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MAIZE DEVELOPMENT AND RESEARCH IN THE NT

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MAIZE

DEVELOPMENT AND RESEARCH IN THE NORTHERN TERRITORY

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INTRODUCTION

Maize, like rice and peanuts, has captured a considerable amount of attention from agriculturalists in the Northern Territory since early settlement. Like rice and peanuts, the establishment of a permanent maize industry has eluded the attempts of farmers and agronomists.

A good part of the blame for the failure of agricultural enterprises in the past can be attributed to a lack of understanding of the environment, and a systematic research programme is needed to improve our knowledge of the crop environment inter-relationships.

In the past, maize research has generally lacked direction. The main information available consists of results of variety trails, many of them contradictory.

In an endeavour to assess the present situation and to suggest future directions for research work, this article has been prepared.

HISTORY

The first mention of maize being grown in the N.T. was made by Bremer in 1824. Curteis (1965) quotes him as saying that at the settlement at Port Essington "..... the maize was above ground on the fourth day after it was sown."

Later he quotes lieut. G. Sluman in a report to the colonial secretary in 1828 as saying "I feel satisfied it will be a productive and valuable garden as ..... maize ..... and other plants look healthy, and I think will answer well."

Ernestine Hill, in her book "The Territory" quoted a prospectus for "persons of respectability" wishing to settle at Port Essington which had "flourishing gardens of plantains, tamarinds ..... maize ..... mangosteems ..... gardens now advancing to perfection."

In a Government Resident's report "A Sketch of the Northern Territory " (1880), a description of early agricultural exploration work was given. A wide range of crops, including maize, had been tested, apparently quite successfully.

In 1881, the Government Resident was able to state that "the following plants may be looked on as a most perfect success:-

Sugar, cotton, rice, maize, jute, tobacco, groundnut, sesame, indigo, grass cloth, arrowroot."

Some commercial maize production must have commenced about that time. Bauer (1964) in discussing the period 1869-89 stated that "a little maize was raised at various places, the Daly producing the best."

The Resident's report of 1888 confirmed the agronomic success of maize on the Daly saying that "at the Daly Mr. Brown had a fine crop of maize, but the cost of chartering a launch to bring it to market is of course too heavy a charge to be borne and for the present he has abandoned cultivation."

Thus the problem of freight and markets first began to manifest itself with this crop.

Further problems were noted in the 1889 Resident's report which stated that "owing to the ravages of caterpillars, this crop was not so good as might be expected."

However, the total crop must have been reasonable, since "..... Mr. Driscoll of Queensland described our maize in the 'Queenslander' as the best he saw in his life." (ibid)

During this period locally grown maize was regularly supplied for the use of government horses.

In the 1892 Resident's report, a yield of 50 bushels per acre (2800 lb/ac) was reported by Chinese growers on the Daly. The result, if reliable, would compare favourably with much wet season maize produced experimentally and commercially in the N.T. to this day.

Bauer (1964) reported continued successful cultivation of maize during the period 1890-1910 on the Daly, both by the Chinese and by the Catholic mission, while the 1910 Resident's report talked of "good quality maize growing over quite a large area in the North."

In 1912, two experimental farms were set up, one at Batchelor and one on the Daly River. Maize was grown at both of these.

The maize variety "90 day" grown at Batchelor was reported as affected by moisture stress, but that from the Daly showed "satisfactory results - good cobs of well filled corn growing to 11-12 ft. The cereal can be considered a success in the district". (Administrator's report, 1912).

Over the next few years maize was regularly grown at the two research stations with yields of from 10 to 35 bushels/acre. A fertilizer trial with blood and bone fertilizer produced an apparent slight response to the fertilizer.

In 1920, the experimental farms were closed. With this shut down, reports of maize became less frequent.

In 1925, the Administrator's report spoke of "small areas of maize being grown with limited success."

