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TESTING OF MAIZE HYBRIDS RESISTANT TO PUCCINIA POLYSORA ON THE ATHERTON TABLELAND, QUEENSLAND

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SUMMARY

Eighteen new maize hybrids resistant to tropical rust (*Puccinia polysora*) were tested throughout the maize-growing area of the Atherton Tableland in trials extending over three seasons. Current commercial varieties were included as standards.

Yield and susceptibility to ear rot varied widely between varieties, seasons and sites. Three new hybrids, KTW41, KTW36 and KTW37, were outstanding for yield performance, resistance to lodging and resistance to ear rot over the whole range of conditions. KTW41 was superior in yield to KTW36 and KTW37. Yield superiority of these three hybrids over the standards was shown under less favourable conditions experienced in two seasons. The third season offered good growing conditions and yield differences between these hybrids and the better standards were small.

I. INTRODUCTION

Until 1955 only open-pollinated maize varieties were grown commercially on the Atherton Tableland of Queensland (Steele, Rosser, and Walsh 1955). Thereafter, hybrids produced at Grafton in New South Wales began to be grown and, due to their superior yielding ability, two Grafton hybrids, GH128 and GM211, comprised most of the hybrid planting, which amounted to 80% of the total planting, by 1963 (Kelly 1964).

All commercial varieties are subject to marked seasonal variation in yield, which Simonett and Drane (1953) have shown to be caused largely by excessive rainfall during the growing period and during cob development. They attributed the depression in yield during cob development to diseases, particularly Diplodia ear rot. A more recent and more serious disease when weather conditions favour its development is tropical maize rust (*Puccinia polysora* Underw.). Its effect was first evident in 1959 (Pont 1963). As there is a high probability of moist atmospheric conditions favourable to the development of the disease at a time when the crop is most susceptible (after tasselling), tropical rust poses a constant threat.

There has also been a steady decline in yield with time which has been attributed to depletion of soil nutrients. van Haeringen (1965) recorded economic increases in yield with nitrogen application but not when tropical rust was prevalent.

The combined effects of declining yield and threat of disease suggested that a more suitable variety was required to which fertilizer could be applied with confidence. Working towards this end, hybrids with resistance to the strain of *P. polysora* known to be present were bred at Kairi Research Station and tested throughout the maize-growing area.

II. MATERIALS AND METHODS

Three-way cross hybrids resistant to *P. polysora* were grown during the 1964-65, 1965-66 and 1966-67 seasons. Five sites were established in each season. Only one, situated on good soil at Kairi Research Station, produced sufficient maize for harvest in the first year. In each of the other two years the sites and their description were as follows:

Site 1. Kairi Research Station 1. History of high yields.

Site 2. Kairi Research Station 2. History of low yields.

Site 3. East Barron. Higher rainfall.

Site 4. Tolga Forest. Lower rainfall.

Site 5. Walkamin Research Station. Virtually rust free.

In 1967 the Walkamin site was discontinued in favour of another Tolga forest site.

The treatments each year were:

1965: 10 new rust-resistant hybrids and 5 standards.

1966: Walkamin Research Station—16 rust-resistant hybrids and 5 standards. Other four sites—18 rust-resistant hybrids and 5 standards.

1967: East Barron—10 rust-resistant hybrids and 3 standards (GH128, GM211 and Kairi Durum). Other four sites—10 rust-resistant hybrids and 5 standards.

All new hybrids included in 1965 that could be remade went into the 1966 trials; some of these were excluded for various reasons from the 1967 trials. The five standards were two commercial hybrids, GH128 and GM211, two open-pollinated strains, Atherton Dent and Kairi Durum, and a promising Grafton hybrid, GH170. The standards were chosen on the basis of yielding ability (GH128), resistance to lodging (GM211) and resistance to ear rot (Kairi Durum).

Treatments were compared in randomized complete blocks replicated four times in the first 2 years and five times in 1967. Plot size was one row $\frac{1}{2}$ chain long in the first two seasons and two rows $\frac{1}{2}$ chain long in the third. Distance between rows ranged from 40 to 44 in. between sites.

Planting was carried out by hand-dropping the seed through the spout of a commercial planter at approximately twice the required density. At 2–3 weeks after planting, plots were thinned by hand to the first whole plant number above the equivalent of 12,000 plants per acre.

