FSSA LIMING EXPERIMENTS ON MAIZE

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Introduction

In 1975 and again in 1977 the FSSA published provisional liming guidelines based on pH(KCl) and texture (usually done by finger test). It was then envisaged that modifications, or completely new guidelines, based on research, will probably be necessary. The two main problems preventing better guidelines were:

(i) a suitable method for the determination of a soil's lime requirement — although several methods existed, there was no unanimous acceptance of a suitable method, properly calibrated for various crops;

(ii) a suitable and complete method for the determination of lime quality and neutralizing effectiveness — the methods prescribed for statutory control were incomplete.

Since 1975/76 the FSSA has conducted 24 liming experiments on acid soils at eight sites in the Transvaal highveld, (not including the 1984/85 season). Twenty of these were harvested. Drought or hail caused failures in the other cases. Table 1 gives a list of the experiments.

TABLE 1. FSSA liming experiments (L = lime)

Site	Soil form/series	pH(KCl)	Experiment type	Experiment no	Season	Significant responses
Lichtenburg	Hutton/Msinga	4,3	L x depth	M44/WT	1975/76 1976/77 1977/78	NS NS NS
Ottosdal	Hutton/Msinga	4,1	L x NPK	M4/W	1978/79 1979/80 1980/81 1981/82 1982/83 1983/84	L* NPK** (Hail) L* NPK** L* (−) L* (−) (Drought)
Coligny	Hutton	4,4	L x NP	M11/W	1983/84	(Drought)
Bronkhorstspruit	Hutton/Middelburg	4,0	L x depth	M8/0	1977/78	Depth*
Middelburg	Hutton/Clansthal	4,0	L x MgZnB	M9/0	1979/80 1980/81 1981/82 1982/83	NS L** L** L**
Grootvlei	Avalon/Soetmelk	4,0	L x NPK	M4/S	1978/79 1979/80 1980/81 1981/82	NS NPK** L** NPK* L* N**
Heidelberg	Hutton/Hutton		L x P(N)	M10/S	1979/80 1980/81 1981/82 1982/83	NPK** L** P** N** NPK** (PL)* N** P** L** P**

Results

The results are given in Tables 2 - 6 and Figures 1 - 4, and summarised in Figures 5 - 8 and Table 7.

Western Transvaal (i)

Tables 2 and 3 give the results at **Ottosdal.**

TABLE 2. Maize yield responses on lime and fertilizer at Ottosdal: Four-year averages (5 seasons: 1978/79 - 1982/83). M4/W/79 - G C H Venter)

Fertilizer: N - P - K	Yield				
	Lime, t/ha: 0	1,08	2,17	Fertilizer average	
kg/ha	**t/ha**				
41 - 20 - 8	3,21	3,51	3,29	3,32	
108 - 50 - 30	4,27	4,31	4,13	4,24	
154 - 80 - 53	4,28	4,40	4,14	4,27	
Lime average	3,92	4,07	3,83	3,94	
	Soil Analysis, 1984				
	mg/kg				
Ca (Ambic)	230	400	520		
Mg (Ambic)	40	56	73		
	Acidity			Significant responses	
	pH(KCl) - **% Sat**			NPK	Lime
1978/1979	4,1 - **15,5**	4,7 - **5,2**	5,4 - **2,8**	** (+)	* (+)
1980	3,8 - **15,3**	4,1 - **4,2**	4,6 - **0,4**	Hail	
1981	4,0 - **18,7**	4,6 - **2,4**	5,0 -**1,2**	* (+)	* (+)
1982	4,2 - **6,2**	5,0 - **0,4**	5,2 - **1,6**		** (−)
1983	4,1 - **10,9**	4,6 - **1,8**	5,2 - **0,7**		** (−)
1984	4,2 - **22,4**	5,0 - **3,6**	5,8 - **1,6**	Drought	
Average	4,1 - **14,8**	4,7 - **2,9**	5,2 - **1,7**	(*)	(*)

TABLE 3. Maize yield responses on lime and fertilizer at Ottosdal, 1978/79 season (M4/W/78 — G C H Venter)

Fertilizer**: N - P - K	Yield			Soil analysis (Bray 1/Amm Ac)	
	Lime, **t/ha**: 0	1,5	3,0	P	K
kg/ha	**t/ha**			**mg/kg**	
45 - 50 - 15	4,42	4,82	5,05	16 (14)	62
90 - 100 - 30	5,63	5,76	5,79	24 (21)	62
135 - 150 - 45	6,01	6,00	6,01	36 (31)	66
	Soil analysis			() = Ambic1	
	mg/kg				
Ca (Amm Ac)	210	310	390		
Mg (Amm Ac)	30	32	35		
pH(KCl)	4,1	4,7	5,4		
Acid sat, %	15,5	5,2	2,8		

Althoughg the liming effect was significant, it was obviously not economically worth-while in the long run, except perhaps at the lowest NPK level. But NPK was significant and economically worthwhile at the second level. The optimum NPK is probably just under the second level, in which case the long-term liming effect was not significant. Liming had a negative effect in the last two seasons that could be harvested. They were very poor seasons.