No further mention of maize is made until 1937-38 when, in association with renewed experimentation in agriculture, " a small crop of maize was grown during the wet season". Around this time peanuts were the crop in which most interest was shown, and, if any maize was grown, interest in it was very much overshadowed by that in peanuts.

It was not until 1954 that further mention was made of maize in government documents, from this time experimental results were stated in annual reports of the Agriculture Branch.

RECENT N.T. MAIZE RESEARCH

With the formation of the Agriculture Branch of the N.T. Administration, evaluation work on maize as a crop for the N.T. was recommenced.

The first work reported was performed in the 1954 dry season. A sample of "Durum" type maize was grown, and apparently produced a satisfactory yield at Berrimah Experimental Farm (B.E.F.). The same variety was planted at B.E.F. and at Batchelor in the 1954-55 wet season, with a complete failure in each case. Excessive humidity was given as one possible cause of crop failure.

Maize work then lapsed until 1959, when a dry season fertilizer trial was performed, and gave some indication of a response to a mixed fertilizer in the variety D.S. 221.

In the following wet season at B.E.F. a variety trial produced a maximum yield of 1680 lb/ac from the variety G.211, outyielding GH134 (1158 lb/ac) and GH128 (122 lb/ac).

Maize in the same year performed poorly in a fodder trial.

At the Coastal Plains Research Station (C.P.R.S.) in that year a wet season evaluation of a number of crops, including maize was carried out in the rice bays. Maize, both on ridges and on the flat produced poor growth, and was considered an unsuitable crop in that environment.

In the 1960-61 wet season, a variety trial at B.E.F. produced poor growth and no yield. However, at the same time, a trial at Batchelor produced a mazimum yield of 2990 lb/ac from the variety DS65A. The difference between the two trials must be attributable to disease. Yields from the Batchelor trial are shown in Table I.

TABLE I. - Yields produced from a variety trial performed in the 1960-61 wet season at Milton Springs, Batchelor.

Variety	Yield (lb/ac)
DS65A	2990
Q23	2761
GH128	2660
Q739	2228
DS303	2050
DS606A	2033
GH134	1949
DS28	1865
DS99	1865
Emblem	1467

A dry season trial at C.P.R.S. in 1961 on the upland soils produced poor growth in both sweet corn and hybrid maize. An experiment at the Upper Adelaide River Experimental Station failed due to grazing by cattle.

Further varietal testing at B.E.F. was carried out in the 1963 dry season. Comments about the crop indicate that there was reasonable production, although no yield figures were given.

From 1963 there was a lapse in maize work done at B.E.F. The next work on maize was performed at Tipperary Station in the 1968-69 wet season.

In that year 22 varieties were tested in a non-replicated trial. The variety DS28 performed best of those tested, although again absolute yield levels were not determined.

In 1969-70 further testing of varieties and an examination of fertilizer response were carried out at Tipperary. Three trials were performed. Results are shown in Tables II, III and IV.

TABLE II. - Results of variety trial 1, Tipperary 1969-70 wet season.

Variety	Yield (lb/ac)
DK1004	3186
DK1006	2796
G2	2541
DK1212	2492
DS28	2287
XL385	1988

N.S.

TABLE III - Results of variety trial 2, Tipperary 1969-70 wet season.

Variety	Yield (lb/ac)
CH1003	1913
CH1001	1451
CH1002	1309

N.S.

TABLE IV - Results of N X P trial, Tipperary, 1969-70 wet season.

(Yields in lb/ac)

	N Level	0	50	100	200	400	Mean
P Level	0	2668	2354	1740	2094	915	1954
	80	2138	2464	1625	2052	1555	1967
	Mean	2403	2409	1682	2073	1555	1960

N.S.

The results of all experiments in 1969-70 were affected by the dryness of the season, and the fertilizer trial further affected by probable movement of N fertilizer (urea) between plots.

Another variety trial was performed at Tipperary in 1970-71. Results are shown in Table V.

