FERTILIZATION OF MAIZE

(Met opsomming in Afrikaans)

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Abstract

The results from a nitrogen, phosphorus, potassium and lime factorial experiment on maize carried out at the research station of African Explosives and Chemical Industries Ltd at Bapsfontein showed that the most economical yields over a period of 11 years (1957/58 to 1967/68) were obtained with a fertilizer combination comprising 53 kg N, 23 kg P and 53 kg K per hectare (100 lb N, 44 lb P and 100 lb K per morgen) applied on soil with a pH (in KCl) over 4.7.

A comparison of the mean yields for the first five-year period (1957/58 to 1961/62) with those of the last six-year period (1962/63 to 1967/69) shows that the yields of the unbalanced treatments have become lower while those of the balanced treatments have increased.

There was a close correlation between the yield and mid-January rainfall, but not between yield and total annual rainfall.

Introduction

Maize yields vary considerably from season to season in South Africa, mainly due to the variation in amount and distribution of rainfall. Consequently production methods are of prime importance in order to obtain maximum return from invested capital.

The effect of fertilization in maize production is not always realized in practice. This paper deals with the results of a nitrogen, phosphorus, potassium and lime factorial experiment carried out at the research station of African Explosives and Chemical Industries at Bapsfontein over an 11 year period (1957/58 to 1967/68). During this period good rainfall seasons and seasons with poor rainfall with regard to total as well as distribution were experienced. Some of the results were discussed in previous publications (Dijkhuis, 1968).

The soil on the research station belongs to the Hutton form. The average rainfall for the period 1958/59 — 1967/68) was 680 mm (26.8 inches).

Methods, procedures and results

The maize was planted mechanically in 91 cm (3 ft) rows with a maize planter with a modified system of fertilizer application, enabling accurate fertilizer measurement. A split plot design was used with a P x Lime (3 x 2) factorial in whole plots, which were split into 9 sub-plots on which an N x K (3 x 3) factorial was laid down.

The levels of NPK and lime applied are given in Table 1.

TABLE 1 Treatments

	kg/ha	lb/morgen		kg/ha	lb/morgen
N_0	0 N	0 N	P_0	0 P	0 P
N_1	53 N	100 N	P_1	23 P	44 P
N_2	106 N	200 N	P_2	46 P	88 P
K_0	0 K	0 K	L_0	0 lime	0 lime
K_1	26.5 K	50 K	L_1	2 118 lime	4 000 lime
K_2	53 K	100 K			

Lime was not applied annually, but only when the pH (in KCl) fell below 4.7. The relevant plots were limed with calcium hydroxide in 1957, with agricultural lime in 1960 and 1961 and with dolomitic limestone in 1966.

At the end of the 1967/68 season the pH (in KCl) of the unlimed section was 4.0 and of the limed section 5.1.

The phosphorus, in the form of single superphosphate, was banded at the time of planting. The nitrogen, as urea, and the potassium, as potassium chloride, were sidedressed by hand and cultivated in when the maize plants were 30 cm (12 inches) high.

In 1957/58 and 1958/59 varieties were planted and in the other seasons hybrid maize, at a rate to obtain a population of 35 000 plants per hectare (30 000 per morgen) at harvest.

Mean yields

The mean yields for the period of 11 seasons 1957/58—1967/68) are given in Table 2.

TABLE 2 Mean yields for eleven seasons (1957/58–1967/68)

P	K	L	kg per hectare			bags per morgen		
			N_0	N_1	N_2	N_0	N_1	N_2
0	0	0	2 215	2 427	2 457	20.91	22.92	23.19
0	0	1	2 523	2 649	2 870	23.82	25.01	27.09
0	1	0	2 351	3 177	2 530	22.20	25.99	23.88
0	1	1	2 758	3 179	3 282	26.04	30.02	30.98
0	2	0	2 387	2 853	2 711	22.54	26.94	25.59
0	2	1	2 903	3 330	3 267	27.41	31.44	30.85
1	0	0	2 564	2 958	2 545	24.21	27.93	24.03
1	0	1	2 690	2 848	3 025	25.39	26.89	28.57
1	1	0	2 367	3 317	3 720	22.35	31.32	35.12
1	1	1	3 184	3 600	3 739	30.07	33.99	35.30
1	2	0	2 424	3 606	3 570	22.88	34.05	33.71
1	2	1	3 332	3 961	3 962	31.46	37.39	37.41
2	0	0	2 667	2 852	2 786	25.18	26.93	26.30
2	0	1	2 784	3 110	3 040	26.28	29.37	28.70
2	1	0	2 719	3 468	3 589	25.68	32.75	33.88
2	1	1	2 949	3 774	3 744	27.85	35.63	35.35
2	2	0	2 498	3 686	3 723	23.58	34.80	35.24
2	2	1	3 171	3 811	3 907	29.94	35.98	36.88

