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### Kimberley Research Station - A progress report, November, 1957

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# KIMBERLEY RESEARCH STATION

A Progress Report, November, 1957

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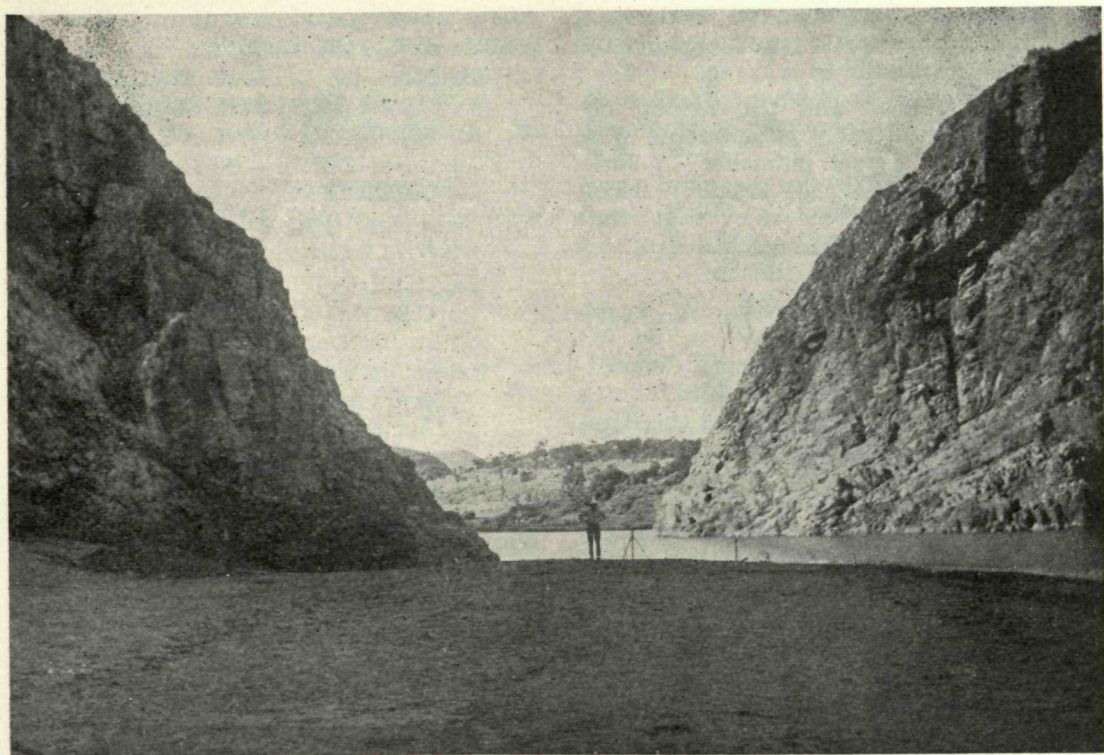


Fig. 1.—The Ord River flows through this gorge in the Carr Boyd Ranges. The proposed dam site is in this area

# KIMBERLEY RESEARCH STATION

## A Progress Report

*[Prepared by the Supervisory Committee of the Kimberley Research Station,  
November, 1957.]*

### INTRODUCTION

**T**HE Kimberley Research Station was established in 1945 following upon proposals to dam the Ord River where it passes through a gorge in the Carr Boyd Ranges. Land reconnaissance and soil surveys indicate that an area of between 100,000 and 200,000 acres of potentially irrigable soils is available, which could possibly be utilised for intensive agricultural settlement.

The Station is 2,000 acres in area and is situated on the Ord River about 60 miles by road from the port of Wyndham on Cambridge Gulf in the far north-eastern portion of Western Australia. It is jointly operated by the Commonwealth Scientific and Industrial Research Organisation and the West Australian Department of Agriculture—the former assuming direction and control of the plant industry

research programme and the latter providing station labour and management and assuming responsibility for research into soil and animal problems as the need arises in the development of the area.

The Station is concerned with agricultural investigations in the region and the immediate objectives of the research programme are to determine whether the soils are satisfactory for irrigation and



whether a stable system or agriculture could be developed to provide a sound basis for settlement.

These objectives and the results obtained from the early experiments were described in a report published in June, 1950 (J. Agric., W.A., 27; 199-208). This report reviews progress since that time and presents certain conclusions based on results obtained at the Station.

The planning and supervision of experimental work has continued to be the responsibility of the Supervisory Committee, which was appointed in 1946,\* but a further committee designated as the Kimberley Research Station Policy Committee was appointed in 1951, by agreement between the Prime Minister of the Commonwealth and the Premier of Western Australia. The functions of this second Committee in brief are:

- (1) To review progress at the Station and to make recommendations for future work, including forecasts of expenditure involved.
- (2) To recommend annual appropriation of funds.
- (3) To report on the foregoing, through the appropriate Ministers, to the Commonwealth and State Governments.

This Committee consists of four members, two from Western Australia and one each from C.S.I.R.O. and the Ministry of National Development, representing the Commonwealth. The present constitution of the Committee is:

- Mr. C. S. Christian—Chairman, C.S.I.R.O.
- Mr. T. Plumb—Department of National Development.
- Mr. W. M. Nunn—Department of Agriculture, Western Australia.
- Mr. E. K. Steere—Public Works Department, Western Australia.

The research and extension staff at the Station this year include:

Director—L. C. Lee, C.S.I.R.O. (resigned May, 1957, successor to be appointed).

Technical Officer—E. C. B. Langfield, C.S.I.R.O.

Technical Officer—A. L. Chapman, C.S.I.R.O.

Technical Assistant—D. Beech, C.S.I.R.O.; G. Finn, Western Australia, Department of Agriculture.

Extension Staff—K. Fitzgerald, Western Australia, Department of Agriculture; J. Ritson, Western Australia, Department of Agriculture.

In addition, various officers of the Western Australian Department of Agriculture and the Division of Land Research and Regional Survey, C.S.I.R.O., have spent periods at the Station on specific problems.

An important factor influencing the Station's programme during the period under review was a recommendation by the Kimberley Development Committee of 1951\* that crop areas on the Research Station should, where possible, be raised to an actual farm scale. In particular, that Committee recommended as a result of the examination of the position at that time, that rice and sugar cane be expanded in this way as soon as adequate planting material became available. The Station's Supervisory Committee, in accepting this recommendation agreed that "farm scale" might be interpreted as referring to areas of the order of 20 acres.

During the period covered by the first progress report of the Station (1946-50) some experience had been gained with a wide range of crops on the heavy-textured Cununurra clay soils of the Kimberley Research Station, and, with this information as a back-ground, the Supervisory Committee recommended that efforts should be concentrated, at least for the

\* This committee consisted of:—

Chairman—C. S. Christian, C.S.I.R.O.

Executive Officer—W. M. Nunn, Officer-in-Charge, North-West Branch, Dept. of Agriculture of W.A.