TABLE V. - Results of the wet season variety trial, Tipperary, 1970-71.

Variety	Yield (lb/ac)
XL385	4021
CH1003	3811
NES	3353
DS456W	3075
DS28	2837
DK1006	2814
XL361	2704
DK1004	2694
PQ500	2693
QK37	2612
GH128	2478
DK1212	2437
XL45	1046

LSD5% = 879

In this trial, an indication of a positive yield response to contour hilling was obtained.

At Coomalie Creek, two variety trials were performed on raised beds, in an area prone to waterlogging. The trials were both seriously affected by excessive water. The best areas of the plots were harvested, and yielded 3527 and 5575 lb/ac from the varieties CH1003 and PQ500 respectively.

In 1971-72 a variety trial was performed at B.E.F. This trial suffered from two major diseases, Southern Corn Leaf Blight and Wallaby Ear. Due to this, the trial was ploughed in.

DISCUSSION

(a) Varietal Assessment

With the relatively large numbers of varieties tested under different, poorly documented conditions, accurate varietal assessment is difficult. In an effort to obtain a degree of comparability of results, yield levels from various trials were compared, where possible, to a standard.

The standard chosen was DS28, which had been tested in 4 trials. This was assigned a value of 100, and other yields referred to this.

Where DS28 was not included in a trial, the comparison was made through an intermediate variety.

The results of the comparison are shown on Table VI.

TABLE VI - The yield index of Maize Varieties from Agriculture Branch data

Variety	Yield index	No. of Years Tested	Variety	Yield Index	No. of Years Tested
NES1001	118	1	Q739	79	3
DK1004	117	2	DS303	78	2
XL385	114	2	Q724	76	1
G211	112	3	QK37	76	2
G2	111	1	XL81	75	1
DK1006	110	2	Q1280	73	2
CH1003	108	3	Q692	73	2
DS65A	105	2	Emblem	72	2
DS28	100	4	DS601	70	1
DS99	100	1	XT664	66	1
Q23	99	3	PQ301	65	1
DK1212	97	2	CH1002	64	2
GH134	97	3	XL45	64	3
GH128	95	4	DK848	58	1
PQ500	91	2	NEH1151	57	1
XL361	87	2	DS221	54	1
DS456W	83	2	Q790	51	1
DS606A	80	2	805A	43	1
CH1001	80	2			

Probably the best use of the table at present is in identifying the poorer varieties, which should aid in selecting varieties for further testing.