Since the average values give the cumulative effect, one perhaps needs to consider also the effect of lime in the first year (Table 3), because one year's liming may have been sufficient on this soil. (See also Figure 5).

Again, it is obvious that lime was only effective at the first level (1,5 t/ha) and then only at the lowest NPK level. A pH(KCl) value above 4,7 does not seem warrented (Tables 2 and 3) in this case.

Acid saturation need therefore not be as low as 5%, but perhaps somewhat under 15%. Liming once only, also seems to be sufficient in this case, but the acidity would need to be monitored.

Relationship between pH(KCl) and % acid saturation is illustrated in Figure 1, compiled from the six years' data from the three lime treatments.

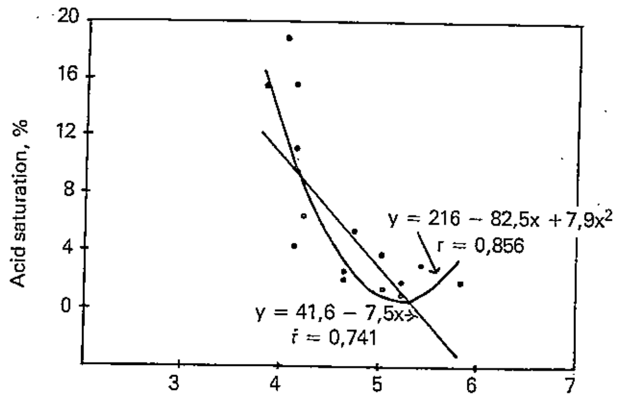

FIG 1. Relationships between acid saturation and pH(KCl) for six years' data at Ottosdal.

Regression equation:
% acid sat = 47,5 - 8,86 pH(KCl)
r = −0,709; r^2 = 0,503 (**)

An apparent outlier is the 22,4% acid saturation for a pH(KCl) of 4,2. If regarded as a possible error in analysis and omitted, the relationship is as follows:

% acid sat = 41,6 - 7,5 pH(KCl)
r = 0,741; r^2 = 0,549

Quadratic regression gives a better correlation coefficient, viz r = 0,856; r^2 = 0,733. The equation is:
% acid sat = 216 - 82,5x + $7{,}9x^2$

The relationship between lime application and pH/KCl) and also % acid saturation is shown in Figures 2 and 3 respectively.

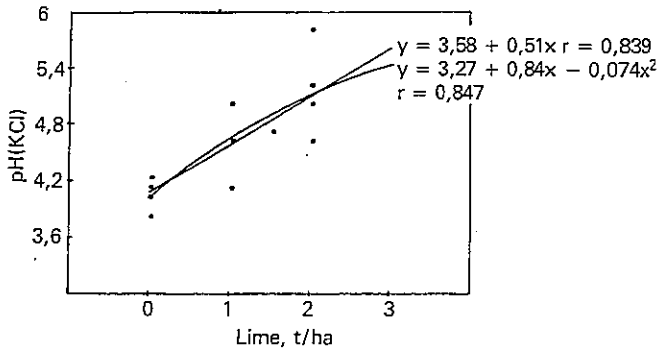

FIG 2. The relationship between pH(KCl) and lime application for six years' data at Ottosdal.

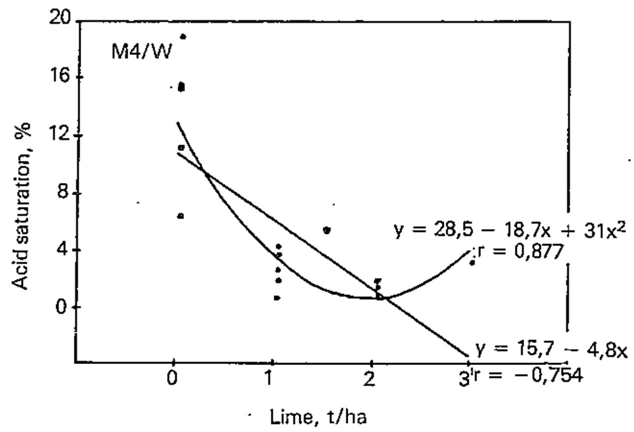

FIG 3. Relationship between acid saturation and lime application for six years' data at Ottosdal.