G. H. Burvill—Chief Plant Research Officer, Dept. of Agriculture of W.A.

L. C. Snook—Animal Nutrition Officer, Dept. of Agriculture of W.A.

H. J. K. Gibsons—Officer-in-Charge, Irrigation, Dept. of Agriculture of W.A.

\* This Committee consisted of—

G. Ruddock, Director, Division of Regional Development, Department of National Development.

P. A. Reid, for Director, Bureau of Agricultural Economics, Department of Commerce and Agriculture.

C. M. Dimond, Engineer, North-West Branch, Department of Public Works, Western Australia.

W. M. Nunn, Officer in Charge, North-West Branch, Department of Agriculture, Western Australia.



time being, on those cash crops which showed the most promise of forming a basis for agricultural settlement in the region. This recommendation was endorsed by the Policy Committee at its inaugural meeting in 1952, and has been the major principle in determining policy in the period under review. In the view of the several committees guiding the Station's policy, sugar cane and rice were the two crops showing most promise for development purposes.

## II. SUGAR CANE

### (a) Reasons for its Investigation.

Sugar cane was not mentioned in the 1950 Report on the Station, for it was not introduced into the Ord River region until June, 1950, when small quantities of 12 varieties of cane, selected by the Queensland Bureau of Sugar Experiment Stations on the basis of suitability for growing under irrigated conditions, were received from the Burdekin district of Queensland. In view of the general overproduction of sugar throughout the world, and the consequent restrictions on planting acreages, there have been certain questions as to the justification of the Station's policy of concentrating on sugar cane.

The justification arises mainly from the Report of the Royal Commission on the Sugar Industry in Queensland (1951) in which it was forecast that as Australia's

population rose, probable production in Queensland would fall below the estimated available markets to an increasing extent. An estimated deficit of 90,000 tons in 1962 was expected to increase to 167,000 tons by 1975. Western Australia's consumption of sugar in these two years was estimated to reach 44,000 and 52,000 tons respectively. The Committee was advised that the minimum mill size for economic production of raw sugar is about 45,000 tons per annum. The clay soils of the Ord River plains which could be immediately commanded by irrigation if a dam were built, cover about 40,000 acres. It appeared to the Committee that this compact area would provide for an efficient mill in the region, that Western Australia alone could absorb the major part, if not all, of the mill's output, and that on the basis of the Royal Commission's Report, the expected deficit between Queensland production and market requirements in the next decade could absorb the total output. A 45,000 ton mill would require about 10-12,000 acres in cane each year and this would utilise 50-70,000 ac. ft. of water annually on the farms. Allowing for distribution losses a dam supplying about 100,000 ac. ft. annually would suffice. For the minimum size mill therefore a relatively small engineering scheme would be required and such a scheme could well be regarded as a pilot scheme for larger irrigation development in the region.

Other points in favour of a sugar industry are the nearness of the area to a deep-water port (Wyndham), the existence of an established shipping line between Wyndham and south, with a demand for back-loading, and the much shorter distance from Wyndham to the south of Western Australia than from Queensland, the present source of supply.

Apart from these arguments it is the responsibility of the Research Station from the long-term point of view to determine what forms of production are best adapted to the region irrespective of their immediate economic importance. The investigations so far have indicated that sugar is the best of the crops examined.

From the point of view of settlement, no crop better suited than cane could be imagined. With an assignment of 60 to



Fig. 2.—An experimental plot of sugar cane



100 acres of cane per grower, there could be some 200 family units directly concerned with cane cultivation for one mill, plus perhaps double this number required for ancillary services, giving a very worthwhile concentration of permanent population in this very sparsely populated area of northern Australia. The gross annual income of the industry would reach several million pounds annually. If the whole of the available 40,000 acres was devoted to cane production these estimates of population would be more than doubled.

### (b) Results of Investigations with Sugar Cane.\*

The 1951-52 season was occupied by bulking up the original stocks of cane, and the experimental programme commenced in the following season. Sugar cane is normally grown on a ratooning system. Short pieces of cane, with three eyes or nodes, known as setts, are planted in the bottom of a furrow, which is filled in as the cane grows. The "plant cane" is harvested at about a year old by cutting off the canes at ground level. Shoots arise from the root mass, known as the stool, giving rise to a second year's crop of canes known as the first ratoon crop. These are cut at the end of the second year and the process can be repeated several times. In practice the crop of canes harvested each year diminishes, slowly on very fertile lands, but rapidly on infertile ones and at some stage it is no longer profitable to continue ratooning; the stools are ploughed out, and after a suitable period, the land is replanted with setts. Much of the commercial success of a cane planting is dependent on the length of the ratooning period, and few areas go beyond two ratoons. Two ratoons have been adopted as standard practice at the Kimberley Research Station during this early period. Experience has been varied: in some cases second ratoon yields have been only fair (20-25 tons per acre), whilst in other trials yields of between 40 and 50 tons of cane have been obtained.

\* A full report on investigations with sugar has been prepared by L. C. Lee, formerly Director of the Kimberley Research Station, and A. L. Chapman, and will shortly be published.



Fig. 3.—Harvesting and weighing sugar cane

Yield levels (with 2 cwt. each of ammonium sulphate and superphosphate fertiliser per acre) have been good, and there are several records of a three year crop (plant cane + two ratoons) yielding over 100 tons of cane per acre. Table I summarises the yields of all crops up to and including 1956. It should be emphasised that these values include all varieties, both good and not so good, all crops, whether adequately fertilised or not, and all cultivations. With the knowledge now available concerning cultivation, varieties and fertilisers yields of 100-120 tons of cane for a three-year crop may be expected with some assurance.

The sugar content in the cane crops has been studied, by refractometer on expressed juice in the earlier years, and since 1954 by an actual calculation of extractable sugar following methods standardised in Queensland. These methods involve expression of juice from cane samples in an experimental three roller mill, and estimation of sugar in the expressed juice with the aid of a polarimeter. It has been found that sugar content is low at the end of the wet season, and that it rises sharply during the bright winter period, reaching a maximum about September. Renewed growth begins with the warmer spring weather, provided water is supplied, and sugar content falls: Early-cut canes may require as much as 10 tons of cane to produce a ton of sugar, whilst canes cut at the height of their sugar content may require as low as 6 tons of cane per ton of sugar.



Fertiliser trials have indicated that sugar cane responds markedly to ammonium sulphate in the presence of superphosphate, but not markedly to either of these fertilisers applied singly. Following the exploratory experiments, an annual dressing of 2 cwt. each of superphosphate and ammonium sulphate has been adopted as a standard, although there is considerable evidence to show that this is by no means optimum. Superphosphate can be replaced by ground rock phosphate. Pre-

there is little point in studying complex variety fertiliser interactions at this stage.

Water usage has been examined both by soil measurements, by observations on leaf wilting and by measurement of cane elongation. During exceptionally hot dry weather such as may occur in November, irrigation may have been necessary at ten-day intervals, but in the cooler months the intervals may be as long as a month. In addition to rainfall, about 20 irrigations each of 3 in. may be required annually.

Table 1.  
VARIETY YIELDS AND SUGAR CONTENTS—1951 to 1956.