Climatic Effects

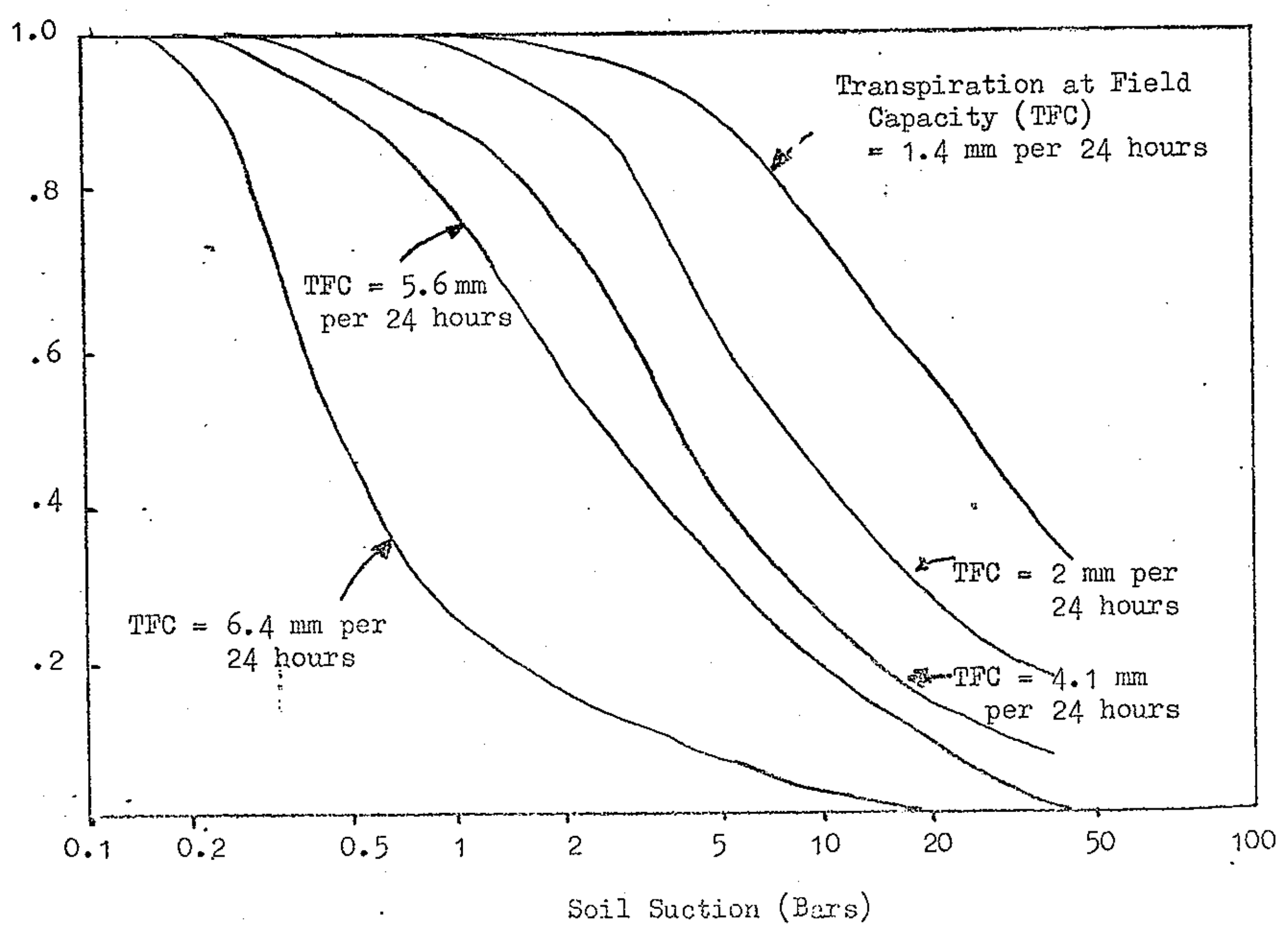
During varietal testing, many apparent inconsistencies in performance have occurred within a variety. In seeking reasons for this, a study of the effects of climate on the growth of maize is necessary. Of the varying climatic parameters, water and temperature seem to be the most likely to cause variability in crop growth.

(a) Water Status -

Maize is generally considered to be sensitive to moisture deficiency. Studies of factors influencing the onset of stress have been made by Denmead and Shaw (1962). They showed that the point where the crop wilted (lost turgor whether in temporary or permanent wilting) coincided with the time when the actual transpiration became less than the maximum transpiration for those meteorological conditions when the soil is at field capacity. This was shown to be of physiological significance to the plant, since at wilting the plant ceased gaining weight.

Denmead and Shaw also studied the interactions of soil moisture and atmospheric conditions on relative transpiration rates. They produced a series of graphs (see fig. 1) illustrating the relationships.

Fig. 1 - Relative transpiration rate as a function of soil moisture content for different potential evaporation conditions (after Denmead and Shaw (1962).



From this series of graphs it can be seen that the capacity of the plant to extract soil moisture from soils and continue to transpire at high rates (i.e. remain turgid) is dependent both on the level of soil moisture and the rate of potential evaportranspiration. At high levels of potential evapotranspiration as experienced in the N.T. the soil moisture has to be at a low potential (near field capacity) if moisture stress is to be avoided.

Dale and Shaw (1965) derived a figure (see fig. 2) relating evapotranspiration rate at field capacity, percent available water in the root zone, and turgor loss point.

