THE IMPORTANCE OF FERTILIZATION WHEN EVALUATING MAIZE CULTIVARS*

(Met opsomming in Afrikaans)

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Abstract

In the Republic of South Africa maize cultivars are usually evaluated by comparing yields at different localities. No special attention is normally paid to espacement or fertilization.

In order to determine whether the cultivars which can give high yields under favourable conditions are penalized by not fertilizing the soil properly, this investigation was undertaken.

Three maize cultivars, one adapted to unfavourable, one to average and one to optimum climatic conditions were selected, planted during 1971 at eleven different localities at three planting densities and fertilized at three levels.

The overall effect was that the cultivar selected for unfavourable conditions was out-yielded by the other two. Raising the fertilizer levels increased the yield of all cultivars, but no interaction between cultivar and fertilization could be determined. The results confirmed further that when comparing cultivars, a realistic plant population should be chosen according to local climatic conditions. Cultivars could then be evaluated by determining the yields at any reasonable level of soil fertility.

Introduction

During recent years a few research workers have studied maize cultivars to determine their ability to utilize plant nutrients. Klimashevskii & Pisetskaya, (1964) found in Russia that maize varieties differed in their reactions to different levels of nutrients. During the same year Kudzin & Chernayavskaya (1964) concluded that the amount of nutrients removed per hectare, the amount of nutrients consumed per tonne of grain and increases in grain yield due to P, NP and NPK were different in different hybrids. Robertson, Hammond & Thompson (1965) found that increases in plant population increased yields and N, P and K uptake. They also showed that hybrids differed greatly in their ability to utilize applied nutrients.

By breeding maize cultivars with increased potential, a continuous testing programme exists in all countries for evaluating the cultivars for commercial production. In the Republic of South Africa new maize cultivars are usually evaluated by comparing their yields against standard hybrids at different localities. Unfortunately no special attention is given to factors such as espacement or fertilization.

It was felt, therefore, that as a result of low soil fertility and incorrect plant populations, high-yielding hybrids might not be able to express their full yield potential.

This study was conducted in the 1971/72 season and was initiated with the object of determining whether different maize cultivars respond differently to fertilizer under varying dryland farming conditions. Furthermore, in order to establish the importance of espacement on yield under different conditions, three plant populations at eleven localities were included in this investigation.

Procedure

The field experiments were planned in such a way as to achieve the highest yields under a particular set of conditions. Plant population and fertility levels were common so that yields at the different localities could also be compared.

Cultivars

After consulting Laubscher (1971) and Geerthsen (1971) cultivars adapted to favourable and unfavourable climatic conditions, were selected as follows:

1 Unfavourable conditions, PPxK64r
2 Unfavourable and favourable, SSPPxK64r and
3 Favourable conditions, Pioneer 99.

According to Geerthsen & Robertse (1969) the adaptability of these three maize cultivars can be seen from their regression lines where they are compared with the average yield (standard) of all cultivars planted in South Africa. See Figure 1.

From these regression lines it can be concluded that PPxK64r will yield better than the average under low production potential conditions. Pioneer 99 on the other hand

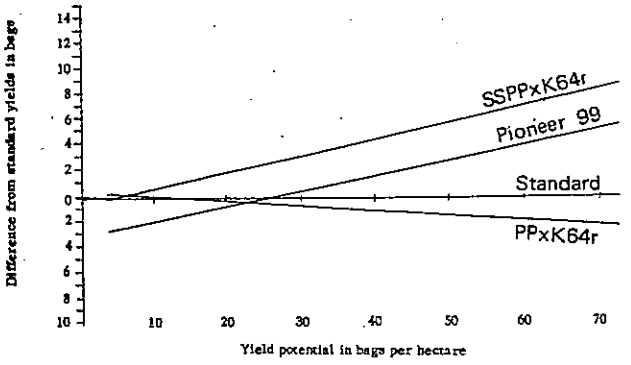

Fig 1 Relative yields of the cultivars PPxK64r, SSPPxK64r and Pioneer 99 in comparison with the average yield of some 72 cultivars used in 85 cultivar trials (Geerthsen & Robertse, 1969).

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produces lower yields under similar conditions but has got the potential to outyield the other cultivars under conditions favourable for high yields. The cultivar SSPPxK64r will always give higher yields than the average.