A basal dressing of mixed fertilizer was made at planting at all sites except the two on Kairi Research station in 1966, where it was side-dressed at 3 weeks. In 1965 and 1967 the fertilizer applied was 67 lb N, 11 lb P and 9 lb K per acre, and in 1966 it was 67 lb N and 13·5 lb P per acre. The nitrogen level was approximately the optimum economic level in the old maize land shown by van Haeringen (1965) and the phosphorus was an insurance against possible deficiency.

Weeds were controlled by inter-row cultivation. The Tolga forest site in 1966 was sprayed with 30% dieldrin at 3/4 pint per acre at 2 weeks after planting to control approaching armyworm (*Spodoptera exempta* Walk.).

Before harvest the total number of plants in each plot and the number of plants lodged more than 30 deg. from the vertical were counted. Those with a lean of more than 30 deg. were considered difficult to harvest with a commercial maize picker. Most of the lodging resulted from broken stalks.

Plots were hand-harvested. To calculate the amount of diseased grain, the cobs were counted and graded into proportion infected. In the 1965 season cobs were separated into four groups—0, $33\frac{1}{3}$%, $66\frac{2}{3}$%, and 100% infection—and in the next two seasons into five groups—0, 25%, 50%, 75% and 100% infection.

Yield was calculated from the weight of shelled grain per plot adjusted to 14% moisture. Bushel weight was taken as 56 lb.

Inverse sine transformations of the percentage lodged and percentage diseased grain were used for statistical analysis in 1966 and 1967.

III. RESULTS

Yield of each variety at each site for the three seasons is given in Table 1. There was a large variation in yield between seasons and between sites as well as between treatments. The open-pollinated strains were the most susceptible to seasonal variation in yield.

TABLE 1

YIELD DATA (BUS/AC.)

Variety	1965 Harvest. Site 1	1966 Harvest Site						1967 Harvest Site					
		1	2	3	4	5	Mean	1	2	3	4	5	Mean
KTW 41 ..	53·2	94·8	47·4	105·4	50·4	95·5	78·7	94·5	70·4	62·6	64·0	39·6	66·0
KTW 37 ..	53·1	91·0	55·6	98·0	51·3	77·3	74·6	91·8	75·0	50·3	63·3	38·1	63·7
KTW 36 ..	38·5	91·0	47·9	92·6	48·3	89·1	73·8	91·8	76·5	57·0	72·9	41·0	67·8
KTW 42 ..	51·7	91·7	46·2	82·4	44·0	82·1	69·3	87·4	69·1	52·0	53·5	32·1	58·8
KTW 34 ..	44·7	98·2	37·6	85·1	49·8	94·8	73·1	81·5	73·8	51·9	62·6	37·2	61·4
KTW 49 ..	..	82·0	44·3	83·2	48·1	82·7	68·1	94·6	69·3	5·48	63·5	36·8	63·8
KTW 33 ..	42·0	85·8	38·4	86·8	48·1	78·3	67·5	73·8	65·5	55·3	57·6	32·6	59·0
KTW 38 ..	39·9	80·8	51·2	83·7	51·0	76·6	68·7	..	..	..	..	..	..
KTW 48 ..	..	81·8	44·5	81·6	50·6	74·6	66·6	74·5	72·6	54·8	59·5	35·3	59·3
KTW 40 ..	37·1	83·2	49·7	83·0	33·1	84·1	66·6	79·7	76·9	57·8	55·3	30·8	60·1
KTW 39 ..	47·1	71·0	34·9	79·2	55·4	87·5	65·6	76·4	51·0	46·5	48·2	25·3	49·5
KTW 51 ..	..	85·0	33·2	87·5	35·9	92·6	66·8	..	..	..	..	..	..
GH 170 ..	29·2	76·0	37·1	65·2	50·1	55·2	56·7	61·9	57·9	..	60·8	38·1	54·7
GH 128 ..	21·1	86·6	45·8	78·4	54·5	78·1	68·7	64·9	49·9	47·6	47·5	24·7	46·7
GM 211 ..	17·6	66·6	44·2	71·1	55·4	83·0	64·1	60·8	66·1	35·8	60·7	25·5	49·8
KTW 45 ..	..	75·8	40·2	81·8	37·3	84·4	63·9	..	..	..	..	..	..
KTW 44 ..	..	87·5	33·8	86·0	45·8	..	63·3	..	..	..	..	..	..
KTW 43 ..	..	86·5	32·1	80·6	44·0	69·9	62·6	..	..	..	..	..	..
KTW 50 ..	..	90·3	29·4	79·4	49·9	..	62·2	..	..	..	..	..	..
KTW 35 ..	40·8	77·0	39·6	69·9	42·3	81·1	62·0	..	..	..	..	..	..
KTW 46 ..	..	75·3	37·8	87·9	42·0	..	60·8	..	..	..	..	..	..
Kairi Durum ..	15·4	62·0	29·4	66·6	40·4	76·9	55·1	41·8	34·8	19·9	22·6	19·6	27·7
Atherton Dent	12·1	61·2	23·4	65·2	28·0	65·9	48·7	15·3	19·5	..	14·0	15·9	16·2
Mean	36·2	81·8	40·2	81·8	45·9	80·5	..	72·6	61·8	49·7	53·7	31·5	..
L.S.D. 5% ..	8·8	18·4	12·9	14·8	8·1	17·2	..	10·5	8·4	9·1	9·2	4·8	..
L.S.D. 1% ..	11·8	24·4	17·2	19·6	10·8	22·9	..	14·0	11·2	12·2	12·2	6·4	..