Variety.	Classes of Cane.				Average Age (months)	Arithmetic Average of all Determinations			
	No. of Plant Crops.	1st Ratoons.	2nd Ratoons.	3rd Ratoons.		Tons cane/acre.	C.C.S.	Tons Sugar/acre.	Tons cane/ton sugar.
Pindar	9	7	4	1	12.8	39.90	13.00	5.04	7.74
P.O.J. 2878	4	3	1	1	13.3	36.28	14.71	5.89	6.86
Q. 50	2	1	1	0	12.5	34.10	14.33	4.57	7.03
Q. 57	3	1	0	0	13.0	36.74	12.43	4.89	8.03
Q. 28	2	2	1	1	11.8	30.57	15.05	5.02	6.70
Trojan	2	2	2	0	12.3	30.69	13.59	4.12	7.45
Comus	3	3	3	1	11.9	29.65	12.07	3.42	8.46
S.J. 4	2	2	1	1	11.8	27.32	13.63	4.45	7.40
S.J. 16	2	1	1	0	12.5	32.37	13.69	4.14	7.40
Badilla	2	2	1	1	11.8	24.93	14.32	4.09	7.03
S.J. 2	3	2	2	1	11.9	26.80	14.27	3.57	7.15
E.K. 28	3	2	2	1	11.9	26.80	14.05	3.56	7.18
H.Q. 426	4	3	2	1	13.0	18.86	14.74	2.54	6.84
Means	....	....	....	....	12.4	30.84	13.84	4.25	7.33

liminary trials indicate that over a crop of plant cane plus two ratoons, annual dressings of 4 cwt. of rock phosphate gave the same response as 1 cwt. of superphosphate per year, but the differential residual effects of these fertilisers were not measured. Potash fertilisers have not given any response.

At least half of the dozen varieties originally introduced are of value in this new environment. Some varieties such as Pindar do well whether planted early or late, whilst others, e.g., Comus, succeed only when planted early. Some varieties, including Pindar and P.O.J. 2878, ratoon better than others; it is possible that these current varieties may be superseded by newer and still better ones (such as Q57) by the time commercial cultivation could begin in the Kimberleys, and therefore

The only serious insect damage so far experienced with sugar cane has been an attack by a grasshopper plague from beyond the Station boundaries. This was met by spraying the cane with a BHC-diesolene solution from a mist blowing machine. No diseases of any consequence have been noted in the cane, and in particular, the virus which causes ratoon stunting has been up till now successfully excluded from the Kimberley Research Station.

### (c) Conclusions and Comparisons.

The Committee is confident that sufficient experience and sufficient data have been gained with sugar cane to conclude that sugar cane is well adapted to the Ord River region, and to suggest that economic and social investigations are now of more



importance than continued agronomic investigation on the scale hitherto pursued. If a decision should be taken to produce cane commercially in this region, further agronomic investigations would then be justified and indeed essential to ensure the most economic level of production.

At this stage it is of interest to compare the experimental yields obtained at Kimberley with those obtained in other areas. The average yields for the period 1951-56, covering all trials, are given in Table 1. The yield levels now being obtained with the better varieties with the standard fertiliser dressing of 2 cwt. each of ammonium sulphate and superphosphate per annum are illustrated by those for a current experiment:—

Variety.	Plant Crop, 1956.				Ratoon Crop, 1957.	
	Tons cane/acre.	C.C.S.	Tons sugar/acre.	Tons cane/ton sugar.	Tons cane/acre.	
Pindar	46.7	12.6	5.91	7.9	43.0	Sugar
Q50	46.9	13.5	6.34	7.4	50.8	deter-
P.O.J.	48.1	13.8	6.65	7.2	45.2	mina-
2878						tions
Q57	45.8	12.3	5.62	8.1	45.3	not
Mean	46.9	13.05	6.13	7.65	46.1	avail-
						able

The Lower Burdekin region of Queensland grows varieties included in the range of those grown at Kimberley, and has included mainly Trojan, Badilla, SJ16 and Pindar. The average annual yields for the 5-year period to 1955 were:—

	Tons cane/acre.	Tons sugar/acre.	Tons cane/ton sugar.
Lower Burdekin	34.5	5.05	6.84
All Queensland	24.0	3.26	7.35

These comparisons serve as a guide to the relative level of production possible in the Kimberleys. A strict comparison between the data should not be made as the Burdekin data are commercial production figures for a large area and the Kimberley data are from experimental plots.

The ratio of plants to ratoons for the Burdekin was 1 : 0.74 in 1954 and 1 : 0.78 in 1955. "Annual" values can however be somewhat misleading in that "plant" cane crops may occupy the land for somewhat over a year. The Kimberley results quoted above refer to a crop planted in June, 1955

and harvested in August, 1956 (plant crop) and in July, 1957 (ratoon crop). The soundest basis for comparison is sugar per acre per month of growing season. During the 1953 season (a record one for the area) sugar was produced on the Burdekin at the rate of 785 lb. per acre per month. The Kimberley trial quoted above was producing sugar at the rate of 980 lb. per acre per month. A time of planting experiment which included a plant and ratoon crop in a 24-month period produced sugar at the rate of 935 lb. per acre per month. The highest figure so far recorded at Kimberley is 1,300 lb. per acre per month.

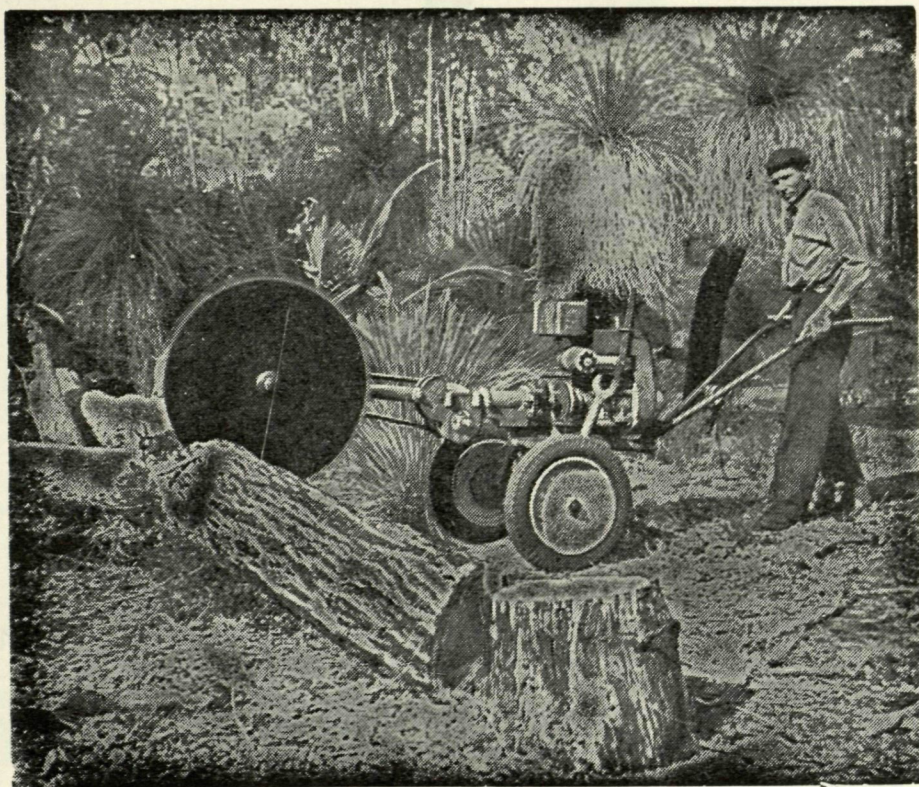
It can safely be concluded that sugar production on the Ord River is at least on the same general level as that in the Burdekin region. This region is Queensland's outstanding producer, and since its yields are exceeded on a commercial scale only by the better areas of Hawaii, it can be concluded that the Ord River region seems ideally suited to sugar production.