Western Transvaal (ii)

Because of drought no yields were obtained at the new liming experiment at **Coligny**.

The relationship between pH(KCl) and % acid saturation has, however, been determined for the first season and is given by the following regressions:

% acid sat = 13,1 - 2,47 pH(KCl) − r = −0,838 or,
% acid sat = 80,1 - 30,1 pH(KCl) + 2,8 $(pH(KCl)^2$ - r = 0,897

At 50% flowering the pH(KCl) was raised from 4,4 to 5 with 4,5 t lime/ha, while the acid saturation decreased respectively from about 2% to 0,25.

Eastern Transvaal

Table 4 gives the results at **Middelburg.** (See also Figure 6).

The significance of the liming effect is striking and economical. The pH values are not very revealing, except that a pH(KCl) of at least about 4,5 should be

TABLE 4. Maize yield responses on lime at Middelburg: Four-year averages (1979 - 1982/83). (M9/0/79 — G C H Venter)

Year	Yield			Significant responses
	Lime, t/ha: 0	1,63	Year average	
	t/ha			
1979/80	7,40	7,41	7,41	NS
1980/81	7,58	8,62	8,10	L**
1981/82	3,60	4,26	3,93	L**
1982/83	3,04	3,35	3,19	L**
Lime average	5,40	5,91	5,66	
	Soil analysis			
	mg/kg			
Ca	110	290		
Mg	21	29		
	Acidity			
	pH(KCl) - % Sat			
1979/80	4,1 -	4,8 -		
1980/81	4,1 - **51**	4,5 - **19**		
1981/82	3,9 -	4,5 -		
1982/83	4,0 - **24**	4,5 - **4**		
Average	4,0 - **37**	4,6 - **11**		

achieved. An acid saturation of between 5 and 20 seems to be acceptable.

The relationship between pH(KCl) and acid saturation is given in the following regressions for two out of the four years:

1980/81: % acid sat = 282,4 - 57,8 pH(KCl) - r = −0,871 or,
% acid sat = 1820,7 - 763,4 pH(KCl) + 80,6 $(pH(KCl))^2$ r = 0,922

1982/83: % acid sat = 125,1 - 25,8 pH(KCl) r = 0,684 or,
% acid sat = 377,8 - 141,3 pH(KCl) + 13,1 $(pH(KCl))^2$ r = 0,690

It is not clear why the relationships for the two years differ so much. It would seem to indicate that either the pH or the acid saturation is not a sufficiently sensitive parameter for the evaluation of acidity, or, conversely, either of them is too sensitive. (See also Figure 9).

Southern Transvaal (i)

Table 5 gives the results at **Grootvlei.** (See also Figure 7).

The highest level of liming was still economically justifiable. An acid saturation between 5 and 12% seems to be about optimal in this case — pH(KCl) between 4,3 and 4,6.

Southern Transvaal (ii)

Table 6 gives the results at **Heidelberg.** (See also Figure 8).

Liming to the first level (ave 1,13 t/ha) and at the second level of fertilizer (final year 38 kg P/ha) was economically justifiable. This level of liming resulted in a pH(KCl) of about 4,4 and an acid saturation of about 15%.

The relationship between pH(KCl) and % acid saturation is shown in Figure 4 and the following regressions:
% acid sat = 164,8 - 34,8 pH(KCl) r = -0,973 or,
% acid sat = 381,7 - 135,9 pH(KCl) + 11,7 $(pH(KCl))^2$ r = 0,979

TABLE 5. Maize yield responses on lime at Grootvlei: Four seasons 1978/79 - 1981/82. (M4/S/78 - G C H Venter)

