the unlimed treatments. The inactivation of ionic aluminum, particularly at lower soil depths, with concomitant improvement in root development and moisture uptake is considered the main reason for higher yields.

INTRODUCTION

Liming acid soils in the top 20 cm (or 0–20 cm zone) is a general practice as common as surface plowing. If attempts are to be made to exploit surface nutrients and moisture to stimulate maximum growth and yield, the expenditures that deep plowing and subsurface liming entail must be considered in the light of the benefits that are derived, particularly in dry years, when deep rooting crops can make more efficient use of these factors of production. Basic information has been obtained by Wahab et al. (7, 8) to help clarify the relationships between rooting depth,

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[3] Soil Scientist, Agricultural Experiment Station, Mayagüez Campus, University of Puerto Rico, Río Piedras, P.R., and former Soil Scientist, Agricultural Experiment Station, Mayagüez Campus, University of Puerto Rico, Río Piedras, P.R., now consultant, Cornell University.

growth, and yield of corn and sorghum, and soil water availability in Ultisols and Oxisols.

Pohlman (4) found in a 4-year study that liming a Gilpin silt loam in the top 40 cm almost tripled alfalfa yield when compared to liming the surface 20 cm. The original pH was 4.86 in the top 20 cm and 5.06 in the 20 to 40 cm depth. Base saturation values were 35 and 60%, respectively. Root distribution was markedly affected by liming the 40 to 60 cm layer to about neutrality. This treatment resulted in an increase of 50% in the proportion of the total root growth in the 40-60 cm layer. Englebert and Truog (2), working on an acid, compact subsoil, found that hay yield was consistently increased in a second year by subsoil liming and fertilizing, and especially so in the third and fourth years. They point out, however, that yield was not increased where the fertilizer was omitted. Deeper root penetration of alfalfa was promoted by subsoil liming and fertilizing but not by subsoiling alone. Corn and oats did not appear to respond to subsoil treatments even in dry years. Younts and York (9) found that dry matter yield of corn was unaffected by the depth of lime and fertilizer distribution. Crimson clover yield, on the other hand, was increased somewhat where soil was limed and fertilized to a depth of 60 cm. Yield of the latter was related to increased K absorption with deeper lime placement. Giddens et al. (3) in a 2-year study found that placement to 45 cm of fertilizer and lime on a Cecil sandy loam was not conducive to increased alfalfa or Coastal Bermuda grass yield.

Experiments conducted in Brazil (6) in which four rates of lime were incorporated at depths of 0-15 and 15-30 cm, revealed that deep incorporation of lime was superior to shallow incorporation when three corn crops were grown. The difference between the two depths of incorporation increased with lime rate and with each successive crop. The paucity of information on deep liming of soils of the humid tropics led to the present study.

MATERIALS AND METHODS

The experiments were conducted on a Humatas clay, an Ultisol of the uplands of Puerto Rico. It is one of the Typic Tropohumults, with an organic matter content of 3% and a cation exchange capacity of 10 meq/100 g as determined by the sum of Ca, Mg, and Al extracted with 1.0 *N* KCl. Its pH, measured prior to application of the treatment differentials, was 4.8 in the top 20 cm, 4.9 at the 20 cm to 40 cm depth, and again 4.8 at the 40 to 60 cm depth. The average exchangeable Al content was 4 meq/100 in all three layers. The treatments, arranged in a randomized block design and replicated five times, were as follows:

1. No lime, profile disturbed to 0-60 cm
2. Lime 0-20 cm, profile disturbed to 0-60 cm

3. Lime 0–40 cm, profile disturbed to 0–60 cm
4. Lime 0–60 cm, profile disturbed to 0–60 cm
5. No lime, only top 20 cm disturbed
6. $Ca(NO_3)_2$[4], only top 20 cm disturbed
7. Lime + urea, topmost 20 cm disturbed

The amounts of lime applied depended on the exchangeable Al content. For each meq of Al, 3 meq of Ca, as $Ca(OH)_2$, were applied. The lime was thoroughly mixed with the appropriate layers of soil. In treatments 1 through 4, the soil profile to a depth of 60 cm was disturbed alike, irrespective of lime required, in order to minimize differences other than those which could be attributed to incorporation of materials. Treatments 5 through 7 were disturbed only in the top 20 cm.