From the agricultural production point of view it is established that with irrigation the Ord River region could carry an extensive sugar cane industry and that such an industry could support a greater farming community than exists anywhere in northern Australia at the present time outside the high rainfall eastern coastal strip of Queensland. A relatively small development of the sugar industry involving one mill in the Kimberley Division would give to the region a gross income of the order of £2,000,000 per annum. For comparison this is much greater than the annual payment to cattle stations by the Wyndham Meatworks.

### III. RICE

The second crop with possibilities for the development of the region is rice. At the time of the previous report, all experimental work had been carried on with the only available commercial varieties from the Murrumbidgee Irrigation Area, mainly Caloro. It has been found that these varieties, and all similar Japonica types are unsuited to growth in the wet hot summer at the Kimberley Station. They do much better when grown in the cooler weather of May-October. Examination of a wide range of varieties imported from tropical countries has indicated some





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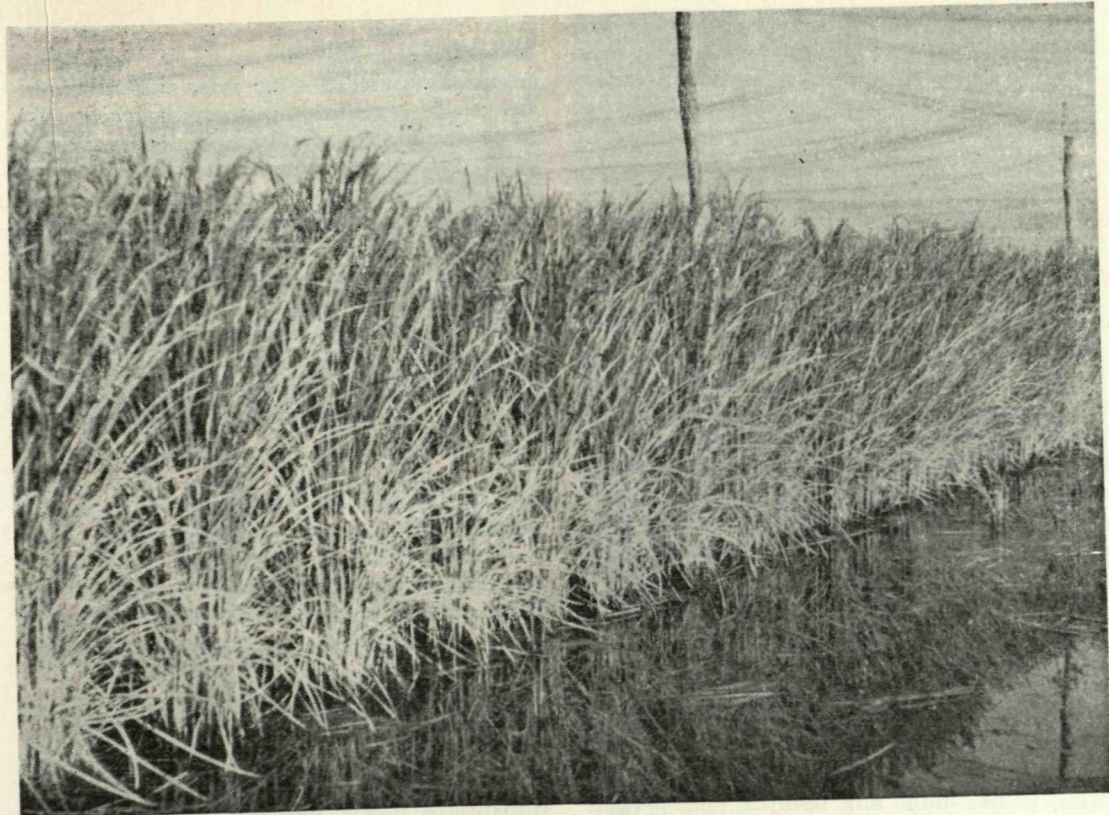


Fig. 4.—A crop of rice grown under netting to protect it from birds. This method was used in the early stages of the experiments in order to obtain accurate yield figures

much better suited to the hot wet season. Some 350 varieties have been introduced from tropical countries—South America, Africa, India, Asia and Polynesia, and out of these, a range of types has been selected, all of which appear capable of good yields. The more promising varieties so far investigated include Emata-Yin and Hnan-wa-phin-gauh from Burma, Mas from Ceylon, Mbuyu, Moshi, Kohogo and Meli from Central Africa, Radin Siak from Malaya, Taichu 65 from Taiwan and a group of rices originating in the east (Japan) but developed in America, and further selected in N.S.W., of which Caloro is the best example.

One of the complications with rice is that there is not just one rice type, but a very wide range of types with differing qualities. The Station must study a range of types to determine which are the best marketable types suited for northern Australian production. A wide range of types is studied at the Research Station,

for quality in rice may be defined quite simply as the desire of the purchaser. A soft rice which disintegrates on cooking may be top quality for some culinary purposes, but is unacceptable to most tropical peoples, who much prefer the harder flinty types which do not disintegrate on cooking.

Experimental yields approaching 4,000 lb. paddy per acre have been obtained with long-grain tropical varieties in the summer period, and with short-grain Japonica varieties in the winter. The tropical Indicas fail in winter, mainly through sterile heads, whilst the Japonicas give only poor yields of the order of 1,000 lb. per acre or less in the summer.

A bulk cropping trial in the 1955/56 summer period (November-April) gave the following yields:—

Variety.	Area.	Yield in lb. paddy per acre.
Meli .....	1.2 acres	4002
Radin Siak .....	3.5 acres	2285
Hnan-wa .....	1.7 acres	3323





Fig. 5.—Rice—Radin Siak variety—in one of the experimental plots

No comparable bulk data are available for dry season crops, but on experimental plots, yields of Caloro have reached 3950 lb.

The procedure for bulk cropping adopted as a result of experience in the Station is to sow rice seed into a prepared and pre-irrigated seed bed. Superphosphate may be drilled in with the seed, which is sown about an inch deep, while ammonium sulphate is placed as deeply below the seed as possible. At present the fertiliser is drilled in at 4 in. and the seed sown in a separate operation, but these could be combined with suitable equipment. The area is then irrigated and all surplus water drained away as quickly as possible. It has been found that the slightest ponding due to surface irregularities leads to a lowered stand and weakened seedlings, so that considerable attention is paid to the levelling of the area. An Australian-made Ashton Leveller is used for this. The bay is kept moist by irrigation, but no water is retained on the land until the rice is

5 to 6 in. high. It is then flooded and the water level raised slowly as the rice grows, until a depth of 4 to 6 in. can be maintained by regular supplementation. This is drained off after flowering to enable the land to carry a header harvester some thirty days later. Experiments have been carried out to determine the optimum depth and duration of flooding, but the results are not yet sufficiently definite to recommend any departure from the procedures outlined above.

Estimates of the amount of water required by a rice crop vary considerably, depending on the season, on the variety which may require from 100 days to 200 days to mature, upon the cultural practices followed, and, with small bays, the amount of seepage. In general it may be reckoned that some five to six feet of irrigation water in addition to rainfall will be required for typical summer crops, and about three feet for short-term winter crops.

The main soil deficiencies are nitrogen and phosphorus, and growth in the absence of added fertiliser is very poor. Neither ammonium sulphate nor superphosphate alone has given a worthwhile response, but applied together marked responses have been obtained. From the experience available, the most satisfactory procedure would appear to be the application of 2 cwt. superphosphate plus 1 cwt. ammonium sulphate at planting with a further 1 cwt. of ammonium sulphate applied as a side-dressing when the crop is about six weeks old. It is obvious however, that there is still much to learn about the manuring of rice in this region.