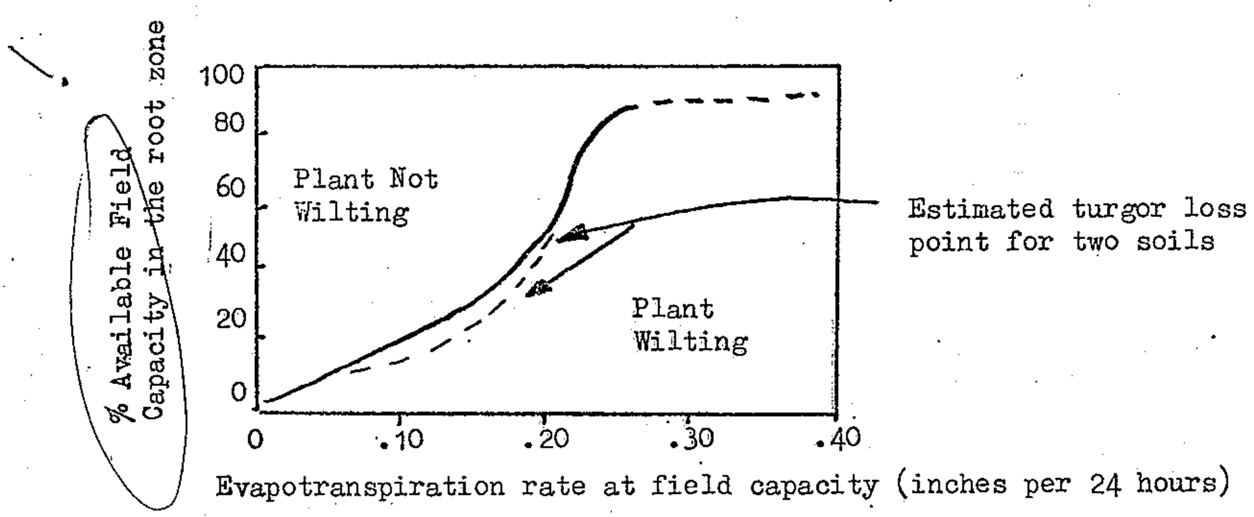


Fig.2 Relation between evapotranspiration rate at field capacity, per cent available field capacity and turgor loss point (After Dale and Shaw, 1963).

The figure enables the onset of turgor loss to be predicted from a knowledge of the potential evapotranspiration and moisture status of the soil. The figure was derived from two soils, with a curve of the same general shape being produced each time. Although use of this figure for N.T. conditions must be made only with some caution, for the exercise it will be assumed that the form of the figure has general validity. Assuming a potential evapotranspiration rate of 0.22 inches per day, turgor loss would occur when about 30% of available water was removed from the soil.

Considering a crop grown in Tippera clay loam, the soil has an available moisture range of one inch per foot of soil (Slatyer, 1954). A rooting depth of four feet will be assumed. Under these conditions the plant could remove 1.20 inches of water before turgor loss occurs. At an evapotranspiration rate of 0.22 inches per day, this would be accomplished in six days, if no rain fell in the meantime.

A trial planted in late December with varieties tested in the 1970 work produced silking in most varieties in the period Feb. 26 - March 25. In Darwin there is a 90% chance of an eight day dry spell occurring at this time (COM. Bur. of Met. 1961). In the period February 12 - March 11 the chances are 60% (ibid). Thus if silking occurs in the period Feb.26 - March 25 there is a very good chance of moisture stress occurring at that stage for a crop around Darwin. The probability of an eight day dry spell never falls below 60%. Away from Darwin the chances of moisture stress progressively increase.

It should be noted that in the tables of probabilities of dry spells referred to, a dry spell is defined as "a number of consecutive days with less than 1.00 inches of rain in any two day unit". The use of this criterion was based on the work of Slayter (1960) at Katherine, who stated that falls of more than 0.50 inches were needed for any worthwhile contribution to soil moisture to be made and that falls in excess of 1.00 inches were needed if plant growth were to be maintained for more than a few days.