The first corn crop was planted on October 2, 1973, 2 weeks after treatments had been made and field moisture had approached field capacity. Funk's G-795 W hybrid corn was planted 2 days after the application of a mixture of 112 kg/ha of N as urea, or as $Ca(NO_3)_2$ on the plots where the treatment was imposed, 224 kg/ha of P_2O_5 as triple superphosphate, 168 kg/ha of K_2O as sulfate and 112 kg/ha of Mg as Epsom salt on plots 9.45 m^2. The second N application of 112 kg/ha was administered immediately after tasseling. Corn was planted at 75 cm between rows and 30 cm between plants. Leaves number 4 were sampled at tasseling time, just before the second N application, and analyzed for N, P, K, Ca, Mg, and Mn.

The second corn crop was planted on May 24, 1974. Again, Funk's G-795 W was planted 2 days after the application of the same fertilizer mixture used in the first crop, except that the amount of N was increased from the 224 kg/ha used in the first crop to 336 kg/ha. The increase was made to provide more calcium as $Ca(NO_3)_2$ since, with the application of 224 kg/ha of N, the amount of Ca provided by the salt was only 0.78 meq/100 g. As in the first crop, the second N application was made just after tasseling.

In order to determine the approximate percentage water removed by the crop, calibrated Bouyoucos[5] blocks were installed at the 20-, 40-, and 60-cm depth in 3 out of the 5 replications of treatment 1 through treatment 4. Beginning when the crop was 1½ months old, weekly readings were registered with a Delmhorst soil moisture tester during a 6-week period.

The third crop was planted on October 22, 1974. Pioneer X-306 B, a

[4] The $Ca(NO_3)_2$ treatment added 224 kg/ha of N and 350 kg/ha of Ca.

[5] Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico or an endorsement over other equipment or materials not mentioned.

high yielding hybrid corn, was used because of its marked resistance to northern blight and armyworm. A fourth crop of the same hybrid was planted on June 23, 1975. The fertilizer used in the first experiment was also used in these two crops but the second N application was administered when the plants were 1 month old. Dithane M-45 and Lannate were used in order to control northern blight and armyworm, respectively. All four experiments were harvested when plants were 18 weeks old.

RESULTS AND DISCUSSION

Table 1 shows the effect of depth of lime application and of surface application of calcium nitrate, and a combination of urea and surface lime, on yield and on leaf chemical composition of field corn (Funk's hybrid for first crop and second crop and Pioneer hybrid for third and fourth crops) grown on a Humatas clay, an Ultisol. The leaf nutrient status, measured just before tasseling, was not significantly altered within any of the four corn crops. When treatment yields were compared, analysis of variance and subsequent Duncan's tests showed that in the first corn crop the 0 to 60 cm lime treatment outyielded the calcium nitrate treatment in a highly significant way, and outyielded both check treatments and the lime plus urea treatment significantly. However, there were no significant differences among the lime treatments from 0 to 20 cm, 0 to 40 cm, or 0 to 60 cm depth.

In the second corn crop, because grains did not fill, only the dry stover yield was used as a criterion to evaluate the effect of soil pH and acidity factors of the top 60 cm. No significant effects among treatment differentials were observed.

In the third corn crop all lime treatments outyielded the undisturbed check treatment at the 1% probability level. All lime treatments except surface lime plus urea outyielded the $Ca(NO_3)_2$ and disturbed check treatments at the 1% level. All lime treatments, including the surface lime plus urea treatment, produced significantly more corn than both the check and $Ca(NO_3)_2$ treatments.

The fourth crop followed the same general pattern described for the first and third crops. All lime treatments except surface lime plus urea outyielded the undisturbed check at the 1% level. Lime applied in the 0–60 cm treatment outyielded both undisturbed and disturbed checks at the 1% level. Finally, all lime treatments produced significantly more corn than both check treatments. In all cases, lime incorporated in the 0 to 60 cm zone produced higher yields than did the $Ca(NO_3)_2$ treatment.