Harvesting is carried out as soon as the grain can be stripped from the head. If left standing in the field, variations in the rate of drying give rise to fine cracks in the grains, leading to much breakage on milling. The relation between delay in harvesting and breakage on milling is shown in Table 2 (quoted from Langfield,\* 1957). Harvesting at this early stage makes it essential to dry the grain under control before storage.

Birds have proved very troublesome at several stages of the crop. The small acreage of cultivated land in the region

\* J. Aust. Inst. Agric. Sci. 23 : 340-341.



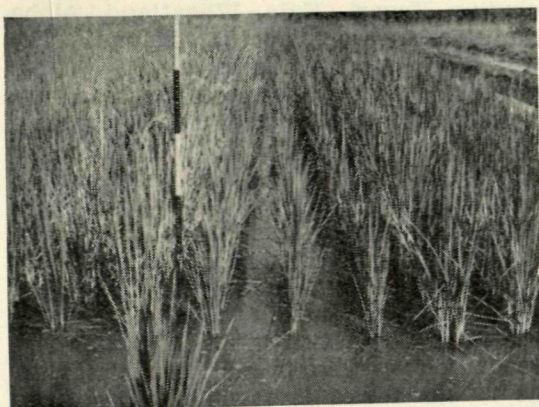


Fig. 6.—Portion of one of the rice trial plots

has no doubt exaggerated the problem, but there appears to be a natural hazard, which cannot be avoided, from finches at harvest time. Widely spaced crops, with clear water areas between the plant are particularly attractive to ducks. Larger drill-sown acreages, where the only open water expanses are in the edges of the field, are much less troubled by them. The finch trouble can be minimised by taking off the grain as soon as possible, for most of the damage caused by finches is from shattering of heads.

Table 2.

RICE.

*Head yield from hand shelled samples.*

Days from Flowering.	Moisture Percentage at Harvest.		Whole grain Percentage on Shelling.	
	Shive Pu.	Hnan-wa-phin-gauh.	Shive Pu.	Hnan-wa-phin-gauh.
28	20.8	26.2	99.0	99.4
29	19.9	25.5	97.2	96.1
30	18.2	25.6	83.1	93.3
31	17.2	22.3	83.9	91.2
32	17.8	23.1	84.2	92.8
33	16.6	21.8	83.7	89.8
35	16.2	16.7	82.0	89.0
37	16.0	15.5	81.1	77.6
39	11.8	13.0	78.2	61.9
42	11.6	11.5	52.0	41.0
45	11.1	11.3	41.0	40.0
58	11.1	....	40.3	....

Cutting of variety Shive Pu commenced on 7th May, 1956, and Hnan-wa-phin-gauh on 14th May, 1956.

Wet season crops have been subject to severe damage from a group of insects known as stem borers. The moth lays its eggs on the leaves of the plant, and on hatching, the larvae make their way to the stem, usually near the base, and bore their way into it. They then proceed to eat out the insides of the stem, causing it to die. This group of insects is widely distributed throughout the tropics, but, until the last year or so, no adequate control measure had been devised. The insects themselves are still confused taxonomically; it is known that there are at least two species, and maybe as many as four, present on the Ord. They are essentially summer pests, and are much less abundant in the cooler months. It has been found at Kimberley that the larvae can hibernate deep in the roots of rice stubble, through the cooler weather, and so carry over from one summer to the next. The moths are nocturnal and a record of their frequency has been obtained with light traps operating through the dark hours. It is known from these light trap catches that the presence of a very few moths can build up to a very heavy crop infestation, since each moth appears to be capable of laying several clusters of eggs, each cluster containing a large number of eggs. Inspection of the crops for egg masses has given information which fits in with the proportion of gravid to spent females caught in the light traps. For three summer periods an entomologist from the W.A. Department of Agriculture has been present on the Station studying the problem. The standard insecticides such as DDT and BHC kill a large percentage of the moths but leave a residual population sufficient to cause serious damage. Recent reports from overseas emphasise the effectiveness of one of the newest insecticides, endrin, and this insecticide is to be tested at the Station.

Rice can be grown in the region and there is every reason to believe that yields would compare favourably with those obtained in other tropical countries, although they might not be as high as the average yields in temperate regions of the Murrumbidgee Irrigation Area. Although the gross return from rice would certainly



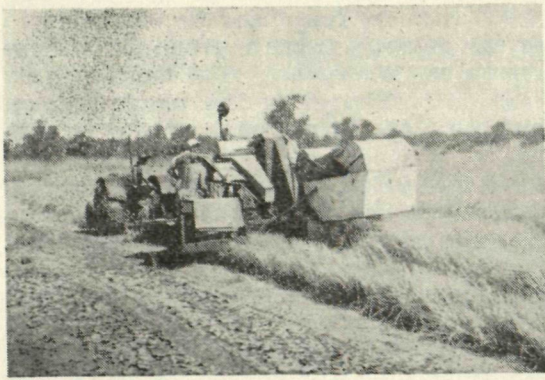


Fig. 7.—Harvesting a rice crop

be very much less per acre than from sugar cane, processing plants would not be so costly, and it must therefore be regarded as one of the crops for development in the area.

#### IV. NATURAL HAZARDS IN RELATION TO GRAIN CROPS

When discussing rice, the hazards from finches at harvest time and from borers were stressed. Some of the grain crops have been found to be much more susceptible to birds and to insects than rice, and the prevalence and difficulty in control has markedly modified certain grain production programmes, notably with sorghum, maize and millet. These crops are not at present grown for grain because of the great difficulties met with in protecting small areas from birds (cockatoos in the case of sorghum and maize, and finches with millet). In addition, they are all very susceptible to locusts. With much larger areas of land under cultivation than at present, these hazards could diminish greatly, but should agricultural development be initiated, a continued examination of these biological problems would be a necessary scientific activity.

#### V. OTHER GRAINS

##### (a) Sorghum.

Early experiments demonstrated that this crop could be grown successfully, the best crops being those planted towards the end of the wet season, coming into head in late June or July. The highest yield has been recorded with the variety Caprock, but a number of other varieties, in-

cluding Hegari, Kalo, Wheatland, Alpha and Martin were not far behind. The maximum recorded yield is 4,600 lb. per acre. Marked responses to phosphate have been recorded, 1 cwt. of superphosphate raising yield from 620 lb. to 1,940 lb. per acre in one trial. Trials on row spacings have shown that rows 1 ft. apart have given higher yields than those 2 ft. or 4 ft. apart. It is suspected that this difference may also be connected with differential watering, for although it was planned to use furrow irrigation in all cases, the narrow 1 ft. rows were in fact, flood irrigated, as it was found impossible to keep the narrow channel open. Attempts to grow sorghum in the dry season, with plantings from May onwards, have failed, the plants exhibiting a period of near-dormancy in the June-August period. Investigational work with sorghum as a grain crop has not been persisted with, owing to the great difficulty in protecting plots against birds, but it is being grown as a forage crop.

##### (b) Millets.

Several introduced millets have been grown successfully in the wet season, but not in the dry. As with sorghum, finch and locust damage have upset most trials, and they are now grown only as fodder crops.

##### (c) Maize.

This has been grown at all times of the year, but has never yielded as well as hoped. The best yields have not exceeded 1,000 lb. per acre, and the heads are normally very imperfectly filled. Like sorghum it is very susceptible to bird damage.