Lodging counts are given in Table 2. A number of new hybrids compared unfavourably with the standards.

Almost all diseased grain (Table 3) resulted from infection by species of *Diplodia,* while *Gibberella zeae* (Schw.) Petch was the causal agent in some grain infection following husk damage by insects. Most diseased grain occurred in the 1967 trials and the district crop was similarly affected. Site 5 in this year was worse than the others. A similar variability from farm to farm occurred in the district also.

The first year's trial (1965) was grown under colder conditions than the others, as shown by the monthly means of the mean hourly temperature during growth of the 3 years' trials (Figure 1). The mean of the previous 10 years (1955–1964) mean hourly temperature is included for the period during which the crop is usually grown. A record district yield per acre for 28 years was

TABLE 2

Percentage of Plants Lodged

Variety	1965 Harvest, Site 1	1966 Harvest Site						1967 Harvest Site					
		1	2	3	4	5	Mean	1	2	3	4	5	Mean
KTW 37 ..	10·5	6·0	3·7	6·6	6·4	0·0	4·5	3·3	0·3	2·1	0·1	9·1	3·0
KTW 36 ..	7.9	12·8	2·3	15·3	17·2	5·7	10·7	3·6	1·7	5·2	4·5	5·9	4·2
KTW 39 ..	7·4	32·7	4·3	25·3	36·3	3·6	20·4	3·1	4·1	2·3	3·7	5·4	3·7
GH128 ..	14·2	9·0	4·4	10·8	9·9	15·0	9·8	10·5	5·4	0·8	4·6	17·2	7·7
GM211 ..	16·8	10·1	2·7	11·3	22·5	3·5	10·0	8·0	2·4	7·4	5·2	3·8	5·4
KTW 41 ..	19·6	19·2	5·7	13·8	21·8	9·1	13·9	4·8	1·9	3·6	9·1	9·2	5·7
GH170 ..	17·0	15·9	2·8	22·1	21·7	3·5	13·2	17·6	8·9	..	3·6	12·1	10·5
KTW 51 ..	..	26·8	2·3	20·7	16·5	6·6	14·6	..	..	..	..	..	..
KTW 45 ..	..	29·9	9·6	11·2	21·5	0·9	14·6	..	..	..	..	..	..
KTW 38 ..	2·6	10·7	3·9	22·0	27·0	15·0	15·7	..	..	..	..	..	..
KTW 49 ..	..	26·6	5·8	31·0	40·1	7·4	22·2	5·1	1·7	4·1	3·8	3·6	3·7
KTW 34 ..	15·0	22·6	7·2	24·1	34·9	6·2	19·0	20·6	9·3	3·4	9·4	6·4	9·8
KTW 44 ..	..	17·3	6·6	20·4	24·5	..	17·2	..	..	..	..	..	..
KTW 33 ..	12·6	34·0	7·5	20·2	35·2	10·7	21·5	20·6	7·2	14·7	6·2	7·7	11·3
KTW 40 ..	16·5	31·5	2·5	32·7	11·0	16·0	15·8	20·9	5·8	20·1	32·9	9·0	17·7
Kairi Durum ..	23·4	27·1	9·7	13·5	21·4	14·2	17·2	14·0	17·8	29·8	25·5	31·5	23·7
KTW 35 ..	16·3	25·7	11·2	24·0	36·6	13·9	22·3	..	..	..	..	..	..
KTW 43 ..	..	24·4	13·2	15·1	35·0	28·5	23·2	..	..	..	..	..	..
KTW 50 ..	..	41·1	3·7	38·8	26·2	..	27·4	..	..	..	..	..	..
KTW 46 ..	..	38·2	13·9	18·3	43·6	..	28·5	..	..	..	..	..	..
KTW 42 ..	29·4	28·6	15·8	22·5	50·4	3·9	24·2	26·7	11·2	38·9	25·6	15·2	23·5
KTW 48 ..	..	30·1	16·8	24·6	47·8	34·2	30·7	22·4	11·1	16·0	9·1	9·4	13·6
Atherton Dent	22·0	46·4	20·9	31·0	26·8	26·2	30·3	32·0	27·0	..	52·6	31·5	35·6
Mean	15·4	24·6	7·7	20·6	27·6	10·5	..	14·2	7·7	11·4	13·1	11·8	..
L.S.D. 5% ..	16·6	18·7	9·4	15·5	17·2	..	..	..	..	..	..	..	..
L.S.D. 1% ..	22·2	24·8	12·4	20·6	22·9	..	..	..	..	..	..	..	..