Regression analyses of soil pH and related acidity factors on corn yield are shown in table 2. Yields of the first and second crop, were related to the first sampling, and those of the third and fourth to the second sampling. Correlation coefficients and corresponding equations express-

TABLE 1.—*The effect of depth of lime application and surface application of calcium nitrate on yield and on leaf chemical composition of field corn, Funk's G-795 W hybrid, (first and second crops) and Pioneer X-306 B hybrid (third and fourth crops) grown on a Humatas clay, an Ultisol*

Treatment	Yield	Foliar composition					
		N	P	K	Ca	Mg	Mn
	Kg/ha			%			
		First crop (grain)					
No lime[1]	5,583 a[3]	3.00	0.15	1.93	0.22	0.07	121
Lime, 0-20 cm	6,419 ab	3.10	.17	2.03	.23	.06	103
Lime, 0-40 cm	6,620 ab	3.18	.17	1.91	.25	.09	113
Lime, 0-60 cm	7,978 b	3.29	.21	1.89	.27	.09	121
No lime[2]	5,426 a	2.98	.16	1.84	.24	.08	99
$Ca(NO_3)_2$	4,841 a	2.97	.15	2.06	.23	.07	110
Lime + urea	6,054 a	3.18	.16	1.94	.21	.08	106
		Second crop (stover)					
No lime[1]	4,375 a	2.57	0.12	1.69	0.26	0.23	116
Lime, 0-20 cm	5,145 a	2.51	.12	2.09	.25	.19	92
Lime, 0-40 cm	4,963 a	2.66	.11	1.81	.26	.18	85
Lime, 0-60 cm	5,781 a	2.51	.14	1.89	.23	.16	70
No lime[2]	4,031 a	2.57	.13	1.96	.24	.19	111
$Ca(NO_3)_2$	4,996 a	2.55	.12	1.68	.25	.16	99
Lime + urea	5,592 a	2.59	.15	1.80	.24	.19	72
		Third crop (grain)					
No lime[1]	4,281 a	3.27	0.19	2.03	0.30	0.19	32
Lime, 0-20 cm	6,199 b	3.64	.21	2.16	.32	.26	32
Lime, 0-40 cm	7,004 b	3.38	.20	1.91	.35	.25	32
Lime, 0-60 cm	6,865 b	3.68	.21	2.00	.36	.23	32
No lime[2]	3,955 a	3.22	.19	2.07	.28	.21	32
$Ca\ (NO_3)_2$	4,206 a	3.22	.19	2.25	.30	.24	32
Lime + urea	5,878 b	3.53	.22	2.10	.36	.23	32
		Fourth crop (grain)					
No lime[1]	4,288 a	3.25	0.11	2.46	0.18	0.21	113
Lime, 0-20 cm	6,010 b	2.92	.13	2.27	.26	.24	86
Lime, 0-40 cm	6,004 b	3.13	.12	2.29	.24	.22	89
Lime, 0-60 cm	6,587 b	3.10	.14	2.30	.26	.28	66
No lime[2]	3,974 a	3.11	.13	2.33	.19	.19	113
$Ca\ (NO_3)_2$	4,891 a	2.84	.13	2.52	.22	.21	106
Lime + urea	5,885 b	2.99	.13	2.28	.25	.24	78

[1] Plots were disturbed down to 60 cm depth.

[2] Plots were disturbed down to 20 cm depth.

[3] Values followed by one or more letters in common do not differ significantly at the 5% level.

ing acidity parameters throughout the soil profile (0–60 cm) with the corresponding corn yield are shown in table 3.

In the first corn crop, a significant relation (r = 0.50) was measured between soil pH (0–60 cm) and corn yield with $Y = 740.1 + 1150.5X$ to predict yield at a particular pH. Likewise, exchangeable Ca + Mg was significantly related (r = 0.52) to corn yield and linear effect $Y = 5067.3 + 79.8X$ measured. Neither exchangeable Al nor percent base saturation was significantly related to yield. Exchangeable bases contributed more to increased corn yield than exchangeable Al did to decrease it.