##### (d) Wheat, Oats and Barley.

These have all been grown as dry season crops. Yields have been very variable, and it appears that the general level of yield is determined by the weather conditions around flowering time. High temperatures appear to be associated with poor yields, and vice versa. The 1953 crop of Kondut wheat planted in early June with 1 cwt. super per acre yielded over 2,000 lb. per acre, but the following year's trial, planted about a fortnight later, gave only half the yield. A fertiliser trial showed a good response to superphosphate up to the 2 cwt. per acre level, with no further



response to higher applications, or to nitrogen added with the superphosphate. Gabo wheat, planted late in July, 1953, gave a very poor yield.

Ballidu oats planted in early June gave a very poor return. Beecher and Atlas barley planted at the same time as the oats also gave poor returns, the former (an early variety) giving some grain whilst the latter, a later variety, yielded hardly any.

Investigation with cereals has been retarded in the last two years, first because of water shortages resulting from reorganisation of the pumping plant and more recently from staff shortages, but will be resumed when conditions permit.

Wheat has required some 20 in. of irrigation water, and as the grain has been described as a very suitable wheat for the supply of flour for the breadmaking trade, there would seem to be a distinct possibility of wheat being a subsidiary economical "catch crop" for the region.

Wheat, oats and barley, in contrast with other grains, have so far been relatively immune from bird damage. There have been mild attacks from stem borers (a different species from those attacking rice) and there have also been mild outbreaks of aphids. On the whole, however, the crops have been relatively free from pests and diseases.

## VI. COTTON

The previous report emphasised the need for suitable varieties of cotton for the special conditions of Kimberley Research Station. A wide range of cotton varieties representing the world's major cotton growing areas has been tested, but no varieties have emerged showing any greater promise than the Queensland-selected American types which were first tried.

The first difficulties associated with cotton growing appear to be entomological ones. The Kimberley region has a wide range of native Malvaceous plants including *Hibiscus* and *Sida* species and these act as host for a wide range of pests, both of the vegative plant and of the developing bolls. These include the rough boll worm, the pink boll worm, the cotton seed bug and cutworms. The leaf-eating pests

can be controlled by frequent application of DDT-BHC mixture, but these insecticides have not controlled the boll pests. Preliminary tests with a newly developed insecticide, endrin, have given very encouraging results, and if this protection can be repeated over a number of seasons, the prospect for cotton investigations will be much more promising. A recently concluded trial with Miller, Acala and Oklohoma Triumph varieties gave an average yield of 2,200 lb. seed cotton per acre when protected by endrin. Cotton free from insect damage has been produced on the Station from plants sown towards the end of the wet season. Such plants make fair growth until the cooler months of the early dry season when there is a check, and growth is not resumed until the advent of warmer weather in late August or September. Flowering may commence about the end of September and the resulting bolls are generally free from insect damage. But with cotton which does not open until November, there is a great risk of damage by early rains, as well as great difficulties in harvesting. A further disability is the very poor quality of the lint produced at this time of the year.

The ideal timing of the crop would appear to have flowering commencing towards the end of the wet season when the risk of insecticide applications being washed off is diminished, and to have bolls opening in the early dry season, say May-July, when good weather conditions could be anticipated.

There is a fair prospect of cotton being the crop which will make development of the region possible. Yield of 1,000 lb. seed cotton per acre would bring in a return greater than any crop other than sugar cane, and such a yield level must be regarded as a very modest one for an irrigated area. The main difficulty so far experienced has been in pest control; but current work gives hope that endrin may give this essential control, and once this is established this would be a sound basis for renewed investigations.

## VII. OTHER FIBRES

When the Station first commenced investigations there was a marked interest in jute and similar fibres, owing to the



high price of imported jute. As a consequence, considerable attention was paid to jute, and to substitute fibres such as kenaf and roselle. Over a three year period (1951-1954) jute gave an average yield of 10½ tons per acre with 5 per cent. fibre content. Comparable figures for the Bengal Province of India are 13 tons and 6 per cent. fibre. The quality of the fibre, as tested by C.S.I.R.O. Flax Research Station, was comparable only to second grade imported jute and fibre strength was "only just satisfactory" and was considerably lower than that of average Indian jute. One major disability with jute is that no satisfactory mechanical means of preparing fibre direct from the plant have yet been developed. In India the stems are "retted" with the aid of native labour.

A fibre which can be prepared mechanically—kenaf—has also been tested. Yields varied considerably from year to year and from variety to variety, but on average, were about twice those obtained with jute. The fibre produced was inferior to jute.

If the position should ever arise when it becomes urgent for Australia to produce its own fibres, both jute and kenaf could be produced in the Ord River region.

## VIII. OILSEEDS

### (a) Peanuts.

Peanuts have been a successful crop on the Station, as stated in the first report. They present particular problems both in harvesting and separating nuts from similar sized soil lumps. Investigations on peanuts have not been sustained because of these harvesting and sorting difficulties, which however, should not be mechanically insuperable. At present it does not seem that peanuts would be the cash crop to develop the area.

### (b) Linseed.

Linseed was grown for three years as a dry season irrigated crop. Very erratic yields were obtained, ranging from virtual failures to half a ton per acre. Most of the difficulty of growing the crop occurs in the establishment phase, for the soil is ill-adapted to the preparation of the fine seed bed required for linseed. Bigger-seeded varieties have now been obtained and further trials are to be commenced.

### (c) Safflower.

Safflower is a plant of the thistle family, and has been grown in the East from ancient time, where it has been raised both for oilseed production and for a yellow dye obtained from the flower. It produces an oil which in Australia sells competitively with linseed. Like linseed, yields have been erratic, ranging from



Fig. 8.—Safflower seedlings planted out

500 lb. to 3,000 lb. seed per acre, with an average oil content around 30 per cent. As a result of several seasons experience, it would appear that early plantings, which flower before temperatures begin to rise in late August or early September can give high yields, whilst late flowering leads to lower yields. It is hoped that yield levels may shortly be stabilised towards the high end of the observed range.

### (d) Sunflowers.

These have been sown in both the wet and the dry season and also as an intermediate wet-dry season crop. In most cases, good plant stands have been obtained but there has been heavy mortality during growth. Imperfectly filled seed heads have also been common, with the net result that although some attractive looking crops have been obtained, yield levels, with a maximum around half a ton per acre, have been disappointing. Work



on sunflowers has been abandoned in favour of safflower, which appears to have much better prospects.

## IX. PASTURES, FODDERS AND CATTLE

Grasses and legumes grew well at the first investigational centre on the Ord River—the Carlton Reach Station, which was sited on "red" soil (Ord sandy loam), but when investigations were transferred to the main soil type of the region, the black soil plains (Cunnunurra clay) very different results were obtained. This was especially marked in the case of legumes, and it is emphasised by the behaviour of legumes on the very limited areas of Ord sandy loam (red soil) along the river levee of the present Station when compared with the same legumes on the adjacent black clay. A wide range including various species of *Phaseolus*, *Stylosanthes*, *Centrosema*, *Calapagonium*, *Cajanus* and *Clitoria* grow well on the red soil, but of this wide range, only one, *Clitoria ternata* has persisted on the clay. All the legumes so far tried on the Station, with the single exception of *Clitoria*, appear susceptible in varying degrees to an insect transmitted virus disease of the "witch's broom" type. This virus appears to be much more damaging than its southern counterpart which attacks lucerne (*Medicago sativa*), for while witch's broom may take several years to severely damage a stand of lucerne in southern Australia, it can do so in a few months under Kimberley conditions. This virus or group of viruses is widespread amongst the native plants of the region, and does not confine its attacks to legumes. It has been discovered on grasses, cucumber and tomatoes.

