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Cropping for Fodder Conservation and Pasture Production in the Wool-growing Areas of Western Queensland

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foreword . . .

The Wool Industry of Queensland contributes very largely to the prosperity of the State. In the period 1911-1945, wool was responsible annually for 15 to 25 per cent. of the total value of production and from 50 to 60 per cent of pastoral production in Queensland. Of overseas exports, wool accounted for about 50 per cent.

In view of the importance of this industry, it is regrettable that so little has been ploughed back in the form of research to assist the production side of the industry.

Mr. J. G. Crawford, Director of the Bureau of Agricultural Economics, on February 2nd, 1947, requested that Australian Universities investigate the economic problems of the wool industry. This request was enthusiastically received by the Vice-Chancellor of the University of Queensland, Mr. J. D. Story, and plans were developed for work in Queensland by a Committee of University Staff, in consultation with Mr. P. A. Reid of the Bureau of Agricultural Economics, to commence a Wool Research Programme.

Later, an Advisory Committee was established in Queensland with representatives from the University, Department of Agriculture and Stock and the Lands Department.

The research programme in the economic field was commenced in 1948 by Mr. E. H. George, who assessed unfavourable seasonal conditions as the major factor causing sheep losses. It was evident that a detailed study of a selected district was necessary to give precision to the economic investigations, and Mr. A. R. Bird, a recent graduate in Agriculture, was appointed in January, 1949, to undertake a statistical study of the sheep industry within a hundred mile radius of Charleville. From the 200 grazing properties in the district, a random sample of 50 was selected and information obtained from the owners by personal interview on the properties. The enquiry covered three years in the field and gave further evidence of the drastic effects of drought on sheep numbers. The 1945-46 drought directly or indirectly caused the loss of one-third of the sheep population in the Charleville district as recorded on January 1st, 1945. A full discussion of this survey has been published by Mr. Bird as a University of Queensland Faculty of Agriculture paper.

It is evident that some form of economical fodder conservation is necessary to mitigate the effects of drought. Purchased fodders are expensive and many graziers feel that the cost is prohibitive. The need to investigate the possibility of fodder production by modern dry farming methods was apparent from the economic surveys already conducted, and the University decided to continue the Wool Research Programme in the field of Agronomy. It was known that a good crop of wheat could be grown on the Darling Downs with less than 3 inches growing-period rainfall, provided the land had been well fallowed. Ten inches of water, whether from rain or soil or both, would grow a good crop of wheat, taking about five months to mature. If 5 or 6 inches of water were stored in the root zone, it should be possible to grow a quick-maturing fodder crop in a fair proportion of the years where the average annual rainfall is 15-20 inches.

To carry out this investigation, an experienced agronomist was required. Mr. P. J. Skerman was appointed Senior Lecturer in Agriculture in 1953 and took charge of the work as well as other University duties. He found that already two graziers had grown fodder crops in 1953. Mr. J. Kelman, of "Dundee," Richmond, grew a crop of forage sorghum, and Mr. A. C. McClymont of "Inverness," Muttaburra, produced a crop of Sudan grass for ensilage using dry-farming methods.

In order to cover the Western wool-growing districts, four sites were selected for study of the growing of fodder crops, principally forage sorghum for ensilage, and a variety of legumes and pasture species. Associated with three seasons of abnormally high rainfall, results have been outstandingly good. During this period, some thirty graziers have grown sorghum for ensilage and it is estimated that about 80,000 tons of forage have been ensiled as a result of opportunist farming in these good years. Yields of 8 to 10 tons of green matter per acre have been common. Modern machinery has made ensilage a practical proposition with a minimum of labour. The three years of good results are very encouraging and an incentive to carry on the investigations to determine accurately the soil, climatic and crop factors which will determine the success of the project over a period of years, good, bad and indifferent.

Many graziers and a number of banks and machinery firms have co-operated to finance this work, which is very costly on account of long distances necessitating air travel. To these, grateful acknowledgment is made, and an invitation offered to all interested in the future of the industry to support the University to ensure a continuation of the investigations.

I commend this progress report on the production of fodder crops in Western Queensland to readers, both in the technical and grazing fields.

L. J. H. TEAKLE

PROFESSOR OF AGRICULTURE

Cropping for Fodder Conservation and Pasture Production in the Wool-growing Areas of Western Queensland

by P. J. SKERMAN

I. INTRODUCTION

Queensland's wool-growing area (Fig. 1) is contained largely within the 10-inch and 20-inch isohyets with an extension eastwards into the 20 to 25-inch belt in the Central Highlands, the Western Downs and the Maranoa. The belt stretches from the N.S.W. border in a N.W. direction through the centre of the State to just north of the Great Northern Railway beyond Julia Creek and Hughenden. A final swing S.W. from Cloncurry encompasses what are known as the Boulia sheep lands.

We may conveniently divide this area into two main regions—

I. the Southern region;

II. the Central and Northern region.

I. The Southern region comprises four main soil and vegetation groups—

(a) the "trap-rock" country between Warwick and Inglewood where skeletal soils occur on indurated shales and hornfels;

(b) seasonably flooded plains of the Dumaresq, Barwon, Weir, Balonne, Culgoa and Warrego rivers;

(c) brigalow *(Acacia harpophylla)*, belah *(Casuarina lepidophloia)*, and box *(Eucalyptus populnea)* and sandalwood or budda *(Eremophila mitchelli)* plains just north of the Goondiwindi to Talwood area; and

(d) a vast mulga *(Acacia aneura)* belt at a slightly higher elevation extending westwards and north-westerly from St. George to Augathella, Adavale and Windorah.

This Southern region of the sheep belt is regarded as being reasonably "safe" country because, in addition to the normal summer rains, appreciable winter rain is likely to fall. Further, the presence of edible shrub, particularly the mulga, cushions the effect of a severe drought. A further factor in favour of the mulga belt for drought endurance is that the graziers in this area run mainly dry sheep which can quickly be removed in unfavourable seasons. Despite the relative reliability of rainfall, however, the area can be struck by severe drought. Indeed, few parts of Queensland escape such visitations. Bird (1953) has indicated the importance of drought in the Charleville district as it affects the sheep population.