TABLE 2.—*The effect of soil pH and related acidity factors of the topmost 60 cm of soil on the yield of corn (first, third, and fourth crops) and dry corn stover (second crop) grown on a Humatas clay, an Ultisol*

Soil property	First crop	Second crop[1]	Soil property	Third crop	Fourth crop
Soil pH	*Kg/ha*	*Kg/ha*	*Soil pH*	*Kg/ha*	*Kg/ha*
4.3–4.8	5,951	5,442	4.0–4.8	5,004	4,822
4.9–5.4	6,662	4,656	4.9–5.7	6,790	5,822
5.5–6.0	7,810	5,629	>5.7	6,903	6,381
>6.0	7,952	7,110			
Exch. Ca + Mg Meq/100 g			*Exch. Ca + Mg Meq/100 g*		
0–3.0	5,256	4,341	2.0–5.0	4,124	4,659
3.1–6.0	6,916	5,727	5.1–8.0	6,262	5,966
6.1–9.0	7,048	5,124	8.1–11	6,979	6,212
>9	7,783	6,383	>11	6,809	6,595
Exch. Al Meq/100 g			*Exch. Al Meq/100 g*		
0–0.66	7,261	6,336			
0.67–1.33	6,186	5,429	0–2.0	6,551	6,438
1.34–2.00	5,570	5,673	2.1–3.0	4,986	5,338
>2.00	6,142	4,723	>3.0	3,357	3,144
Percent base saturation			*Percent base saturation*		
40–60	5,258	4,341			
61–80	7,236	5,993	40–60	3,420	3,496
>80	7,104	6,185	61–80	6,457	6,212
			>80	6,935	6,991

[1] Dry weight of stover.

No significant relations were observed between soil pH and related acidity factors of the top 60 cm and the dry stover yield of the second crop.

The third crop was characterized by the quadratic effects of soil pH and acidity parameters on crop yield. Highly significant correlation coefficients of 0.78, 0.70, 0.78, and 0.86 were measured when corn yield was related to soil pH, exchangeable Ca + Mg, exchangeable Al and percent base saturation of top 60 cm soil profile, respectively.

TABLE 3.—*Correlation coefficients and corresponding equations expressing the relationship between soil acidity parameters and corn yield*

First crop	Second crop	Third crop	Fourth crop
		Soil pH	
$r = 0.50^{*}$ $Y = 740.1 + 1150.5X$	$r = 0.34$ N.S.	$r = 0.78^{**}$ $Y = -54175.1 + 20998.6X - 1798.1X^2$	$r = 0.62^{**}$ $Y = 287.3 + 1112.8X$
		Exchangeable Ca + Mg	
$r = 0.52^{*}$ $Y = 5067.3 + 79.8X$	$r = 0.28$ N.S.	$r = 0.70^{**}$ $Y = 1490 + 1129.1X - 55.9X^2$	$r = 0.60^{**}$ $Y = 4055.1 + 224.4X$
		Exchangeable Al	
$r = 0.34$ N.S.	$r = 0.38$ N.S.	$r = 0.87^{**}$ $Y = 6921.9 + 472X - 387.3X^2$	$r = 0.73^{**}$ $Y = 6831.5 - 741.2X$
		Percent base saturation	
$r = 0.40$ N.S.	$r = 0.39$ N.S.	$r = 0.86^{**}$ $Y = -6515.8 + 298.6X - 1.63X^2$	$r = 0.71^{**}$ $Y = 2020.0 + 47.2X$

In the fourth crop, as in the first, the effects of the aforementioned acidity parameters were of a linear nature when related to the crop yield.

Table 4 shows the dry stover yield and approximate water percentage used from each soil layer during the period of maximum growth rate of the second crop (Funk's G-795 W). Even though no significant differences among treatments were measured, it can be observed that where stover yield was higher, approximately all available water was used by the crop in each soil layer. Conversely, where available water was only partially removed, yield was lower.

Since leaf nutrient status was not significantly altered by treatment differentials in any of the crops, it is in this area that ionic aluminum is to be considered in the light of the speculations made relative to its possible interference in moisture absorption by roots. Bonner and Galston (1) state a proposal as to the mechanism by which ions act as they do in influencing membrane permeability: That the monovalent ions may act in the direction of dispersing or decreasing the binding forces between adjacent molecular components of the membrane, whereas polyvalent cations function in the reverse way, binding adjacent components more closely together. The best studied case of ion antogonism is that involving the monovalent ions K^+ and Na^+ and the divalent Ca^{++} ion. The way in which these ions influence permeability has been demonstrated strikingly (1) in experiments involving the loss of pigment from fragments of red beet roots.