harvested in the 1966 season. During most of the third season (1967) favourable growing conditions prevailed apart from a deluge of rain experienced over the maize-growing area at about 9 weeks after planting. Kairi Research Station recorded 18 in. in 1 day and more than 30 in. in 4 days of the same period.

Tropical rust was present in epiphytotic proportions in susceptible varieties during the 1965 trial. It was not evident at any site in 1966. In 1967 it appeared at between 5 and 6 weeks after tasselling in susceptible varieties at two sites (sites 1 and 3). Only in 1965 could tropical rust have caused a large reduction in yields of susceptible varieties.

Results of the significant differences from the individual analyses are summarized in Table 4.

It is apparent that KTW41 was the most outstanding for yield, while a group consisting of KTW36, KTW49, KTW37, KTW34 and KTW38 was

TABLE 3

PERCENTAGE DISEASED GRAIN

Variety	1965 Harvest. Site 1	1966 Harvest Site						1967 Harvest Site					
		1	2	3	4	5	Mean	1	2	3	4	5	Mean
Kairi Durum ..	10·5	1·5	5·6	0·7	5·4	0·5	2·7	7·7	14·2	10·3	12·0	31·3	15·1
KTW 34 ..	13·0	0·8	12·3	4·2	3·0	0·8	4·2	4·8	10·4	11·8	12·4	43·1	16·5
KTW 41 ..	11·2	1·15	7·9	4·6	1·7	0·4	3·2	3·8	17·0	18·6	9·1	42·9	18·3
KTW 36 ..	15·2	1·7	10·6	2·7	5·4	0·2	4·1	7·9	21·8	15·4	7·4	43·9	19·3
KTW 49 ..	..	2·1	17·2	7·5	3·7	0·4	6·2	8·7	23·4	16·9	12·0	44·6	21·1
KTW 37 ..	11·2	0·3	5·3	1·6	4·7	0·6	2·5	10·5	24·3	23·5	22·6	55·0	27·2
GM 211 ..	20·8	0·7	10·4	4·1	2·7	0·2	3·6	8·9	18·3	13·2	11·7	42·3	18·9
KTW 33 ..	13·8	1·8	9·1	4·0	3·0	0·5	3·7	13·4	28·5	28·3	18·2	58·6	29·4
KTW 38 ..	11·5	0·8	11·4	3·7	4·1	0·4	4·1	..	..	..	..	..	..
KTW 35 ..	18·6	0·5	12·3	6·2	2·1	0·3	4·3	..	..	..	..	..	..
KTW 46 ..	..	2·4	8·6	5·7	3·9	..	5·1	..	..	..	..	..	..
KTW 48 ..	..	2·2	11·3	9·0	4·2	0·9	5·5	5·3	12·0	18·8	30·7	63·4	26·0
KTW 39 ..	16·5	1·7	12·1	9·8	2·0	0·2	5·2	10·8	33·7	23·0	20·3	50·0	27·5
GH 170 ..	20·6	3·8	16·1	10·4	5·6	3·0	7·8	10·6	27·0	..	11·5	25·9	18·7
KTW 44 ..	..	0·7	14·0	6·4	5·6	..	6·7	..	..	..	..	..	..
KTW 43 ..	..	1·4	14·0	7·8	5·9	0·2	5·9	..	..	..	..	..	..
KTW 45 ..	..	1·2	15·8	7·8	3·4	1·1	5·9	..	..	..	..	..	..
KTW 50 ..	..	1·6	12·9	12·0	3·9	..	7·6	..	..	..	..	..	..
KTW 42 ..	12·8	2·2	9·8	11·9	5·4	2·4	6·3	9·9	29·5	28·6	28·2	80·4	35·3
GH 128 ..	23·9	3·3	15·8	12·4	5·2	1·5	7·6	13·1	33·6	16·7	14·0	43·8	24·2
KTW 40 ..	19·0	1·9	16·1	12·7	2·9	0·6	6·8	16·3	29·2	22·9	28·8	65·7	32·6
KTW 51 ..	..	2·4	19·5	8·3	4·4	0·9	7·1	..	..	..	..	..	..
Atherton Dent	22·5	8·4	21·7	11·3	7·6	4·6	10·7	19·6	31·7	..	39·5	59·5	35·1
Mean	16·1	1·8	12·6	7·1	4·2	1·0	..	10·1	23·6	19·0	17·9	50·0	23·9
L.S.D. 5% ..	11·1	2·4	8·2	5·1	3·3	1·8	..	..	..	..	..	..	..
L.S.D. 1% ..	14·9	3·1	10·9	6·8	4·4	2·4	..	..	..	..	..	..	..