II. The Central and Northern region of the sheep belt stretching from Augathella to the Flinders River flood plain in the Gulf comprises—

(a) the so-called "desert" country east of Barcaldine, Aramac and Hughenden, and a somewhat similar but rougher strip of hilly lateritic country some miles west of Longreach and Winton;

(b) the Mitchell and Flinders grass downs.

(a) *The "Desert" Country:*

The "desert" country is characterised by lateritic toprock and relict sandy lateritic soils with occasional lenses of heavier soils of the red-brown earth group and grey and brown soils of heavy texture. The vegetation is mixed, but bloodwood *(Eucalyptus terminalis)*, bauhinia *(Bauhinia carronii)*, dead finish *(Albizia basaltica)*, ghost gum *(E. papuana)*, silver leaf ironbark *(E. melanophloia)* and box *(E. populnea)* are common with gidyea *(Acacia cambagei)* and sandalwood *(Eremophila mitchelli)* on the heavier soils. There is little herbage and the grasses are of poor quality such as *Aristida jerichoensis* and other wire grasses, spinifex *(Triodia pungens)* and, in the better areas, desert blue grass *(Bothriochloa ewartiana)*. This country has a poor breeding record for sheep and is generally used as relief grazing for sheep from downs properties during drought. The soil lacks nutrients, chief of which are phosphorus and nitrogen, and attempts have been made by Edye (1955) and Humphreys (1955) to introduce buffel grass *(Cenchrus ciliaris)* into the sward. This project is being continued as a University research study. This "desert" country varies considerably and the poorer types of soil will not permit buffel grass establishment unless heavy dressings of superphosphate

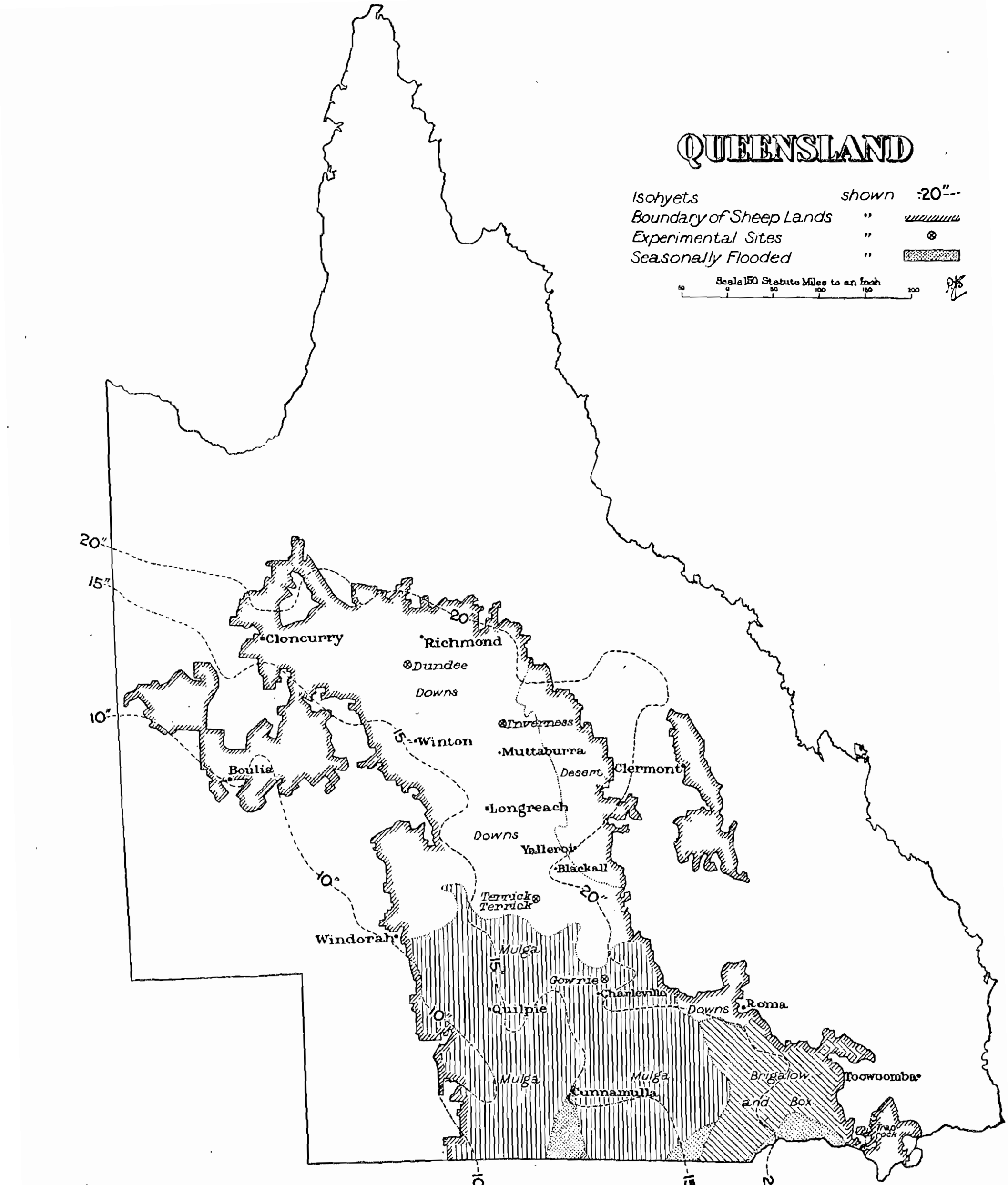


Fig. 1. Map showing the main Queensland wool-growing areas.

are applied. Some soil disturbance by burning, grading or cultivation also appears necessary. Seed removal by seed-harvesting ants, which are common in this area, is also a problem.

(b) *The Mitchell and Flinders Grass Downs:*

These downs are developed on sedimentary material of Cretaceous age, including the Winton formation of freshwater sediments and the marine beds of the Tambo and Roma formations. The soils are heavy, self-mulching clays and usually carry a grassland vegetation, though areas, particularly near Blackall, carry thick gidyea *(Acacia cambagei)* scrub, and others known as lightly-timbered downs carry scattered trees of boree *(Acacia cana)* and white-wood *(Atalaya hemiglauca)*.

Farmer, Everist and Moule (1947), have shown that this area might expect two consecutive summer months with sufficient moisture for pasture growth, but no such winter months in 75 percent of the years. Thus, this region falls outside the influence of effective winter rains, but has a prospect for quick-growing summer crops.