Plant population

For each locality three consecutive populations from the range 8 000, 16 000, 24 000, 32 000 and 40 000 plants per hectare were selected according to average climatic conditions, viz:

Low-rainfall area	8 000	16 000	24 000		
Medium-rainfall area	–	16 000	24 000	32 000	–
High-rainfall area	–	–	24 000	32 000	40 000

In this way at least one population is common and serves as a reference for comparison.

Fertilization and planting

In order to cater for the different climatic regions and soil differences, three consecutive levels of fertilizer were chosen from a series of five possibilities in order to ensure one common reference application level. The five levels of N, P and K (kg/ha) chosen are given below:

	N	P	K
1	15	10	5
2	35	15	10
3	55	20	15
4	75	25	20
5	95	30	25

All the P and K and the lowest level of N (15kg/ha) was bandplaced before planting. For this purpose maize planters equipped with special fertilizer applicators were used to apply the fertilizer in bands approximately 75 mm deep.

Maize was hand planted, (two seeds per hill) and thinning to the desired population was carried out three weeks later. At this stage the balance of the nitrogenous fertilizer was applied as a topdressing.

The gross area of each plot was 1/100th of a hectare and the nett area harvested 1/200th ha.

Localities

Although sixteen sites were selected in the maize triangle, only eleven trials could be planted during the 1971/72 season. Sites were chosen in a manner which allowed low, medium and high production-potential areas to be covered. The location of these sites is given in Figure 2 and covers the Western Transvaal, North Western Orange Free State and Eastern Transvaal. Isotonic lines clearly illustrate the increase in rainfall from west to east.

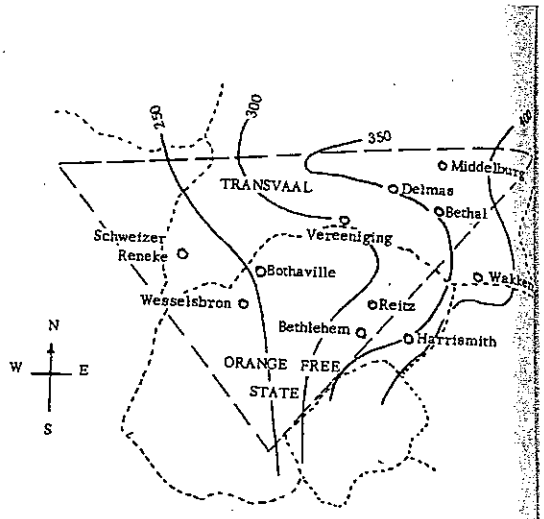

Fig 2 *Map showing the approximate siting of experiments and isotonic lines indicating average rainfall in milimeters*

Soils

The soil form, series and chemical analysis of topsoil samples are given in Table 1.

The effective depth of these soils was between 75 and 100 cm. Harrismith was the only exception, the effective depth being 60 cm.

Gesaprim was used on all plots. All trials were treated for stalkborer.

Harvesting

The ears on the nett plots were hand picked, weighed and final yields calculated by applying a threshing percentage applicable to each cultivar and then expressed in bags (90,7 kg each) per hectare.

Statistical calculations

Yields of the experiments at each locality were analized separately to determine the effects of plant population, cultivar and fertilization on the yields and possible interactions. The influence of plant population, cultivar and fertility on the yield was also determined at the comparable levels for all localities.

Results and discussion

Effect of plant population on yields

Using the statistical results of the individual experiments, the yield of each cultivar was tabulated for each of the five plant densities, irrespective of the fertilization level.

TABLE 1 Locality, soil forms, series and chemical analysis of topsoil samples

Locality, soil form and series	Colour	Text-ture	pH		O.M %	N %	C E M me/100g	Available			
			KCl	H_2O				P* ppm	K ppm	Ca ppm	Mg ppm
Schweizer Reneke Hutton, Shorrocks	RBr	fSaLm	6,4	7,6	0,2	0,025	4,5	10	190	870	100
Wesselsbron Clovelly, Blinkklip	Br	LmSa	4,7	5,8	0,3	0,022	2,9	10	130	280	80
Bothaville Avalon, Soetmelk	Y	fSaCl	5,2	6,0	0,2	–	–	15	50	160	20
Reitz Avalon, Bleeksand	ltBr	LmSa	4,3	5,5	–	–	–	15	70	240	30
Bethlehem Clovelly, Annandale	Y	LmSa	5,3	6,2	0,7	0,034	3,2	15	104	404	57
Harrismith Westleigh, Westleigh	YBr	fSaLm	4,2	5,4	0,1	0,041	4,6	49	108	306	80
Vereeniging Hutton, Msinga	R	SaClLm	4,7	5,7	1,5	0,088	11,1	7	236	980	340
Delmas Avalon, Avalon	Br	SaClLm	4,5	5,4	1,5	0,063	6,6	25	88	586	130
Middelburg Hutton, Msinga	R	SaClLm	4,5	5,8	–	–	5,8	10	150	290	110
Bethal Hutton, Hutton	YBr	LmSa	4,2	5,2	0,9	0,041	2,5	63	72	148	27
Wakkerstroom Hutton, Balmoral	RBr	SaCl	4,9	5,9	4,0	–	29,8	5	80	2110	1000