It is considered that at silking a fall of say, ninety points of rain in a day, followed by a dry spell of one day would be still of use to a maize plant both in its contribution to soil moisture and in reducing evaporation. Similar occurrences are not uncommon in February-March.

Several groups have experimentally measured the effect of moisture stress at various physiological stages on the yield of the maize plant.

Denmead and Shaw (1960) measured grain yield reductions of 25%, 50% and 21% from moisture stress in the vegetative period, at silking, and after silking respectively. It must be assumed that the "after silking" period was towards the grain ripening phase.

Wilson (1968 (a)) reduced grain yields by 32% with stress during vegetative growth and 49% with stress in the reproductive stage.

In other work (1968 (b)) the same author found that in nine different combinations of moisture stress treatments, highest yields were always obtained when the crop was well irrigated in the reproductive stage.

In an interesting study, Barnes and Wolley (1969) imposed moisture stress at tassel emergence, silking and the blister kernels stage, on two varieties and produced the following reduction in yield relative to a non stressed control:

Hy x C103 : 6% (Tasselling) 76% (Silking) 48% (Blister Kernels)

R71 x B60 : 8% (Tasselling) 14% (Silking) 22% (Blister Kernels)

In each case the stress applied at tassel emergence produced the least yield reduction. The other feature of these results is the great difference between the two varieties in tolerance to moisture stress at silking. The relative resistance of the second variety to moisture stress at this time is most unusual among results reported.

In general experimental results have shown silking to be the most vulnerable time for moisture stress. Denmead and Shaw (1960) have explained this as being because during, and soon after silking, photosynthate produced is used in grain filling. A cessation of dry matter accumulation at this time has a direct effect on yield, where earlier the effect was indirect through a reduction in the vegetative plant structure.

In other work Denmead and Shaw (1959) showed that at silking and grain filling, the concumptive water use of the plant is the greatest. Since at silking, the water use by the plant is highest, and the effects of a water stress are most severe, it would appear that to ensure maximum maize grain production under natural rainfall the crop should be grown so as to produce silking at the time of highest and most reliable rainfall.

The critical effect of moisture stress at flowering on yield can explain many of the inconsistencies in varietal performance from year to year when comparing varieties with different times of silking. A rainy period in one year might come at the critical period for one variety but at a less important time for another, with the situation possibly reversed in the next year.

If these inconsistencies are to be avoided in the future, a close monitoring of the water status of the crop will be necessary. The most direct measurement of this that could be made is an assessment of the plant's leaf moisture potential.

While measures of leaf turgidity using the floating disc method or moisture potential using a pressure bomb are accurate techniques and could be used for special purposes, they are time consuming processes. Systematic daily use of them would permit only a small number of plots to be grown each year.

Of more practical usage for general work would be a daily observation of visual wilting. This represents an important physiological condition of the plant, but can still be done rapidly. The data collected would be used to assess "stress" days and "non-stress" days in the crop, as in the work of Dale and Shaw (1965).

Measurements of rainfall, relative humidity, and soil moisture should be taken if possible. Plant weight and nutrient uptake levels would assist in interpreting yield results.

In testing maize varieties, an attempt could be made to screen for differential resistance to moisture stress. This would, if successful, improve the efficiency of varietal testing by reducing the number of years over which it would be necessary.

Studies of meteorological data are needed to establish the time of least likelihood of moisture stress in the potential maize growing areas and work done to find out the feasibility of planting the crop to arrange for silking and grain filling at that time.

Attention needs to be given to methods of reducing moisture stress under natural rainfall.

Trials at Tipperary in 1970-71 gave an indication that the practice of contour hilling could improve moisture filtration and result in improved yields.