*Clitoria* grows well under irrigation, and in pure stand may yield a total of about 3 tons of hay per acre per annum, taken off in three cuts during the dry season. It is very palatable and is relished by stock. It grows well with most grasses, especially the smaller clump grasses, such as fine-leaved Guinea. It is not well adapted to growing with the close sward forming grasses like certain Paspalums, nor can it compete with the giant Guinea grasses or *Pennisetums*, which may reach 10 ft. in height.

When grown in association with grasses, careful management is required to see that the pasture is not overgrazed, in which case the *Clitoria* is preferentially grazed and not given opportunity to reseed itself, nor yet undergrazed, when the *Clitoria* may smother out the grasses. The danger in the latter case is that heavy grazing of the pure *Clitoria* stand at a later stage may lead to a rapid increase of a number of unwanted low-value quickly establishing native grasses.

Grasses grown in close association with *Clitoria* in mixed pastures appear to obtain little, if any, benefit from the association, certainly nothing like the benefit associated with the clovers of temperate region. The general picture is that grasses do reasonably well when first established, but that they soon lose vigour. This loss of vigour is associated with nitrogen starvation, for the grass responds rapidly and markedly to the application of ammonium sulphate. This response is only transient, and when the grasses are again cut, there is no increased vigour in the regrowth. Investigations are still proceeding with this acute nitrogen starvation of pasture which occurs even in the presence of well-nodulated legumes, but attention has been shifted mainly to the production and conservation of cultivated forage crops.

The major growing season of the year is undoubtedly the wet summer period, and even with irrigation, many crops, including fodders which grow well in the summer period, show little or no growth in the cooler weather of the dry season. The summer period is the time when the native pastures are at their best, and when the need for supplementary fodder is at its lowest, consequently material grown at that time has to be conserved in some way, and the most obvious way of conserving wet season production would appear to be as silage.

In these trials, it has been clearly recognised that the nitrogen content of these black clay soils is low (0.03 per cent.), and that heavy continued cropping cannot be expected unless nitrogen is added liberally to the soil. The total nitrogen content of the 6in. surface layer of soil is of the order of 600 lb. per acre; a



five-ton fodder crop containing 12 per cent. protein would contain 220 lb. of nitrogen. It will be obvious that the soils could not produce such a crop for any length of time without liberal addition of nitrogen fertiliser. A trial now in progress using Elephant grass, receives 1 cwt. ammonium sulphate (or 23 lb. nitrogen) at each cutting. Cuttings are made when the grass has grown to a height of about 4 ft. and before any extensive development of woody stems has begun. In practice, about five such cuts can be made each year. With yields ranging between half and one ton of dry matter at each cutting, total yields of over three tons of dry matter per acre per annum have been recorded. The objective behind these trials is the production of palatable, high-protein fodder, which can be used to supplement bulk feeds of lower quality, and it has yet to be determined what minimum levels would represent economic production.

Studies have been made in the changes in weight of cattle maintained on native pastures. Yearling steers loaned by Ivanhoe Station were kept on native pastures throughout the dry season (May to December) at a stocking rate of 8 beasts to 100 acres. Each 100-acre paddock was provided with a watering point. In the wet season, the stock were released into a large holding area containing both red and black soil. Weight change followed the usual pattern in that there was rapid gain for about four months from the commencement of the wet season, and a weight gain of 200 lb. was registered in 100 days. This was followed by a period of slow gain up to the end of August and then a slight decline towards the end of the dry season. These Kimberley results differ from other northern Australian records in that the dry season loss was small (35 lb.), whereas much greater losses have been recorded elsewhere. When *Clitoria* hay of good quality (18 per cent. protein) was fed as a supplement there was a continued increase in weight in the dry season.

These supplementary feeding trials, with mineral amendments as well as with supplementary fodder, are still in the exploratory stages. Preliminary evidence

indicates that good quality supplements can be produced either from heavily fertilised fodders or from the legume *Clitoria*, and that supplementary feeding of stock on native pastures towards the end of the dry season has distinctly beneficial results so far as live weights at the end of the dry season are concerned.

## **X. GENERAL MATTERS**

### **(a) Rain-Grown Crops.**

A number of crops have been tried under non-irrigated conditions in the wet season; in most cases over a period of at least two or three years, but such poor results were obtained in comparison with irrigated crops that further attempts were abandoned. Peanuts gave the best promise, but difficulties were met with in getting a good stand.

### **(b) Irrigation.**

The use of plastic syphons to lead water from the main irrigation channel into the furrow has made irrigation much easier, and has permitted land to be used right up to the main channel. Syphons permit much better control of water application than the old system whereby a pipe let into the side of the channel fed water into a distributory system.

### **(c) Mechanical Properties of this Soil.**

The "black clay" of the plains named Cununurra clay has in fact only 45.50 per cent. clay in the surface layer. Silt and fine sand make up most of the remainder. When dry the black soil cracks into massive blocks and in this condition requires considerable power to work. A Nuffield tractor (37 h.p.) is fully loaded in pulling a single rabbit-ripper tyne to a depth of 14 in. Working the land in the dry condition produces clods which weather down to give good structure. Wet working on the other hand leads to glazed surfaces which set hard and do not break down. When moist, the surface of the soil is very slippery and the passage of any wheeled vehicle is almost impossible. The Station now uses a track tractor (D4) for all heavy work and for work under wet conditions.

In spite of the high non-clay content of the soil, no difficulty has been experienced in constructing water-conducting channels which carry water, often at a level



of a foot or more above the surrounding country, with very little loss by seepage. The presence of a puddled layer on the surface of the channel appears to be the factor mainly responsible for this impermeability. In a similar manner no difficulty has been experienced in constructing water-retaining walls to rice bays. This impermeability of puddled soil contrasts with the ease with which irrigation water enters cultivated land. The usual application of 3 in. per acre can be applied to furrows a yard apart in a period of three to four hours.

#### (d) Minor Crops and Introductions.

In addition to work on major crops which could hasten development, the Station has built up a body of information on minor crops which could be of great use if development began. It is known, for instance, that a wide range of vegetables can be grown very successfully on the levee soils in the dry season, but that wet season production is difficult, being restricted to a few beans of Indian origin. Of all the species of citrus fruits so far tried—oranges, lemons, grapefruit and limes, only the last has shown much success. Bamboos have been introduced to help stabilise the river banks, but growth has not been encouraging. Mangoes and coconuts have suffered severely from white ants. Bananas are restricted by nematodes, but can be grown in family gardens with care. A number of ornamental trees have been established, including the Saman (rain tree) poincianas, various species of cassia, lemon-scented gum, and forms of bougainvillea.

One section of the Station's activities is apt to pass unnoticed except on those occasions when success is attained. This is the matter of introductions. Each year, a very wide range of introductions from other parts of Australia and from the world at large, is tried on the Station. Apart from rice, emphasis in recent years has been on legumes and grasses. The legumes include forage and pasture species, shrub species for browse, and crop species for cultivation, both as green manures and as cash crops.