In normal and good seasons, these downs properties are excellent wool-growing areas. The main diet of the sheep is, however, not so much the comparatively drought-resistant Mitchell grasses *(Astrebla spp.)*, but an ephemeral gramineous and herbaceous flora of Flinders grass *(Iseilema spp.)*, button grass *(Dactyloctenium radulans)*, spider couch *(Brachyachne convergens)*, Queensland blue grass *(Dichanthium sericeum)*, tar vine *(Boerhavia diffusa)*, some annual chenopods and a sparse sprinkling of legumes such as *Rhynchosia minima* and *Glycine* spp. A detailed account of the Mitchell grass association of the Longreach district has been published by Davidson (1954). In years of above average rain, Queensland blue grass dominates the Mitchell grass in the grassland community.

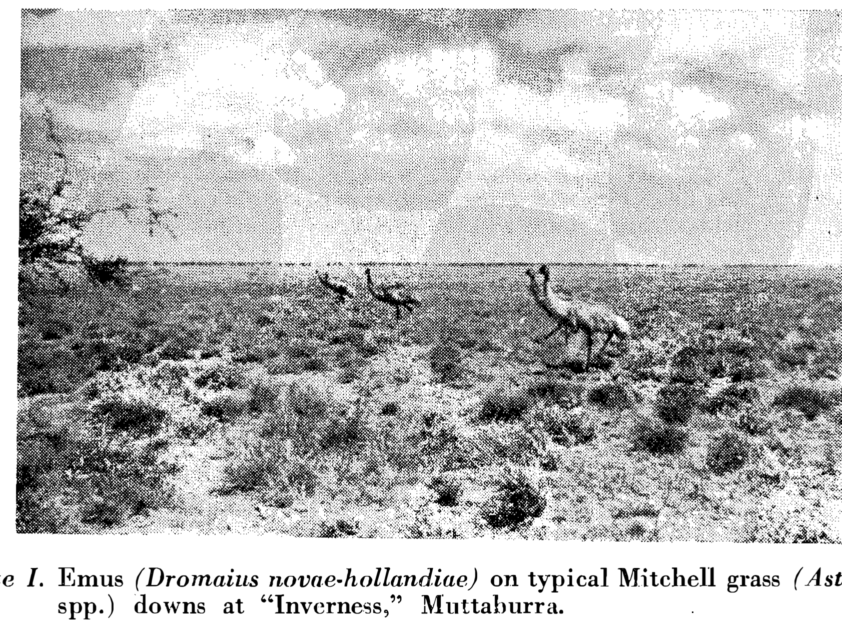


Plate I. Emus *(Dromaius novae-hollandiae)* on typical Mitchell grass *(Astrebla* spp.) downs at "Inverness," Muttaburra.

Note the distribution of Mitchell grass tussocks.

The trees in the distance are coolibahs *(Eucalyptus microtheca)* lining a water course, whilst the shrub in the left foreground is mimosa bush *(Acacia farnesiana)* lining a bore-drain. This shrub provides shade and some fodder.

Roe (1941) and Allen and Roe (1945) determined the average composition by weight of a Mitchell grass pasture on Gilruth Plains, Cunnamulla, on two occasions—in February, 1941, after a series of dry summers, and again in April, 1941, after nearly five inches of rain had fallen since the previous determination. The figures obtained are listed in Table I.

Table I.

Percentage composition of a Mitchell grass pasture.

	Mitchell grasses	Other grasses	Legumes	Miscel-laneous	Inert Material
Feb., 1941	7.9	74.3	0.2	9.7	7.8
Apr., 1941	22.2	62.3	0.5	3.8	11.2

As the Mitchell grasses are less palatable than the other grasses and herbage, it is obvious that the Queensland wool clip from the Mitchell grass downs areas is produced mainly from the latter. The Mitchell grasses, however, do provide some grazing in a good season, and are more valuable when the season gets dry.

Davies, Scott and Kennedy (1938), working at "Elderslie," Winton, showed that a Mitchell grass pasture alone provides a submaintenance ration in the winter and spring and until new season's growth occurs after rain. Selective grazing by sheep probably offsets this general inadequacy to a certain extent, and it is known that Merino sheep reduce their maintenance requirements as the plane of nutrition falls, and thus there is some adaptation to the local environment. There may also be a vitamin A deficiency in old Mitchell grass pastures.

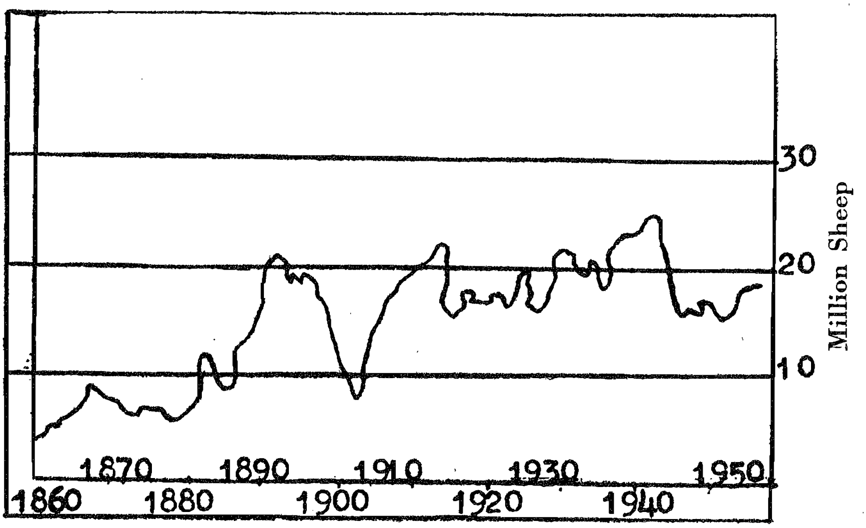
Many deficiencies in a gramineous diet can be made up by browsing "top-feed," the deeper-rooted trees and shrubs having the ability to withstand dry periods much longer than ground vegetation, and they can also draw on deeper soil supplies of nutrients. Unfortunately, much of the Mitchell grass country is devoid of "top-feed" except for limited foraging from the mimosa bush *(Acacia farnesiana)* along bore drains and scattered young trees of boree *(Acacia cana)*, whitewood *(Atalaya hemiglauca)*, or gidyea *(Acacia cambagei)*. These trees, however, with the coolibah *(E. microtheca)* fringing the watercourses, do provide scattered shade for rams during mating (Moule, 1950).