prominent. Yield of any one in this group was exceeded ($P < 0.05$) by only KTW41 and others in the group for any of the analyses at the individual sites. The exceptions were KTW36 and KTW38, whose yields were exceeded ($P < 0.05$) by KTW42 once each. In the favourable season (1966) GH128 was as consistent in yield as the better new hybrids.

KTW37 showed least lodging. The number of times KTW36, KTW41, KTW44 and KTW51 were exceeded was in the same range as GM211. KTW34 and KTW38 were in the same range as GH128, while others, including KTW49, were inferior.

Two new hybrids, KTW34 and KTW41, and the commercial variety GM211 were as consistent in ear rot resistance as Kairi Durum. KTW35, KTW38 and KTW46 were quite good but untried in a "disease" year and KTW36, KTW44 and KTW37 compared favourably with GH128.

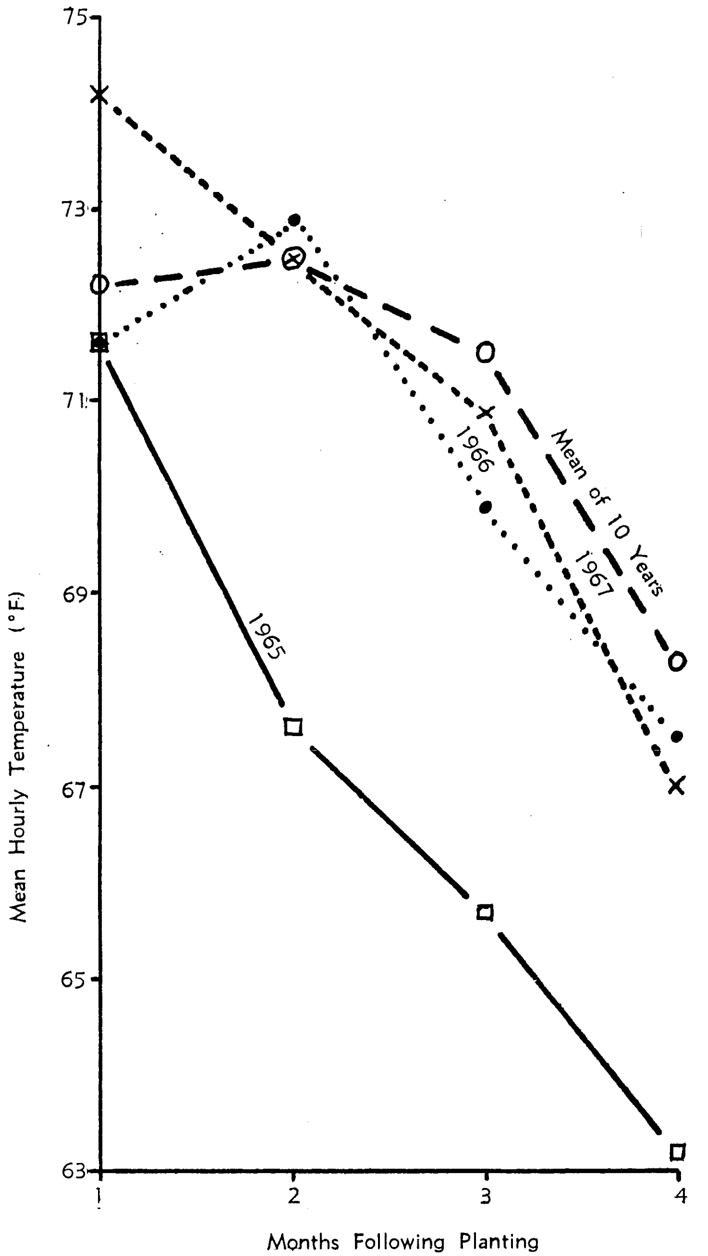

Fig. 1.—Mean hourly temperature during months following planting.

TABLE 4

SUMMARY OF SIGNIFICANT DIFFERENCES

Variety	Number of Times Yield of Each Variety is Exceeded by Another for all Sites ($P < 0{\cdot}05$)			Number of Times Lodging of Other Varieties is less than Each Variety for all Sites ($P < 0{\cdot}05$)			Number of Times % Diseased Grain of other Varieties is less than Each Variety for all Sites ($P < 0{\cdot}05$)		
	1965 Harvest	1966 Harvest	1967 Harvest	1965 Harvest	1966 Harvest	1967 Harvest	1965 Harvest	1966 Harvest	1967 Harvest
KTW 41	0	0	0	1	2	2	0	0	3
KTW 36	3	0	0	0	1	1	0	2	5
KTW 49	..	1	1	..	20	1	..	6	7
KTW 37	0	2	2	0	0	0	0	0	20
KTW 34	0	3	4	0	7	11	0	0	1
KTW 38	3	3	..	0	8	..	0	0	..
KTW 48	..	5	7	..	51	26	..	3	21
KTW 42	0	5	10	5	29	45	0	24	39
KTW 33	3	2	18	0	13	15	0	0	24
KTW 44	..	9	..	..	1	..	..	6	..
KTW 46	..	12	..	..	28	..	..	0	..
KTW 50	..	12	..	..	24	..	..	11	..
KTW 39	0	12	36	0	11	1	0	8	22
KTW 35	3	17	..	0	11	..	0	0	..
KTW 43	..	18	..	..	26	..	..	7	..
KTW 45	..	19	..	..	4	..	..	5	..
KTW 40	4	20	11	0	13	27	0	15	36
KTW 51	..	20	..	..	2	..	..	12	..
GH 128	10	3	40	0	7	6	4	20	14
GM 211	11	18	35	0	0	2	0	0	3
GH 170	9	37	19	0	1	14	0	40	7
Kairi Durum	11	51	64	1	5	46	0	2	1
Atherton Dent	12	74	54	1	55	48	3	77	35

IV. DISCUSSION