TABLE 4.—*Dry stover yield and approximate percent water used at each soil layer during period of maximum growth rate of second corn crop (Funk's G-795 W) grown on a Humatas clay, an Ultisol*

Treatment	Yield	Percent water removed at—		
		0-20 cm	20-40 cm	40-60 cm
	Kg/ha			
Check	4,546	39	51	41
Lime, 0-20 cm	6,853	99	92	71
Lime, 0-40 cm	6,771	98	96	94
Lime, 0-60 cm	8,106	100	100	100

When fragments of the root were placed in distilled water, the pigment permeated outward at such a slow rate as to be hardly detectable. If, however, the tissue fragments were placed in a dilute solution of NaCl, a rapid outward diffusion of pigment occurred. This was due to the increased permeability of the membrane. When the tissue was transferred to a solution containing $CaCl_2$ in addition to NaCl, the permeability was again decreased and the loss of pigment slowed down and ceased.

The highly significant quadratic effects of acidity parameters on the third corn crop yield can be ascribed to the fact that during the period from October 22, 1974 to January 22, 1975, 1,549 mm of rainfall/ha were registered. Considering moisture sufficiency, corn roots did not need to go deeper than 40 cm. Vázquez (5) reported that field corn, Mayorbela variety, has an approximate consumptive use of water of 1.13 m/ha during the 90 days following planting under the conditions of the Lajas

TABLE 5.—*Soil chemical data after first and third corn crops*

Treatment and depth of sampling, cm	pH	Exchangeable Ca	Exchangeable Mg	Exchangeable Al	pH	Exchangeable Ca	Exchangeable Mg	Exchangeable Al
	Values at indicated time—							
	After first crop				After third crop			
Check, disturbed			*meq/100g*				*meq/100g*	
0–20	4.35	2.91	0.63	2.22	4.51	2.39	1.65	3.33
20–40	4.29	1.90	.48	2.60	4.53	2.14	1.87	3.25
40–60	4.38	1.56	.39	2.64	4.65	1.68	2.02	3.22
Lime, 0–20								
0–20	5.35	7.57	0.35	0.30	5.46	5.84	2.95	0.38
20–40	4.32	2.76	.37	1.97	4.64	3.36	1.37	2.37
40–60	4.46	1.79	.50	2.46	4.61	2.04	1.12	3.27
Lime, 0–40								
0–20	5.41	8.05	0.42	0.11	5.60	5.97	2.58	0
20–40	6.32	10.80	.38	0	6.79	10.59	2.58	0
40–60	4.58	5.36	.26	.80	4.83	4.27	1.25	2.14
Lime, 0–60								
0–20	5.49	8.29	0.43	0.06	5.64	5.95	2.95	0
20–40	6.32	12.45	.32	0	6.63	9.56	2.99	0
40–60	6.37	11.09	.24	0	7.13	11.85	2.90	0
Check, undisturbed								
0–20	4.45	3.66	0.49	1.41	4.60	1.79	1.70	3.47
20–40	4.22	1.55	.39	2.49	4.34	1.43	1.04	3.80
40–60	4.35	1.34	.56	2.23	4.35	1.44	1.17	3.18
$Ca(NO_3)_2$								
0–20	4.58	3.25	0.25	1.35	4.93	3.31	1.91	1.87
20–40	4.18	1.80	.43	2.36	4.63	2.03	1.27	3.38
40–60	4.34	1.47	.50	2.48	4.51	1.68	1.22	3.29
Lime + urea								
0–20	4.92	6.10	0.54	0.59	5.09	5.26	2.76	0.57
20–40	4.28	2.48	.31	2.26	4.73	2.94	2.64	2.02
40–60	4.48	1.80	.63	2.03	4.60	2.05	1.88	2.70

Valley. Considering that Funk's G-795 W and Pioneer X-306 B hybrids are high yielders of both stover and grain, consumptive use is probably higher.

In the fourth crop, only 479 mm/ha were registered during the 76 days following planting. On September 9, hurricane Eloise brought 753 mm/ha of water but the stress undergone during those 76 days must have limited corn growth, especially in the treatments where no lime had been applied or lime had been applied in the top 20 cm. Where lime had been applied at deeper layers (0-40 and 0-60 cm) ionic aluminum had been inactivated to the point that corn roots were able to exploit moisture not otherwise available.