The general picture of a Mitchell grass pasture then is an almost complete sward made up of tussocks of Mitchell grass between which annual grasses and herbs flourish in the normal summer monsoonal season. Due to selective heavy grazing or by effluxion of time, the annuals disappear leaving the Mitchell grass tussocks as standing hay from about April onwards. As the drier winter and spring period progresses, the Mitchell grass is gradually grazed down, and if the dry season is prolonged, the grazing pressure increases until only the stubble of the tussocks remains, with practically no feed available. In the vicinity of watering places, the tussocks might disappear altogether. From about April, the Mitchell grass provides less than a maintenance ration and a fodder drought period is set in train. In the absence of rain, this drought can develop quickly, particularly as the warmer spring weather approaches, followed by intense summer heat waves. The absence of "top-feed" aggravates the situation, as the Mitchell grass is given no relief from intensive grazing and is quickly eaten out. Such droughts have been common throughout the Mitchell grass downs and other areas of the State, and have been responsible for severe fluctuations in the State's sheep numbers from time to time.

II. THE DROUGHT PROBLEM

A glance at the graph illustrating the yearly changes in the State's sheep population from 1860 to 1953 (Fig. 2) shows the devastating effect of the 1899-

Fig. 2



Qld. Year Book, 1954.

1902 drought when more than 10 million sheep died, three other serious declines during the 1910-1935 period involving the deaths of some 5 million sheep on each occasion, and the 1946 period when more disastrous losses were experienced. Ten years later, the numbers have still not reached the 1942 figures despite high wool prices and good seasons.

In 1943, Queensland's sheep numbers reached an all-time record figure of 25,650,231 in 1947, the total had fallen to 16,084,340, and five years later, in 1952, the State could only muster 16,163,518 sheep!

Although losses occurred from blowfly infestation, worms, poison plants, and fox and dingo attack, the drought toll was most important. It is not easy to assess the full significance of drought losses such as these. Apart from the actual loss of individual sheep, there is the loss of production of wool and meat; the loss of one, two or more lambings on each occasion; a loss of income during the drought period; some considerable losses on drought feeding; heavy indebtedness in re-stocking at higher prices; and obligations regarding interest on borrowed capital to name some direct costs. There are other related commitments. Perhaps it would be no exaggeration to say that the loss of ten million sheep during the 1943-53 period cost the State some £60,000,000.

Everist and Moule (1952) have published a comprehensive analysis of drought incidence in Queensland for 49 meteorological stations for every year of record between 1894 and 1951. Figures for percentage drought frequency based on this 58-year period for stations typical of the Mitchell grass downs areas are recorded in Table II.

Table II

Percentage Drought Frequency 1894-1951

Station	Drought duration 4 mths.	Drought duration 11 months
Winton	85	2
Longreach	74	2
Richmond	90	1
Hughenden	78	0.7
Aramac	70	0.7
Isisford	73	1
Blackall	50	0.2
Tambo	40	0.2
Augathella	36	0.2
Charleville	52	0.5

It can be seen that, *on the average*, the Richmond area records a drought period for more than four months in 52 years out of 58, or nearly every year, and the general picture in this north-western area is much worse than those of the central and southern areas. The combination of frequent drought and extremely high temperatures for this area is a serious grazing hazard, and has made graziers more conscious of the need for some form of drought mitigation than graziers from other areas within the State.

Drought Mitigation

Several methods of drought mitigation might be considered by graziers, including a deferred grazing system, selling off portion of the flock, moving sheep to agistment, feeding edible scrub or hand-feeding. Carney (1951), in a survey of practices on selected properties in the Longreach district, listed the following policies followed by graziers—

Send on agistment	11
Cut scrub	6
Hand-feed	7
Sell of surplus stock	25
	49 properties

A deferred grazing system is not often practised as it locks up portion of the run during the good seasons and reduces productivity. The deferred section also constitutes a fire risk, and if light rain falls during the winter the standing hay will blacken and be rendered almost useless. It also involves adequate watering facilities for which there is no return on maintenance and capital invested. Disposal of surplus stock usually means retention of rams and the younger ewes and sale of older stock and wethers. Sales would generally have to be made on a falling market with consequent loss, but it relieves drought pressure on the property and is a common precautionary measure. Apart from sale of sheep, moving to agistment is the common form of drought relief, but is subject to the proviso that agistment is available. In a year of general drought, agistment will be hard to obtain, but where local droughts occur this system has many advantages. The cost and availability of transport and the supervision of sheep while away are important hazards to this practice and losses have often been high.

Feeding of edible scrub is possible only in those areas where scrub is available, and is chiefly confined to the mulga belt of the south-east.

Hand-feeding of sheep in a drought is generally practised as a last resort because hand-feeding is costly in terms of money, equipment and labour. In the past, many graziers have hand-fed for a time, but with the prolongation of the drought some have had to cease and have lost heavily. Those who fed right through incurred a heavy indebtedness which took them years to recover. Again, serious losses can occur after the rains fall and the drought breaks.

Common feeds utilised in hand-feeding include grains such as maize, wheat, oats and grain sorghum, concentrates including cottonseed meal, linseed meal, meat meal and nuts, or roughages such as lucerne or cereal hay and chaff. The utilisation of home-produced bush hay has attracted renewed interest, and more recently still, conservation of silage from crops grown on the property.

Apart from home-produced fodder, the concentrated foods and grain are much cheaper to use than roughages because of their high nutritive value and their reduced bulk which materially reduces handling, freight and storage charges. The actual choice of foodstuffs becomes a question of economics.