* Bray No 2

From the calculations and final summaries of the individual experiments, the overall effect of plant densities on the yield of the different cultivars is shown in Figure 3.

From Figure 3 it seems as if SSPPxK64r can produce high yields at high plant populations. Pioneer 99 on the other hand, produced well up to 32 000 plants per hectare and PPxK64r followed the same trend. Over the whole range of plant populations PPxK64r gave lower yields than the other two cultivars. This finding is supported by the results obtained at a comparable plant density of 24 000 plants per hectare. (See Table 2).

When taking all localities into calculation at the same plant density of 24 000 plants/ha, PPxK64r produced significantly lower yields than SSPPxK64r and Pioneer 99.

The higher-yield cultivars utilize more plant nutrients and deplete poorly fertilized soils sooner than low-yielding cultivars. Figure 3 indicates that Pioneer 99 and PPxK64r did not give the same yield increase at high plant populations, which might have been caused by a deficiency of available plant nutrients in the soil.

At Bethal such an interaction between plant population and fertilizer level was significant and the figures are presented in Table 3.

The results in Table 3 shows that at a lower fertilizer level, yields declined with increased plant population while just the opposite happened at the highest fertilizer level.

In general low fertility can be expected to limit maize yields at high planting densities.

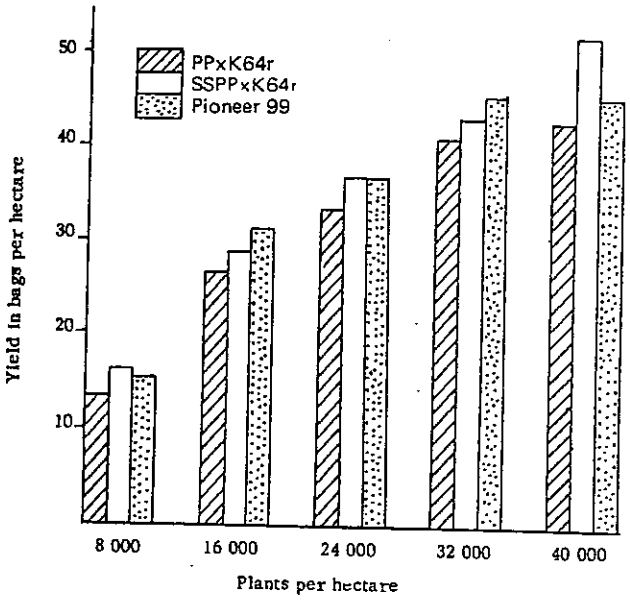

Fig 3 *Yields of cultivars at different plant densities irrespective of fertilization level*

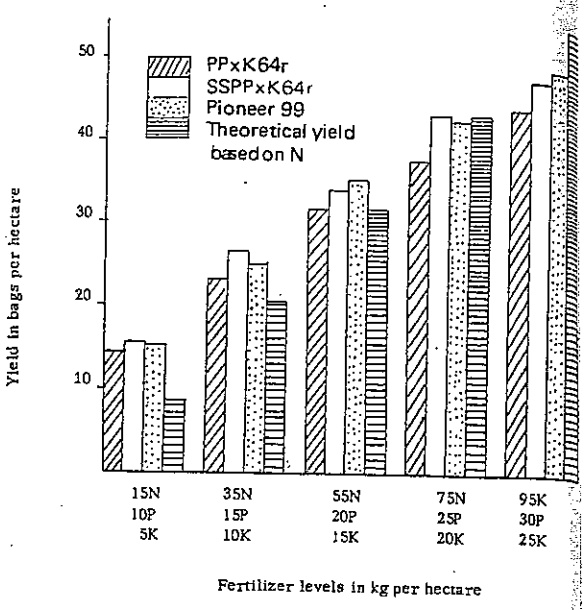

Fig 4 *Yields of cultivars at different fertilizer levels irrespective of plant population and the theoretical yield based on the fertilizer nitrogen applied*