Main effects

	kg/ha	bags/ morgen		kg/ha	bags/ morgen
N_0	2 693	25.43	P_0	2 746	25.93
N_1	3 232	30.52	P_1	3 190	30.12
N_2	3 248	30.67	P_2	3 237	30.57
K_0	2 723	25.71	L_0	2 880	27.19
K_1	3 168	29.91	L_1	3 236	30.56
K_2	3 284	31.01			

The results can be summarized as follows

(i) The inherent fertility of the soil is high. This is shown by the fact that the control plots gave a mean yield of 2 215 kg per hectare (20.91 bags per morgen).

(ii) Nitrogen, phosphorus, potassium and lime were all needed to obtain high yields.

Table 3 shows the NPKL combinations which gave more than 3 700 kg per hectare (35 bags per morgen) and those which yielded less than 2 440 kg per hectare (23 bags per morgen).

TABLE 3 Mean yields from the highest and from the lowest yielding fertilizer combinations

Treatments				Yields in	
N	P	K	L	kg/ha	bags/morgen
2	1	2	1	3 962	37.41
1	1	2	1	3 961	37.39
2	2	2	1	3 907	36 88
1	2	2	1	3 811	35.98
1	2	1	1	3 774	35.63
2	2	1	1	3 744	35.35
2	1	1	1	3 739	35 30
2	2	2	0	3 723	35.24
2	1	1	0	3 720	35.12
1	0	0	0	2 427	22.92
0	1	2	0	2 424	22.88
0	0	2	0	2 387	22 54
0	1	1	0	2 367	22.35
0	0	1	0	2 351	22.20
0	0	0	0	2 215	20.91

Of the nine fertilizer combinations which gave the highest mean yields, six included the N_2 level, five the P_2 and five the K_2 level. Only in two cases was a high yield obtained without lime.

The economic optimum level of fertilization proved to be $N_1P_1K_2L_1$ (53 kg N, 23 kg P, 53 kg K per hectare or 100 lb N, 44 lb P, 100 lb K per morgen at a pH (in KCl) higher than 4.7).

The six lowest yielding fertilizer combinations were all without lime and with one exception were without nitrogen.

(iii) The addition of lime to the NPK treatment increased the yield.

(iv) The effect of the lime and/or pH on the main effects of N, P and K is shown in Table 4.

TABLE 4 Effect of lime application on the main effects of N, P and K

	Yields					
	kg/hectare			bags/morgen		
	L_0	L_1	L_1–L_0	L_0	L_1	L_1–L_0
N_0	2 466	2 918	452	23.28	27.55	4.27
N_1	3 103	3 363	260	29.29	31 76	2.47
N_2	3 072	3 426	354	28.99	32 35	3 36
P_0	2 521	2 973	452	23.80	28.07	4 27
P_1	3 008	3 372	364	28.40	31.84	3.44
P_2	3 110	3 364	254	29.37	31.77	2.40
K_0	2 607	2 838	231	24.62	26.80	2.18
K_1	2 979	3 357	378	28.13	31.69	3.56
K_2	3 051	3 516	465	28.81	33.19	4.38

These results show that in the case of N and P the largest response to lime occurred at the 0 levels and in the case of K at the 2 level.

Comparison of two periods (1957/58 to 1961/62 and 1962/63 to 1967/68).

A comparison of the mean yields for the first five-year period (1957/58 to 1961/62) with those for the last six-year period (1962/63 to 1967/68) shows that the yields of the unbalanced treatments have become lower while those of the balanced treatments were higher in the last than in the first period. The unbalanced and balanced combinations which gave the greatest differences in yield when comparing the two periods are shown in Table 5.