Moule (1956) has recently listed (Table III) the comparative values of various foodstuffs which might be used in the drought feeding of sheep—

Table III

Foodstuff	Landed or production cost per ton	Cost of Dig. Crude Protein per oz.	Cost of energy-producing foods per lb.
Maize grain	£35	2¼d.	5d.
Grain sorghum	£35	2¼d.	5d.
Meatmeal	£45	¾d.	7d.
Linseed meal	£45	¾d.	7d.
Cottonseed meal	£45	¾d.	7d.
Sheep nuts	£45	3d.	8d.
Lucerne hay	£20	1d.	5½d.
Flinders grass hay (1.5% D.C.P.)	£ 3	1½d.	1¼d.
Mitchell grass hay (1.5% D.C.P.)	£ 3	1½d.	1¼d.
Sorghum silage (1.5% D.C.P.)	£ 1/10/-	¾d.	¾d.
Flinders grass hay (0.5% D.C.P.)	£ 3	4d.	1½d.
Mitchell grass hay (0.5% D.C.P.)	£ 3	4d.	1½d.

D.C.P. = Digestible Crude Protein.

With the low cost per unit of protein in the case of meat meal, cottonseed meal and linseed meal, the question of the need for roughage arises. Field trials under drought conditions have proved that roughage is not necessary for the well-being of adult sheep, but is required for young animals. If home-grown roughage is a practical proposition, therefore, its supplementation with concentrates should provide the requirements for drought feeding. Most of the roughages available will be rather low in protein, and hence the protein concentrate is the deficiency in the ration which will normally have to be purchased.

Conservation of Bush Hay:

With the rapid growth of Mitchell and Flinders grasses on the downs properties during and immediately following the normal summer monsoonal rains, a large amount of food material beyond the capacity of existing grazing flocks to handle is produced. This body of natural feed quickly deteriorates in nutritive value after flowering and a large amount is wasted. Some graziers have felt that it would be worthwhile to cut this material before it loses too much food value and store it as bush hay against drought. Marriott and Harvey (1951) have described the large-scale harvesting technique employed by D. M. Collings, of "Colwell," McKinlay.

Two factors yet to be determined in relation to such bush hay are the frequency with which a Mitchell grass pasture can be mown without affecting its persistence, and the deterioration of stored hay under the hot, dry conditions of Western Queensland.

The quality of bush hay made from Mitchell grass had been determined by Harvey (1952), who analysed samples from each of four properties in Western Queensland. The results are set out in Table IV.

Table IV

Composition of Dry Roughage on a Moisture-free Basis

Sample	Crude Protein %	Fat %	Crude Fibre %	Ash %	N.F.E. %	Lime CaO %	Phosphoric P_2O_5 %
1	4.4	1.2	36.5	11.7	46.2	0.470	0.116
2	5.1	1.1	34.8	9.6	49.4	0.212	0.145
3	5.6	1.2	35.8	11.9	45.5	0.60	0.160
4	8.1	1.0	37.1	9.6	44.2	0.314	0.301

Digestibility of Dry Roughages

Sample	Dry Material	Crude Protein	Fat	Fibre	N.F.E.
1	40.5	4.5	21.3	52.7	42.1
2	37.6	26.7	45.4	46.8	37.5
3	46.0	39.0	56.0	54.0	57.0
4	50.4	56.5	46.1	61.2	46.2

Harvey concluded that the digestibility and level of phosphoric acid in Mitchell grass are closely related to the crude protein content, and in most cases both protein and phosphorus will be inadequate for maintenance.

Feeding bush hay with supplements:

Moule, Pierce and Jackson (1955), in an endeavour to improve the feeding value of such material, fed urea, wheat and molasses to sheep grazing on low quality Mitchell grass stubble. Under these conditions, it was found that urea was both toxic and unpalatable and did not bring about an increase in wool production above that obtained with a low protein supplement. Franklin, Briggs and McClymont (1955) studied the effect of various supplements on the utilisation of low-quality roughage by Merino weaners. Linseed meal and a concentrate mixture made up of lucerne chaff, whole wheat, linseed meal, molasses, cobaltised salt and vitamin A, proved the most economical supplements to low quality oaten straw and wheaten chaff.

Conservation of home-grown crops as silage:

Following heavy sheep losses in the 1951-2 drought, Mr. J. T. Kelman of "Dundee," Richmond, who had had farming experience in the N.W. of N.S.W., decided to try to grow summer crops in the Mitchell grass downs country at Richmond, and, at the end of 1952, planted some Sudan grass and sorghum which did reasonably well. Not having any hay-making or silage harvesting machinery, he fed it off. Simultaneously, Mr. A. C. McClymont of "Inverness," Muttaburra, quite independently, also grew sorghum and Sudan grass, and, taking advantage of the newly-introduced forage harvester, ensiled his first crop of Sudan grass. The resulting silage was of high quality. Many crops had been grown previously in this far western belt and some had been ensiled in the stalk, but this "Inverness" venture with a modern forage harvester paved the way for mechanised conservation of silage on a large scale.

III. CURRENT INVESTIGATIONS

The cropping experiments were commenced at the end of 1953 when two experimental sites, Mr. A. C. McClymont's "Inverness" property at Muttaburra, and Baker Bros.' holding at "Gowrie," Charleville, were selected. The following year, experiments were extended to the Australian Estates' "Terrick Terrick" Merino sheep stud at Blackall and Mr. J. T. Kelman's "Dundee" property at Richmond, thus completing a series of experimental sites located at approximately 150 mile intervals in a roughly north-south line throughout the Mitchell grass downs sheep country. The actual experimental sites all fall within the 15 inch and 20 inch isohyets; the two northern stations are outside the influence of effective winter rainfall, and each station has a summer maximum fall.

1. Climatological Data:

Climatological data relating to the recording stations nearest to these four sites are given in Table V.

Summer temperatures are high and heat wave conditions may affect crops in a vital stage of growth. A comparison of heat wave incidence from November to March between Winton in the centre of this area and recognised agricultural centres is given in Table VI.

An attempt has been made to assess the climatic suitability of the far-western areas for cropping based on precipitation (rainfall) and saturation deficit figures. The effectiveness and incidence of rainfall as listed by Everist and Moule (1952) and the length of the growing season as deduced by the formula of Prescott and Thomas (1949) are given in Table VIII. Neither method gives a reliable indication of cropping potentialities as no allowance is made for a preplanting accumulation of soil moisture resulting from fallowing. A more reliable estimate can be derived from measuring the amount of moisture used to grow a crop and examining the chances of receiving this amount. This also presents difficulties, as the amount of run-off must be known. The growing season figures do indicate, however, that Richmond has a better summer season and Charleville a better winter season than the other stations.