TABLE 2 *Average yields in bags of 90,7 kg each per hectare for all localities as determined at the same plant density or fertilizer level*

Cultivar	Yields in bags (90,7 kg) hectare	
	Comparable plant density 24 000 plants/ha	Comparable fertilizer level 55N 20P 15K
PPxK64r	33,31	31,57
SSPPxK64r	36,63	33,72
Pioneer 99	36,75	34,95
LSD (P=0,05)	2,40	2,00

TABLE 3 *Interaction between plant population and fertilizer level at Bethal (bags of 90,7 kg/ha)*

Fertilizer level	Plant population (plants per ha)			Average
	24 000	32 000	40 000	
1	44,8	41,9	39,6	42,1
2	49,2	54,2	49,7	51,0
3	47,8	56,2	63,1	55,7
Average	47,3	50,8	50,8	–

LSD (P=0,05) = 9,3 bags/ha

TABLE 4 Single effects of cultivar, fertilizer and plant population on yields at eleven localities, given in bags (90,7 kg) per hectare

Cultivars	Schweizer Reneke	Wessels-bron	Botha-ville	Reitz	Bethle-hem	Harri-smith	Veree-niging	Delmas	Middel-burg	Bethal	Wakker-stroom
PPxK64r	13,8	15,0	17,0	30,3	34,1	39,0	41,5	41,5	36,4	46,3	47,3
SSPPxK64r	13,8	17,0	20,0	31,2	33,4	44,0	49,6	47,4	40,9	59,5	51,8
Pioneer 99	14,6	16,2	19,2	35,0	34,2	44,7	46,2	46,3	45,0	46,5	49,8
LSD (P= 0,05)	ns	1,5	2,0	2,2	ns	3,2	3,4	3,1	2,6	9,3	ns
Fertilizer 1	14,6	14,3	–	–	–	–	–	–	–	–	–
2	12,5	16,2	19,4	–	30,8	–	44,4	–	–	–	–
3	15,1	17,6	18,6	31,4	35,2	39,2	47,3	37,6	39,2	42,1	44,2
4	–	–	18,2	32,7	35,7	41,9	46,6	46,5	41,6	51,0	53,1
5	–	–	–	32,4	–	46,4	–	51,1	41,4	55,7	51,6
LSD (P=0,05)	ns	1,5	ns	ns	3,0	3,2	ns	3,1	ns	5,4	7,4
Plant population 8 000	14,6	13,8	15,5								
16 000	13,1	16,4	19,6		35,1	42,7	43,6				
24 000	14,5	18,0	21,1	29,8	35,0	42,2	47,9	44,3	36,8	47,3	50,5
32 000				33,7	31,7	42,7	46,7	47,6	40,0	50,8	51,4
40 000				33,0				43,2	45,4	50,8	47,0
LSD (P=0,05)	ns	1,5	2,0	2,2	ns	ns	3,4	3,1	2,6	ns	ns
Interactions	ns	ns	ns	ns	ns	ns	ns	ns	PPxK64r and SSPPxK64r better yields with higher plant density	SSPPxK64r better yields with higher plant population	ns

Effect of fertilization levels on cultivar yields

The average yields of the three cultivars are plotted at the different fertilizer levels in Figure 4.

The histograms in Figure 4 illustrate that Pioneer 99 and SSPPxK64r out yielded PPxK64r at all levels of fertilization. When plotting the theoretical yield which could be achieved by fertilizer alone (using the assumption that every bag of maize requires 1,6kg N) it appears that SSPPxK64r and Pioneer 99 could utilize more N from the soil at low levels of fertilization than PPxK64r.

On the other hand SSPPxK64r and Pioneer 99 must have utilized more of the applied fertilizer at the higher rates of application. It seems therefore that the high-potential cultivars can most probably make more effective use of the available soil fertility, as well as of the applied fertilizer.

Cultivar, fertilizer and plant population effects at different localities

The results of the single effects of cultivar, fertilization levels and plant population on the yield of maize at eleven localities are given for the individual experiments in Table 4.