Work at Katherine (unpublished) had shown that using cow-pea in a rotation could result in an improved yield in a subsequent sorghum crop. Since the improved yield could not be duplicated with extra nitrogen from the bag, it seems likely that the added organic matter from the cowpeas was effective in increasing yields.

While no measurements were taken, one possible mechanism for the improvement in yields would be an improvement in moisture holding capacity in the soil, resulting in fewer moisture stress periods.

If this was the machanism for the improvement, the same effect would apply equally to maize.

Yield reductions can also occur through waterlogging, to which maize is susceptible. Waterlogging stunts the growth of the plant, causes yellowing in the leaves and makes interrow cultivation impossible.

Temperature

The possibility of excessive temperatures affecting maize production must be considered.

Unpublished data from the Ord region have shown lower yields from December than from March maize plantings under irrigation. Temperature was considered a possible source of the reduction.

Berger (1962) has stated that "extremely high" temperatures could injure the maize plant, and that tasselling was the most susceptible time.

Schaal and Blair (1967) investigated the ten poorest and ten best years for maize growing in Tippecanoe, Indiana and found that the highest yields occurred when the temperature was above normal during germination, and below normal during the main growth and reproductive periods (mid June to mid August). This mean July temperature in Tippecanoe is 24.6°C (Armington, 1941).

Corresponding average mean temperatures in Darwin in February - March are 28.7°C. In the same period 28 days are likely to have temperatures in excess of 32.2°C (Com. Bur. Met., 1961). Inland from Darwin, maximum temperatures are likely to increase. In drier years average temperatures are likely to be higher than normal, accentuating the water deficit problem.

Fertilizers

Fertilizer trials were done on two occasions, in 1959-60 and 1969-70. The results in 1959-60 pointed to the possibility of a fertilizer response although the absence of statistical information precluded a firm statement on this.

In 1969-70, a fertilizer trial at Tipperary failed to show any fertilizer response.

In the trial the fertilizer was spread on the surface, and would have been subject to movement between plots with runoff water. This would partly account for the absence of fertilizer response.

Since the trial was performed in an abnormally dry year, the yield ceiling may, in any case, have been governed more by the water status of the plants than by their nutrient level.

The question of fertilizer response in a rain grown crop of maize is one that requires some attention. The probability of varying responses depending on the level of moisture stress will compound the problems in obtaining meaningful recommendations.

Diseases

Diseases of maize have not been mentioned in great detail in the past, although reports have little doubt that some have occurred.

In 1960, Morschell and Grylls were reported as suspecting Wallaby ear disease damage in maize.

A further report on the 1961-62 wet season crop (see Agriculture Branch Annual Report 1961-62) showed the presence of Wallaby ear disease, and described diseased plants as having "main leaves swollen and protuberant, or causing crinkling of the leaf".

It was suggested that control of the disease could depend on time of planting and control of insect pests.

A further major outbreak of this disease was reported in 1971-72 in a variety trial at B.E.F. Varietal differences in susceptibility were identified, as shown in Table VII.

In addition to these two confirmed reports, others not inconsistent with a description of Wallaby ear disease have been made in Agriculture Branch reports.

TABLE VII. Degree of susceptibility of maize varieties to Wallaby ear disease, in a variety trial at B.E.F. in the 1971-72 Wet season.

Scoring - 0 No Wallaby ear symptoms
5 Very severe symptoms

Variety	Score
XL361	1
XL385	2
DS456W	2
CH1003	2 - 5
E9	3
DK805A	3
F3	3
Q1280	4
XT664	4
VA (composite)	4
XL347	4
XL306	4
XL45	5
Q692	5

In the 1971-72 Wet season crop at B.E.F., a severe outbreak of southern corn leaf blight (*Drechslera maydis*) occurred, for the first time in the N.T.

The disease produced greyish tan to straw coloured spots, up to an inch long and ¼ inch wide, parallel to the veins of the leaf, Badly blighted leaves completely lost chlorophyll.