In these experiments, the $Ca(NO_3)_2$ treatment was administered with the idea that the salt, being extremely soluble, would move readily in the profile, the NO_3^- anion upon being absorbed by the roots would produce HCO_3^- that with further hydrolysis would produce OH^- ions to precipitate ionic aluminum. The results with this treatment showed that with relatively small amounts of the salt added [$Ca(NO_3)_2$], no substantial increase in pH was observed. As a matter of fact, the exchangeable Al values shown on table 4 point to a 38% average increase in the profile from the first to the second sampling in spite of 0.3 pH unit increase. In all probability, a good fraction of this exchangeable aluminum determined in the second sampling may well be of the $Al(OH)_2^+$ and $Al(OH)_1^{++}$ species. At any rate, however, corn yields in this treatment, in all three crops, were of the same order as the check treatments.

The changes undergone by exchangeable Al both in the unlimed treatments and in the $Ca(NO_3)_2$ treatment are noteworthy. When plots were originally analyzed, the exchangeable Al values were approximately 4 meq/100 g in all three soil layers. After the first sampling, as shown in table 5, the values registered were 2.22 meq in the unlimed disturbed profile plots, 1.41 meq in the unlimed and top 20 cm disturbed, and 1.35 meq in the $Ca(NO_3)_2$ treatment. After the second sampling, values went up to 3.33, 3.47 and 1.87, respectively. It remains to be determined if a drying period may somehow inactivate exchangeable Al. The first crop underwent a rather dry period, the third crop, a rainy period. The low values of exchangeable Al in the first crop may explain why there was no negative relation to yield.

RESUMEN

En este trabajo se presentan los resultados de cuatro experimentos en los que se estudió el efecto de la profundidad de aplicación de cal en la composición foliar y la producción de maíz seco de los híbridos Funk's G-795 W y Pioneer X-306 B, sembrados en la arcilla Humatas, un Ultisol ácido de Orocovis, Puerto Rico con un alto contenido en aluminio cambiable. La cal se aplicó como hidróxido de calcio a razón de tres meq. de calcio por cada meq. de aluminio cambiable y a profundidades de 0-20 cm., 0-40 cm. y de 0-60 cm. Se incluyó, además, un tratamiento sin cal, pero el suelo se removió hasta los 60 cm. de profundidad para así minimizar las diferencias que podrían atribuirse a la cal propiamente. Se usó otro tratamiento consistente de una sal neutra, $Ca(NO_3)_2$, para estimular el movimiento del calcio y del nitrógeno a profundidades adecuadas, sin tener que remover el perfil completo. Por último, se incluyó un tratamiento consistente de urea y cal mezcladas en la capa superficial de 0-20 cm. Para determinar el consumo de agua del maíz a distintas profundidades, se utilizaron cilindros de yeso de Bouyoucos.

Los resultados revelaron que en el primer experimento había una relación significativa entre el pH medio a 0-60 cm.y el rendimiento de maíz seco, y entre el promedio de Ca + Mg cambiable a 0-60 cm. y el rendimiento. El efecto en ambos casos fue de naturaleza lineal. En el segundo experimento en el que se usó el peso seco del rastrojo como criterio para

evaluar los tratamientos, al no conseguir que el grano de maíz llenara, no se registraron diferencias ni relaciones significativas entre el pH, los factores de acidez y el peso seco del rastrojo. En el tercer experimento, hubo relaciones altamente significativas entre el pH, los factores de acidez y el rendimiento de maíz seco. El efecto fue de naturaleza cuadrática. En el cuarto experimento se repetieron esas mismas relaciones, pero el efecto fue lineal.

Se atribuyen los resultados del tercer y cuarto experimentos a la inactividad de aluminio iónico a profundidades hasta 40 y 60 cm. que permitieron un uso más eficiente de la humedad por la planta. Esta presunción se basa en el hecho de que en el segundo experimento el maíz extrajo más agua a las profundidades donde se aplicó la cal. Esto se reflejó en un peso aún más elevado del rastrojo, aunque por las variaciones no hubo diferencias significativas.

El uso de $Ca(NO_3)_2$ no fue favorable; el rendimiento en las parcelas que recibieron esta sal produjeron maíz seco en cantidades comparables con las parcelas testigo.

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