The significant effects from Table 4 are tabulated in Table 5.

The cultivar PPxK64r was out-yielded by SSPPxK64r and Pioneer 99 at seven localities whilst yields of SSPPxK64r and Pioneer 99 were always comparable.

In six out of the eleven trials, fertilizer could be applied at the medium application rate resulting in better yield responses.

In none of the experiments could an interaction between cultivar and fertilizer level be determined. Interactions between plant density and cultivar were significant at Middelburg and Bethal.

A plant density of 32 000 plant for the Eastern Transvaal 24 000 plants for the central parts and 16 000 plants f the far western parts of the maize triangle, could be chos for comparative studies.

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Opsomming

DIE BELANGRIKHEID VAN BEMESTING BY DI EVALUERING VAN MIELIECULTIVARS

In die Republiek van Suid-Afrika word mieliecultivars ge woonlik geëvalueer deur opbrengste van die onderskei cultivars, soos verkry uit proewe by verskillende lokaliteit te vergelyk.

Omdat die verbouings- en bemestingspraktyke by elke lo kaliteit konstant gehou word vir alle kultivars, het die ver moede onstaan dat sekere kultivars onder dieselfde klimaatstoestande dalk relatief beter kon presteer by 'n meer gunstige voedingspeil van die grond.

Hierdie proewe is derhalwe beplan om die effek van die voedingspeil van die grond op die mielie-opbrengste na te gaan. Die proewe is by elf plekke in die mieliedriehoek uit gelê om die verskillende klimaatstreke in te sluit. Verder is die mielies teen drie plantpopulasies aangeplant om die voedingseffek meer duidelik uit te wys. Bemesting is teen drie peile toegedien. Die verkose cultivars was sulks dat PPxK64r opbrengste sou lewer wat beter is as die verwagte gemiddeld onder lae produksietoestande en dat SSPPxK64r altoos goeie opbrengste sou lewer en Pioneer 99 na verwagting swakker sou presteer onder lae opbrengstoestande maar sou uitstyg as die produksiemoontlikhede verbeter.

TABLE 5 Significant differences as a result of cultivar, fertilizer level or plant population at the different localities

Locality	Cultivar	Fertilizer	Plant Population
Schweizer Reneke	ns	ns	ns
Wesselsbron	PPK < SSPP ≃ Pnr	1 < 2 ≃ 3	8 < 16 ≃ 24
Bothaville	PPK < SSPP ≃ Pnr	ns	8 < 16 ≃ 24
Reitz	PPK ≃ SSPP < Pnr	ns	16 < 24 ≃ 32
Bethlehem	ns	2 < 3 ≃ 4	ns
Harrismith	PPK < SSPP ≃ Pnr	3 ≃ 4 < 5	ns
Vereeniging	PPK < SSPP ≃ Pnr	ns	16 < 24 ≃ 32
Delmas	PPK < SSPP ≃ Pnr	3 < 4 < 5	24 < 32 > 40
Bethal	ns	3 < 4 ≃ 5	ns
Middelburg	PPK < SSPP < Pnr	ns	24 < 32 < 40
Wakkerstroom	ns	3 < 4 ≃ 5	ns

Die keuse van plantpopulasie en bemestingspeile was sulks dat dit aangepas was by die klimaatstoestande van die betrokke gebied. Daar was altyd 'n referensie plantpopulasie en bemestingspeil by alle lokaliteite ingesluit, sodat die prestasies van die drie kultivars volgens lokaliteit ook vergelyk kon word.

Dit blyk uit die resultate dat PPxK64r wat gekies was om goed te presteer onder lae opbrengstoestande, deurgaans laer opbrengste gelewer het as die ander twee cultivars. Verhoging van die bemestingspeile het die opbrengs van alle cultivars verhoog, maar daar was geen wisselwerking tussen cultivar en bemesting nie.

In die oostelike, hoër reënval areas van die mieliedriehoek lewer 32 000 plante per hektaar, in die sentrale deel 24 000 plante en in die droër westelike dele 16 000 plante die beste opbrengste. Hierdie plantestande stem ooreen met die praktyke wat reeds deur boere aanvaar is.

Die resultate bevestig dus dat wanneer cultivars vergelyk word, 'n realistiese plantestand gekies moet word wat aanpas by die betrokke streek en dan kan die cultivarvergelyking by 'n redelike bemestingspeil uitgevoer word.

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