Year	Yield				Significant responses
	Lime, t/ha (ave):			Year average	
	0	1,38	2,75		
	t/ha				
1978/79	7,07	7,28	7,50	7,28	NS
1979/80	7,08	7,03	7,92	7,34	(NPK**)
1980/81	7,74	8,57	9,57	8,63	L** (NPK**)
1981/82	5,31	5,45	6,12	5,63	L** (N*)
Lime average	6,80	7,08	7,78	7,22	
	Soil analysis (1981/82)				
	mg/kg				
Ca	240	350	460		
Mg	29	48	71		
	Acidity				
	pH(KCl) - % Sat				
1978/79	4,3 -	4,3 -	4,3 -		
1979/80	3,9 - **19,0**	4,1 - **11,5**	4,5 - **4,3**		
1980/81	3,8 - **24,7**	4,1 - **13,3**	4,5 - **5,5**		
1981/82	4,0 -	4,5 -	5,1 -		
Average	4,0 - **21,9**	4,25 - **12,4**	4,6 - **4,9**		

TABLE 6. Maize yield responses on lime and phosphorus applications at Heidelberg: Four-year averages (1979/80 -1982/83). (M10/S/79 - G C H Venter)

P	Yield				Significant responses
	Lime, t/ha:			P average	
	0	1,13	2,25		
kg/ha	t/ha				
10	5,30	5,81	6,04	5,72	
38	6,23	6,76	6,70	6,57	
70	6,43	6,62	6,81	6,62	
Lime average	5,99	6,40	6,52	6,30	
	Soil analysis				
	mg/kg				
Ca	130	190	250		
Mg	36	44	51		
	Acidity				
	pH(KCl) - % Acid sat				
1979/80	4,1 – **25**	4,3 – **12**	4,4 – **9**		NPK**
1980/81	3,9 – **31**	4,1 – **21**	4,5 – **6**		L** NPK**
1981/82	4,1 –	4,5 –	5,2 –		(PL)* N** P**
1982/83	3,9 – **28**	4,4 – **14**	4,8 – **0**		L** P**
Average	4,0 – **28**	4,3 – **16**	4,7 – **5**		

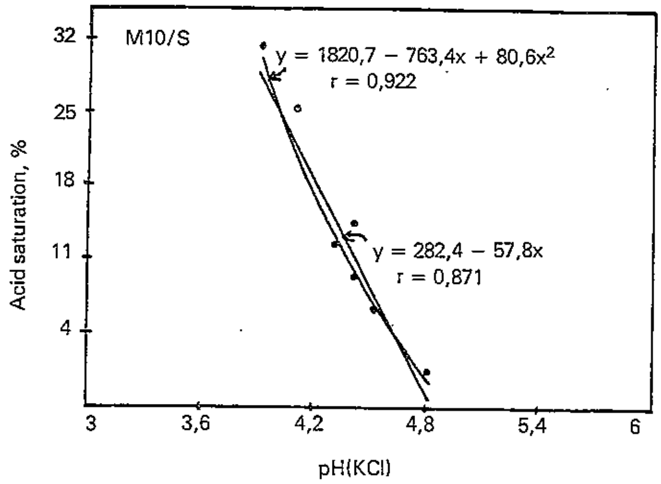

FIG 4. Relationship between acid saturation and pH(KCl) for four years at Heidelberg.

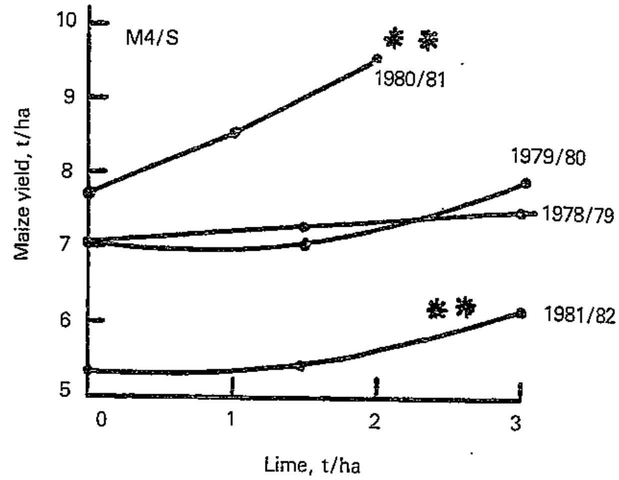

FIG 7. Effect of lime on maize yield at Grootvlei.

Summary

The results are summarised in Figures 5, 6, 7, 8 and 9 and in Table 7.