The prominent varieties were KTW41, KTW36 and KTW37. Yield performance of these three was better than that of the best commercial standards and their ability to withstand lodging at least equal to them. KTW41 was the most consistent for yield in that it was not significantly exceeded by another variety at any site. KTW41 showed more consistent resistance to ear rot than KTW36 and KTW37, which were similar to GH128 in this respect.

Although KTW34 yielded well and had equal ear rot resistance to Kairi Durum, it had a greater tendency to lodge than GH128. KTW49 consistently gave high yields but should be disregarded because of its tendency to lodge. Although other new hybrids performed better than the standards in some respects, their overall performance was not as good as that of those already mentioned. The fact that the standards, especially GH128, yielded well in the favourable season and dropped sharply in yield in the other years suggests that use of one of the better new hybrids in the district would reduce seasonal variation by increasing yield in poorer seasons whether tropical rust was present or not.

The three seasons provided a range of weather conditions. Low yields in the first season (1965) at a site which had a much higher potential and failure of the other four sites to produce any harvestable maize can be ascribed to adverse growing conditions caused mainly by lower temperature. The second season (1966) provided an opportunity for varieties to express their yield potential within the limitations of soil conditions. The deluge of rain in 1967 would have been an important contributing factor to the high incidence of diseased grain in that season.

Low yields at some sites in 1966 and 1967 can be attributed to exhaustion of soil nutrients. Recent nutrition studies suggest that the most economic level of nitrogen and phosphate application at the lowest yielding site in 1967 is higher than was applied in the trials. Diseased grain variation from one site to another would probably depend on carry-over of the fungus species from previous seasons (Pont 1963).

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