Table V

	Lat.	Long.	Alt. (ft.)	Mean Max. Temp. °F.	Mean Min. Temp. °F.	Mean Rel. Humid. 9 a.m.	Mean Ann. R'fall (pts.)	R'fall Varia ability	Mean Fall per wet day (ins.)	Normal summer rain (Oct. Mar.) (ins.)	Normal winter rain (Apr.-Sept.) (ins.)	Mean Ann. Evap. (ins)	Mean no. wet summer mths.	Mean no. wet winter mths.
Charleville	26°25'	146°13'	965	83.9	56.0	48	1975	25—30%	0.45	10½	6	80	4	3
Blackall	24°25'	145°29'	929	86.4	58.5	50	2105	30—40%	0.45	13	5	84	4	3
Longreach	23°27'	144°8'	612	88.1	59.4	50	1653	30—40%	0.40	10	3½	88	2	0
Richmond	20°44'	143°10'	700	91.2	61.4	45	1839	35—50%	0.4 0.5	14	2	90	4	0

(Muttaburra figures, where available, are slightly more favourable than those for Longreach).

A "wet" month occurs when the ratio of rainfall to free-water evaporation ($^P/_E$) exceeds 0.2 in summer and 0.3 in winter. This is taken as the "break of the season," i.e. when the rainfall is just adequate to maintain a bare soil at wilting point.

Table VI

Frequency of Heat Waves 1926-1950

Heat Waves	Winton					Clermont					Biloela					Dalby					Pittsworth				
	N.	D.	J.	F.	M.	N.	D.	J.	F.	M.	N.	D.	J.	F.	M.	N.	D.	J.	F.	M.	N.	D.	J.	F.	M.
3 consecutive days with max. temp. > 100°F.	83	139	140	58	41	11	20	32	9	5		3	9	1	--	1	1	8	1	-	1	—	2	—	-
3 consecutive days with max. temp. > 105°F.	17	46	55	18	5	2	6	9	1	—		-	1	—	—	1	-	2	—	—	—	—	1	—	—
7 consecutive days with max. temp. > 105°F.	3	6	12	2	1	—	1	1	—	—	—	-	—	—	—	—	—	—	—	—	—	—	—	—	—

Frost data for the four stations are listed in Table VII.

Table VII

Station	Year's record from	First occurrence of record < 36°F.	First occurrence of record < 32°F.	Av. time of record < 36°	Av. frost-free period days
Charleville	1908-1945	April 22nd	May 26th	late May/ early June	273
Blackall	1913-1945	May 14th	May 14th	June 28th/ July 3rd	332
Longreach	1908-1945	May 26th	June 9th	June 28th/ July 3rd	341
Richmond	1908-1945	May 14th	June 6th	July 1st/ July 22nd	360

Table VIII

Station	Factor	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Jly.	Aug.	Sept.
Charleville	M	125	164	236	247	264	227	135	122	135	123	77	84
	E	196	189	205	208	186	192	148	110	67	72	115	140
	F	12	20	30	25	27	22	16	18	33	26	17	14
	P/.75 s. d.	2.15	2.47	3.37	3.31	3.94	4.01	2.85	3.70	6.03	5.06	2.10	1.89
Blackall	M	139	151	241	285	320	267	134	136	125	112	66	77
	E	224	202	218	214	182	196	164	125	86	91	130	156
	F	14	17	25	28	33	27	16	17	28	22	11	10
	P/.75 s. d.	2.15	2.15	3.33	3.75	3.35	4.58	2.42	3.79	4.52	3.89	1.66	1.60
Longreach	M	97	115	181	212	338	239	95	85	87	80	28	57
	E	236	205	221	208	176	196	148	149	96	106	144	172
	F	8	13	21	23	30	20	15	11	18	17	4	5
	P/.75 s. d.	1.35	1.62	1.56	2.97	5.36	4.24	1.82	2.14	2.88	2.43	1.50	2.87
Richmond	M	61	131	252	444	387	217	77	57	74	42	11	24
	E	284	243	237	198	170	212	204	178	134	149	197	220
	F	3	12	29	39	44	24	10	7	10	6	0	1
	P/.75 s. d.	0.78	1.63	3.27	6.37	6.09	3.49	1.26	1.40	1.97	0.96	0.21	0.39

M Mean monthly rainfall in points;

E = Minimum monthly requirement for effective rainfall in points;

F = Number of Years from 1894 to 1951 in which effective rainfall was recorded.

P/s.d. .75 greater than 4 indicates an effective rainfall month, where P equals precipitation and s.d. equals saturation deficit.

The sorghum crops so far cut for silage in Western Queensland have taken from 10-12 weeks to reach the stage of maturity for harvest. Thus, where *three* or more consecutive wet summer months occur, it is reasonable to expect a crop would be harvested, and where *two* wet summer months are recorded, there would be a chance of a crop if a year's fallow had preceded planting. The frequency of these occurrences is given in Table IX.

Table IX (after Everist and Moule)

Station	Years of Records	% of Years in which 3 or more consecutive wet summer months occur.	% of Years in which 2 or more consecutive wet summer months occur.
Charleville	60	43	70
Blackall	59	40	81
Longreach	58	40	67
Richmond	60	52	77

Insufficient data are available for Muttaburra, the site of the experimental area and so use has been made of the Longreach figures. It can be seen then that a crop for silage could be expected at least two years in five, and if fallowing were practised the crop expectancy could be lifted to about two years in three. We cannot get much closer than this as a general picture. The variability in the intensity and incidence of individual falls is all-important and it is here that what Professor Teakle is pleased to call "opportunist farming" finds a place. If fallowing is practised so that some fallowed land is always ready for planting, the chances of success are enhanced. Graziers could well adopt the Boy Scout's motto, "Be prepared," and make full use of the rain where and when it falls.

2. Soils and Soil Behaviour:

The experimental areas on "Dundee," "Inverness," "Terrick Terrick" and one area on "Gowrie" embrace soils belonging to Prescott's great soil group known as the Grey and Brown Soils of Heavy Texture; another area on "Gowrie" can be classified as a solonised Red Brown Earth, while the mulga soil on the same property could be classed as a Lateritic Red Earth.