It sometimes happens that species showing promise have to be eliminated on other grounds. Thus Spineless Mimosa

Moisa showed promise on the black soils but was eliminated because of the possibility of reversion to the dreaded spiny types.

A usual occurrence is for an introduction to show marked variation from plant to plant when first sown. A few of these may show decided promise, but invariably the progeny of these promising plants has not shown much success in the following seasons. Soya bean has shown this tendency to a marked degree.

### XI. AN ASSESSMENT OF AGRICULTURAL POTENTIAL OF ORD RIVER PLAINS

The results of experimental work conducted at Kimberley are largely applicable to similar land types found throughout the northern part of Australia, outside the narrow confines of the Ord River region. The Kimberley Research Station Policy Committee has fully recognised this fact, giving the wider aspects of the Station's work increasing attention in planning the research programmes. Nevertheless, the immediate objective of this work is to determine the suitability of the clay soils of the region for irrigation agriculture, and to develop a farming system which could provide the basis for the settlement of the area. Considerable progress has been made in fulfilling these objectives.

Although the climate of the region (Table 3) is not ideal for Europeans and may affect their working efficiency, it is certainly not unbearable, and not worse than in other parts of the world supporting successful and contented European communities. The winter climate of the area is pleasant and nights are cool throughout most of the year. The freedom from frost and seasonally high mean temperatures make the region suitable for a range of tropical and sub-tropical crops. Winds of damaging force, hail-storms and rain-storms of very high intensity are very rare. On the other hand, unreliability of rainfall and the limited length of rainy seasons make irrigation a prerequisite for successful crop production. Perennial crops cannot be produced without irrigation, and the risk of drought makes precarious even the cultivation of annual crops grown in the wet season. Fortunately the Ord River provides an ample



Table 3  
CLIMATIC AVERAGES—KIMBERLEY RESEARCH STATION

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Rainfall— Points .....	734	709	506	65	22	18	7	3	8	78	268	498	Total 2916
No. of Wet Days .....	12	9	7	1	1	0	0	0	0	2	5	9	Total 48
Evaporation in inches	8.265	7.129	8.155	7.894	7.903	7.192	7.465	8.286	9.995	11.302	9.541	8.995	Total 102.122
Temperature in °F.— Maximum .....	97.6	95.6	97.5	94.8	91.5	86.7	87.1	91.0	96.4	102.2	101.7	99.5	Av. 95.05
Minimum .....	74.8	74.9	73.2	74.7	62.8	60.3	57.8	59.9	66.2	72.3	76.0	76.0	Av. 69.09
Relative Humidity at 9 a.m.—per cent.	63	65	55	42	32	33	31	30	32	39	47	53	Av. 44

and reliable source of irrigation water. The topography of the area is well suited to gravity irrigation. From the engineering design point of view the gentle slopes of the plains should make distribution and application of water a relatively simple matter. With the exception of levee land along the river, the erosion problem is not serious. The major part of the plains is usually free from natural flooding.

The cultivation of the heavy clay soils of the area requires skill, powerful tractors and sturdy implements. When wet these soils are extremely plastic and sticky. They dry out slowly, but when dry they become very hard. Although they do not present any insoluble mechanical problems, the possibilities of improving ways and means of their cultivation are considerable and further work in this field is well worth while.

The soil itself, as distinct from the land surface, does not drain freely, and water-logging after rain imposes some limits on the range of crops which can be successfully grown on these soils. Because of the impermeability of the soil sub-surface, drainage measures would be both very difficult and expensive.

The physical characteristics of the clays make the plains impassable for vehicular traffic when they are thoroughly wet. Even track vehicles become immobilised in thick, sticky mud. The provision of suitable access roads would be essential for the development of this region. The swelling capacity of these soils would increase the cost of construction and maintenance of sealed roads.

The results of Kimberley manurial trials show conclusively that the black soils of this region, like many other tropical soils, are deficient in phosphorus and nitrogen. Moreover up till now, none of the legumes tried at Kimberley has shown the nitrogen-fixing qualities comparable with the clovers of temperate zones. The legumes tried appeared to be self-sufficient in nitrogen but did not benefit succeeding crops or the associated pasture grasses to any marked degree. Consequently the development of any form of agriculture suitable for the area must largely depend on the comparative returns from fertiliser application to various crops.

The experimental work at Kimberley has already indicated a range of promising crops for local conditions, and several crops have been successfully grown on farm-scale areas. These could provide the basis for a variety of farming systems. However, before such systems are tested on a pilot farm-scale a thorough study of economic and organisational aspects of agricultural production in the region is desirable.

Sugar cane appears to be at present the most promising crop, giving uniform stands and uniformly high yields. The economic and organisational difficulties of its introduction on a commercial scale in present conditions have been already mentioned. Rice has given very promising yields, although some nutritional problems are still largely unsolved. Its future in this area will largely depend on economic factors. Of other cereals only sorghum at present is agronomically promising, and the economics of its production as a main crop are doubtful. If the effectiveness of



recently tried insecticides is proven and high cotton yields can be maintained, this crop may become the backbone of local agriculture together with oil crops, especially safflower. In the absence of a biological source of cheap nitrogen, the special production of pastures and fodders for stock is more dependent on the use of artificial fertilisers and does not appear to be so promising as in the temperate, clover-growing regions. However, some of the crops showing promise at Kimberley, such as cotton and oil seeds, would provide also a useful source of protein concentrates.

Both sugar cane and rice are often grown in monoculture, and it appears at present that the system would have to be seriously considered for Kimberley conditions if these crops form the basis of development. On the other hand cotton and safflower might well be grown in a rotation, the former being planted towards the end of the year and harvested in June-July, the latter occupying the land from April-May to October. The short fallow

during the wet summer months would replenish soil moisture supplies and reduce irrigation water requirements.

Except in the case of cotton where insecticidal control is still new, it is possible to give some estimate of what yields could be expected from the various crops mentioned above. It now remains for other specialist groups interested in development to ascertain whether such yields offer sufficient promise to form the basis for the planned development of the region.

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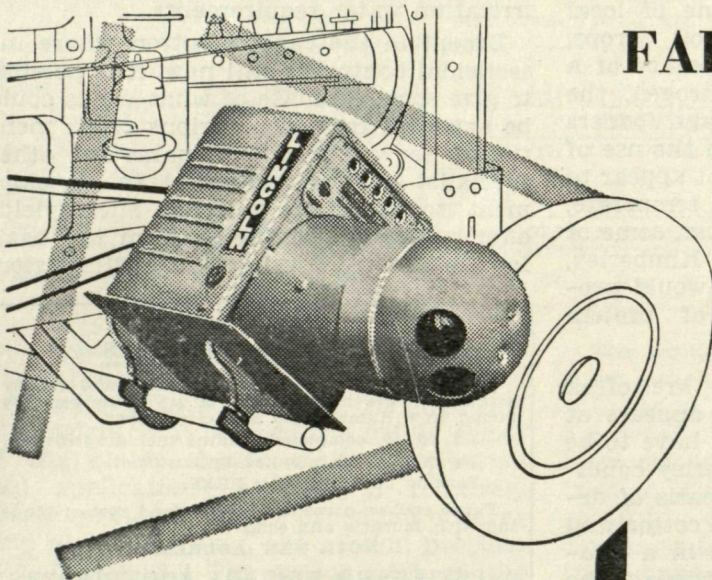
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