TABLE 5 Mean yield over first 5-year period (1957/58–1961/62) over last 6-year period (1962/63–1967/68) and their differences for four unbalanced and three balanced fertilizer combinations

Treatment				kg/hectare			bags/morgen		
N	P	K	L	1 57/58–61/62	2 62/63–67/68	2–1	1 57/58–61/62	2 62/63–67/68	2–1
2	1	0	0	3 040	2 129	—911	28.75	20.10	—8.65
1	0	0	0	2 820	2 085	—735	26.63	19.68	—6 95
2	0	2	0	3 061	2 418	—643	28.90	22.83	—6.07
2	0	1	0	2 879	2 238	—641	27.18	21.13	—6 05
2	2	2	1	3 495	4 252	+757	32.99	40.15	+7.16
2	1	2	1	3 559	4 300	+741	33.60	40.59	+6.99
2	1	1	1	3 340	4 072	+732	31.54	38.45	+6.91

TABLE 6 Annual yields over 11-year period obtained from the three highest and from the three lowest yielding fertilizer combinations

N	P	K	L	Yields in kg/hectare										
				1957/58	1958/59	1959/60	1960/61	1961/62	1962/63	1963/64	1964/65	1965/66	1966/67	1967/68
2	1	2	1	3 988	2 159	3 206	5 454	2 775	4 251	5 206	2 636	1 905	4 743	4 338
1	1	2	1	4 168	2 532	3 586	5 331	2 847	4 061	5 445	2 838	1 329	4 686	4 507
2	2	2	1	4 141	2 215	3 145	5 686	2 389	4 480	4 947	2 456	1 594	5 301	4 575
0	1	1	0	3 474	2 176	2 394	2 983	1 701	2 152	2 872	1 712	1 063	2 065	2 609
0	0	1	0	3 518	2 326	2 127	2 993	1 768	2 464	2 903	1 351	1 750	1 394	2 169
0	0	0	0	3 518	1 909	2 219	3 098	1 725	2 226	2 554	1 193	1 705	1 284	2 033

N	P	K	L	Yields in bags/morgen										
				1957/58	1958/59	1959/60	1960/61	1961/62	1962/63	1963/64	1964/65	1965/66	1966/67	1967/68
2	1	2	1	37.66	20.38	30.27	53.49	26.20	40.14	49.16	24.88	17.98	44.78	40.96
1	1	2	1	39.36	23.91	33.86	50.34	26.88	38.34	51.41	26.80	12.55	44.25	42.56
2	2	2	1	38.09	20.91	29.69	53.68	22.56	42.29	46.71	23.18	15.05	50.05	43.20
0	1	1	0	32.80	20.55	22.61	28.17	16.06	20.32	27.12	16.17	10.04	19.50	24.64
0	0	1	0	33.22	21.96	20.08	28.27	16.69	23.27	27.41	12.76	16.52	13.17	20.48
0	0	0	0	33.22	18.03	20.95	29.25	16.28	21.02	24.11	11.27	16.10	12.12	19.20

Annual yields

The annual yields for the three fertilizer combinations which gave the highest, and for the three which gave the lowest mean yields over the 11 year period are shown in Table 6.

The increase in yield due to balanced fertilization was apparent in every season, apart from 1958/59 and 1965/66. The size of the increase was determined by the weather conditions, especially the distribution of rainfall. The critical period of flowering occurred some time during the month of January, depending on the date of planting of the maize. Therefore, the amount and distribution of rainfall in the month of January was important.

Table 7 shows the annual total rainfall, the rainfall for each 10-day period in January and the total for January.

There was a close correlation between the yield and the rainfall in the period from the 11th to the 20th January (Tables 5, 6 and 7). High total rainfall was no guarantee for high yields.

The yields obtained from the most economic balanced fertilizer combination ($N_1P_1K_2L_1$) and of an unbalanced combination ($N_0P_1K_1L_0$) are shown graphically in Figure 1. The figure shows that the maize made best use of favourable weather conditions when the balanced fertilizer combination was applied.

Soil analysis

Soil analysis figures show clearly the effect of the fertilizer applications on the build up of elements in the soil. This is illustrated by the results of a soil analysis carried out in August 1964, seven years after the start of the experiment.

Table 8 shows the ppm P, K and Ca in the different treatments and the pH of the limed and unlimed sections.

TABLE 8 Soil analysis

ppm P		ppm K		ppm Ca		pH (in H_2O)
P_0	12	K_0	65	L_0	270	4.3
P_1	40	K_1	100	L_1	640	5.4
P_2	75	K_2	140			

TABLE 7 Rainfall in mm

	1957/58	1958/59	1959/60	1960/61	1961/62	1962/63	1963/64	1964/65	1965/66	1966/67	1967/68
Annual total	–	823.8	596.5	614.0	535.6	610.5	777.8	601.5	417.9	1 048.8	770.7
January 1–10	76.2	21.0	2.7	3.5	33.9	41.3	70.5	30.6	0.9	38.6	12.2
11–20	62.1	26.2	23.1	65.4	0.0	42.3	78.0	23.7	15.2	171.6	54.0
21–31	25.5	136.7	36.3	21.7	21.2	57.6	68.9	17.9	98.9	54.7	73.0
January total	163.8	183.9	62.1	90.6	55.1	141.2	217.4	72.2	115.0	264.9	139.2