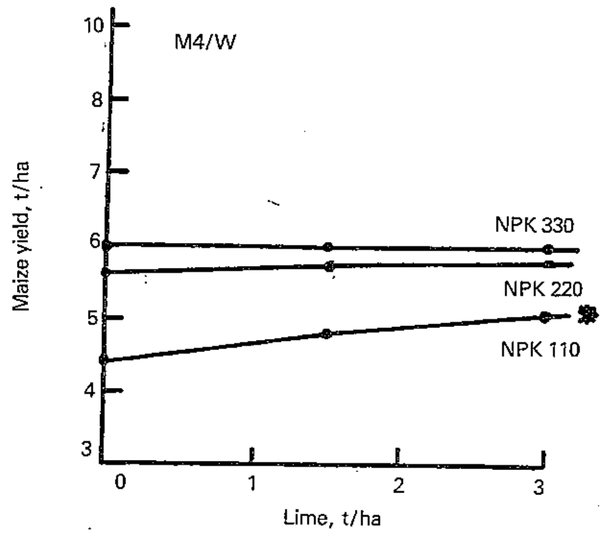

FIG 5. Effect of lime on maize yield at different fertilizer, levels in 1978/79 at Ottosdal.

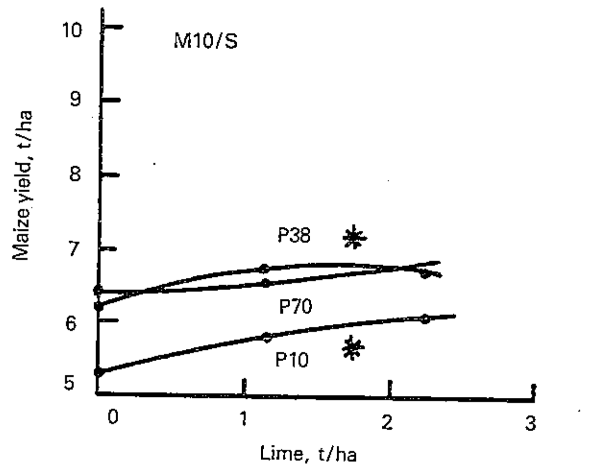

FIG 8. Effect of lime on maize yield at different P levels at Heidelberg (four-year average).

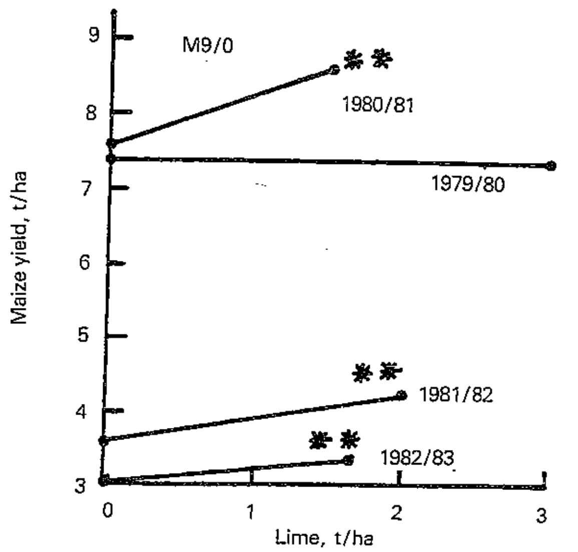

FIG 6. Effect of lime on maize yield at Middelburg.

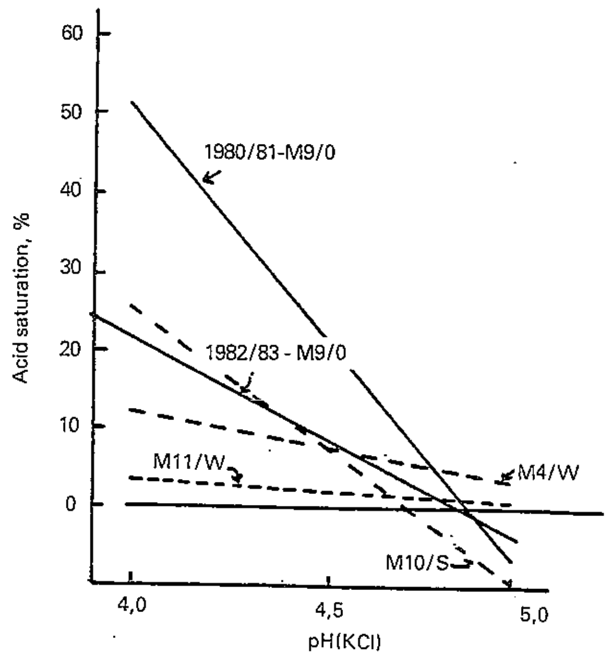

FIG 9. Relationship between pH(KCl) and acid saturation in various liming experiments.