Grey and Brown Soils of Heavy Texture:

These soils occupy some 34 million acres between the 15 inch and 20 inch isohyets within this western sheep area stretching intermittently from the N.S.W. border below Cunnamulla to just north of Augathella, from whence they emerge in a broadening belt some 100-200 miles wide extending to beyond the Great Northern Railway. Hereabouts, the sheep give way to cattle and a further 8 million acres of such soils occupy the flood plains of the Saxby, Flinders, Leichhardt, Gregory and Nicholson rivers almost to the shores of the Gulf of Carpentaria.

They are heavy, self-mulching clays capable of good moisture storage, but crack extensively in times of moisture stress.

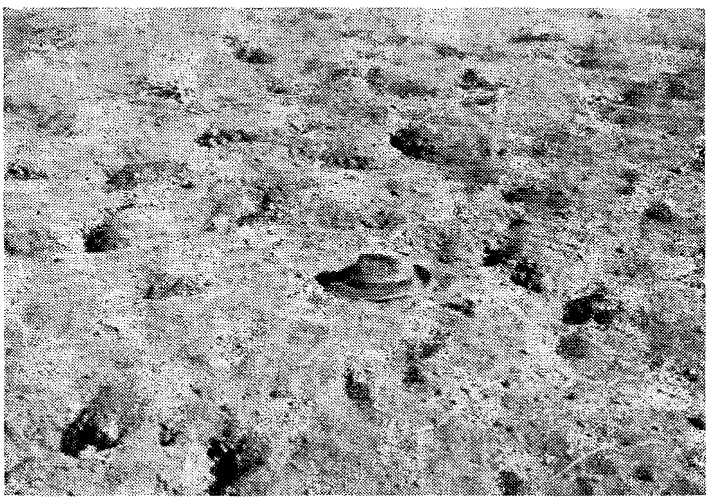


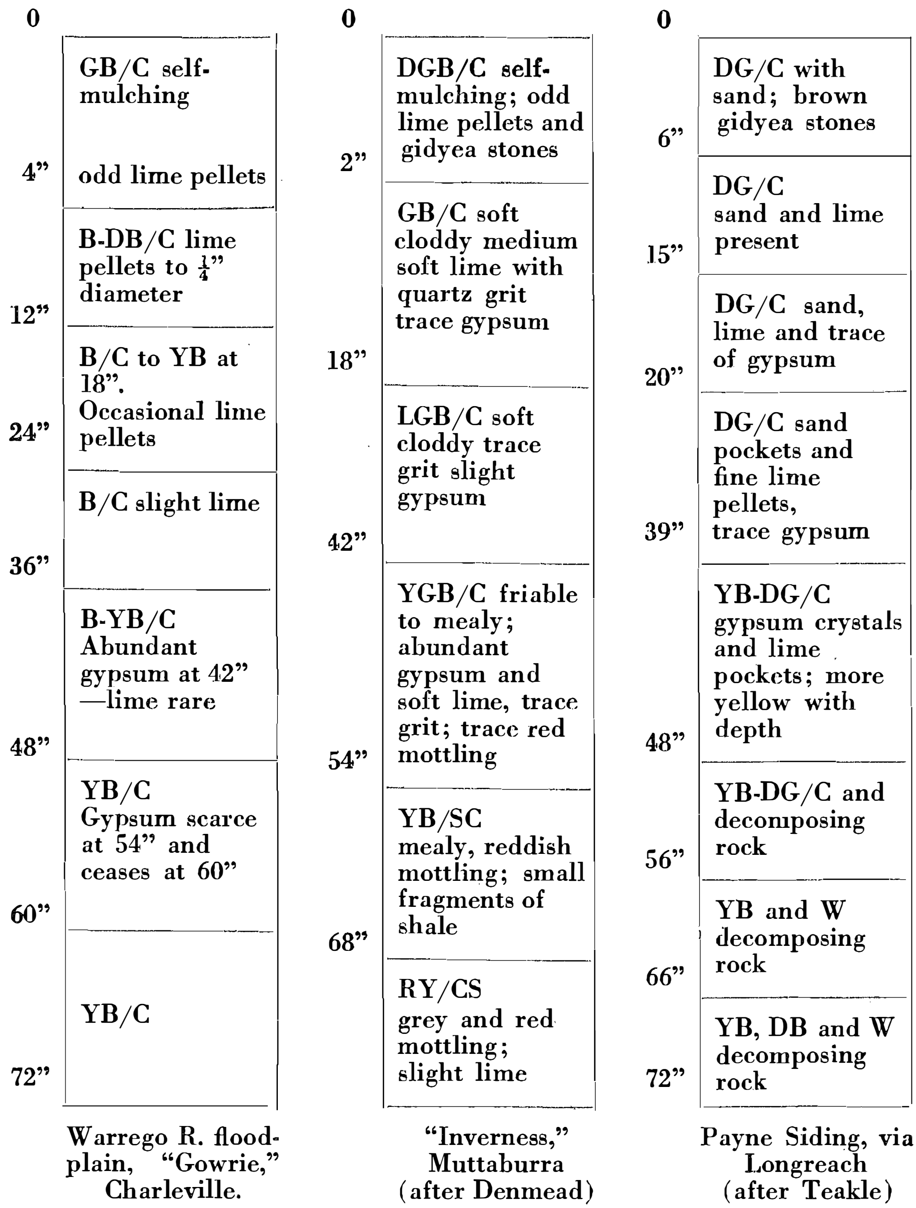
Plate II. Deeply cracked grey-brown soil of heavy texture, Julia Creek, 1951-2 drought.

The vegetation on this soil at "Gowrie" was originally coolibah *(E. microtheca)* and forest blue grass *(Bothriochloa intermedia)* while that at "Inverness" and Payne Siding was the Mitchell grass association previously described.

Typical profiles are set out in Figure 3.

Figure 3

Typical profiles of the Grey and Brown Soils of Heavy Texture



DGB/C, dark brown clay; Y, yellow; R, red; W, white; S, sand; L, light.

There are no textural boundaries to differentiate A and B horizons, but the structural change to the C horizon of calcareous sand, shale or sandstone is generally marked. The depth of 36"-48" where there is abundant gypsum and some soft lime would seem to mark the normal limit of water penetration into this soil.

Catchpoole (1956) analysed the typical profile from the experimental area at Muttaburra, the results of which are set out in Table X.

Table X

Analysis of Grey-Brown Soil of Heavy Texture, "Inverness," Muttaburra (after Catchpoole).