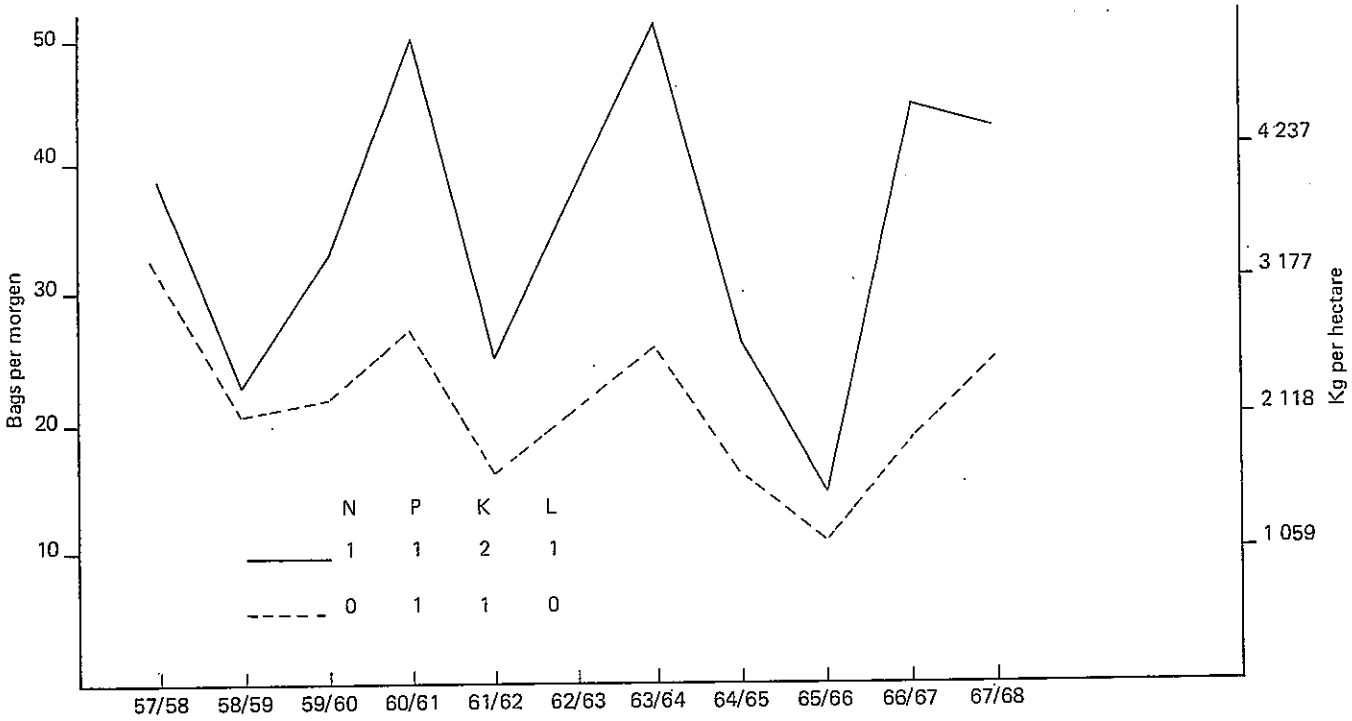

Fig 1 Yields obtained from balanced and unbalanced fertilizer combinations

Opsomming

DIE BEMESTING VAN MIELIES

Die resultate van 'n stikstof, fosfor, kalium en kalk faktoriaalproef met mielies wat uitgevoer is by die proefstasie van Afrikaanse Springstowwe en Chemiese Nywerhede te Bapsfontein het aangetoon dat die mees ekonomiese opbrengste van mielies oor 'n periode van 11 jaar (1957/58-1967/68) verkry is met 'n kunsmismengsel wat saamgestel is uit 53 kg N, 23 kg P en 53 kg K per hektaar (100 lb N, 44 lb P en 100 lb K per morg) op grond met 'n pH (in KCl) wat hoër is as 4.7.

'n Vergelyking van die gemiddelde opbrengste vir die eerste vyf jaar periode (1957/58-1961/62) met dié vir die laaste ses-jaar periode (1962/63-1967/68) toon dat die opbrengste van die ongebalanseerde behandelings laer geword het terwyl dié van die gebalanseerde behandelings toegeneem het. 'n Noue verband tussen die opbrengs en die reënval vir die periode van Januarie 10 tot 20 is gevind, maar nie tussen opbrengs en totale jaarlikse reënval nie.

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