Varietal differences in susceptibility to the disease were evident, with those varieties having the Texas male sterile cytoplasm being more susceptible than others to the disease. The degree of susceptibility is indicated in Table VIII.

TABLE VIII. Index of susceptibility of Maize Varieties to Southern Corn Leaf Blight. 0 = nil infection, 5 = very heavy infection.

Variety	Susceptibility	Cytoplasm
CH1003	0.5	100% normal
DK805A	0.33	100% normal
DS456W	0.67	65% TMS, 35% normal
XL385	.33	100% normal
E9	0	100% normal
F3	0	100% normal
Q692	1.5	100% normal
Q1280	2.1	60% TMS, 40% normal
VA	0.1	100% normal
XL45	1.1	65% TMS, 35% normal
XL306	2.5	65% TMS, 35% normal
XL347	2.1	100% TMS
XL361	3.5	100% TMS
XT664	2.1	65% TMS, 35% normal

It can be expected, that given varieties in future that do not depend on T.M.S. ctyoplasm for male sterility, infestation of southern corn leaf blight should not be of great significance in the future.

Two other diseases have been reported. At Coomalie Creek a bacterial stalk was identified in a commercial dry season irrigated crop.

Other references to stalk rots have been made but the disease does not seem to be widespread.

In 1965 bacterial blight, caused by Xanthomonas sp. was identified at Lake Deane by J.B. Heaton. No other specific reference to this disease has been made.

In all, the Wallaby ear disease seems to be potentially the most serious in view of the lack of knowledge of the disease and its vectors.

It should be noted that the disease has never so far been reported as serious outside the Darwin area.

Maize has an advantage over sorghum in areas where the two could possibly be grown in that the ear of maize is less susceptible to disease than is the sorghum head. This makes the time of harvest of maize less critical than that for sorghum, and so extends the area that could be harvested by a single machine.

INSECT PESTS

The most significant pest of maize in the N.T. is the corn ear worm (Heliothus armigera). While the larvae of this insect can cause damage to the crop at all stages, damage in the early stages is usually minor. The most susceptible stages are at tasselling, where pollen is consumed, and after silking, when damage to the cob results. The corn ear worm larvae can invade the corn cob from either the top or through the side, causing considerable damage.

Control of the insect can be obtained either by using a 0.25% spray of Trichlorphon, or a 0.1% spray of Carbaryl. Spraying at silking time is particularly important.

The next most important pests are leaf hoppers. These cause damage both by feeding on plant juices, and by transmitting virus diseases, notably wallaby ear.

Control can be achieved using Dimethoate at 0.03% or Malathion at 0.1%.

Army worm (Spodoptera spp) larvae can cause damage to leaves and developing cobs. This pest is far less important than Heliothus armigera; control procedures are the same as for that pest.

Locusts and corn aphids have been observed on plants, but are of minor importance.

Pests of the stored grain, mainly weevils occur, but these can be reduced by observing sanitation in storage areas. Malathion, at 1 oz. of 1% dust per bushel gives weevil control in grain used for feed, while in seed grain, 3 ozs. of 1% Lindane can be used.

CONCLUSIONS AND RECOMMENDATIONS

It seems apparent that future experimentation in corn will have to accommodate considerable inter seasonal variation in growth and yield due to climatic variations.

Meaningful results will be obtained only if these can be explained.

It is therefore recommended that for all maize experiments the following observations be taken as a matter of course:

1. Soil moisture at sowing, silking and harvest.
2. Rainfall and evaporation.
3. Observations on plant wilting.
4. Dates of planting, emergence, tasselling, silking and harvest.

Further varietal assessment, fertilizer, and rotation work will need to be pursued, and the limits of economic production defined.

It would appear that the climate of the N.T. will prevent maize from achieving its full yield potential in any but a very few seasons. However, past results have been such that given sound agronomic practices, maize should, in the future, take its place as part of the N.T. cropping scene.

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