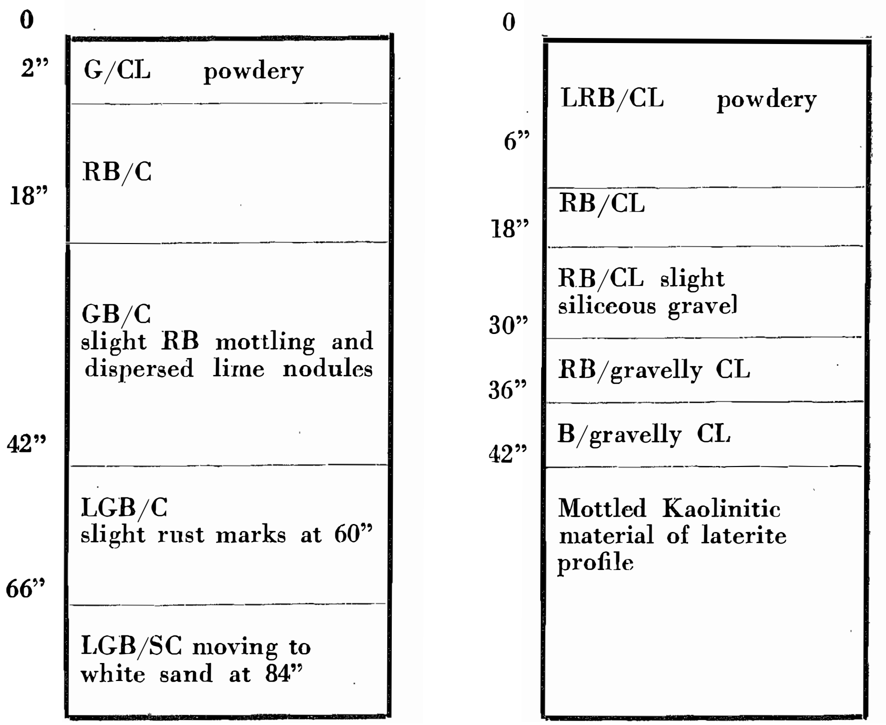
	Chemical Analysis														Mechanical Analysis				
Depth	pH	Exchangeable metal ions									Avail. P_2O_5 p.p.m.	Total N %	Organic Carbon %	C/N Ratio	Coarse Sand	Fine Sand	Silt	Clay	Texture
		m.e. per 100 g.					% of Total												
		Ca	Mg	Na	K	Tot.	Ca	Mg	Na	K									
0 - 2"	8.1	38.1	7.2	0.7	1.3	47.3	80.9	15.3	1.5	2.8	165	.05	.38	7.6	7.9	35.5	6.6	50.2	Clay
2 - 18"	7.3	41.0	6.9	1.5	0.4	49.8	82.2	13.3	3.1	0.8	124	.04	.28	7.0	9.3	33.8	5.5	52.4	Clay
18 - 36"	7.6	22.9	15.8	9.9	0.8	49.4	46.4	32.0	20.1	1.8	127	.04	.26	6.5	5.1	32.8	7.7	46.9	Clay
36 - 42"	7.6	17.4	13.4	12.0	0.8	43.6	39.9	30.7	27.5	1.8	290	.03	.20	6.7	3.5	26.5	8.1	54.7	Clay
42 - 54"	7.5	17.7	12.4	10.4	0.7	37.2	47.6	33.3	27.2	1.9	1200	.02	.11	5.5	2.5	33.8	7.4	50.8	Clay
54 - 66"	7.5	13.7	11.7	9.8	0.6	35.8	38.2	32.7	27.4	1.7		.01	.05	5.0	2.6	37.7	8.8	45.8	Clay

Features of the above analyses are the high percentage of sodium (up to 17.5 per cent.) in the exchangeable metal ions, the high exchange capacity, alkaline pH, low percentage of total nitrogen and the increase in available phosphorus with depth. This latter feature is typical of these heavy soils formed on materials of the Cretaceous age. Similar soil at Wrotham Park, at the base of the Cape York Peninsula, although low in available phosphorus in the top two feet of the profile, records over 1000 p.p.m. at a depth of 3 ft. Low figures for available phosphorus are recorded for the grey and brown soils of heavy texture developed on alluvium from the Tertiary sediments such as occur on the Flinders River floodplain as it approaches the Gulf.

Red Brown Earths

The soils of the Warrego floodplain comprise alluvial sandy levees adjacent to the stream, backed by Grey and Brown Soils of Heavy Texture and Red Brown Earths irregularly mixed. The Red Brown Earths show some degree of solonisation. Chemical and mechanical analyses of the soil at Charleville are given in Table XI. This soil sets hard on the surface after rain and its permeability is reduced. The natural vegetation is box *(E. populnea)* and budda or sandalwood *(Eremophila mitchelli)* with a ground cover of grasses such as kerosene grass *(Aristida arenaria)*, curly windmill grass *(Chloris acicularis)*, tall chloris *(Chloris ventricosa)*, needle grass *(Triraphis mollis)* and bottle-washers *(Enneapogon avenaceus)*.

Figure 4



Solonised Red Brown Earth—Warrego R. floodplain, “Gowrie,” Charleville.

Lateritic Red Earth (Stephens) Mulga ridge, “Gowrie,” Charleville.

Table XI

Analysis of a Red Brown Earth, "Gowrie," Charleville (analysis by Dept. of Agr. & Stock).

	Chemical Analysis														Mechanical Analysis				
Depth	pH	Exchangeable Metal ions									Avail. P_2O_5 p.p.m.	Total N %	Organic Carbon %	C/N Ratio	Coarse Sand	Fine Sand	Silt	Clay	Texture
		m.e. per 100 g.					% of Total												
		Ca	Mg	Na	K	Tot.	Ca	Mg	Na	K									
0 - 2"	7.3	9.5	10.5	2.0	0.8	22.8	41.7	46.0	8.8	3.5	16	.04	.2	5	19.3	28.5	18.8	26.3	Clay loam
2 - 18"	8.3	27.5	7.5	5.0	0.5	40.5	67.8	18.6	12.4	1.2	10	.05	.1	2	15.3	23.2	12.3	43.1	Clay
18 - 42"	8.9	19.8	13.3	4.5	0.5	38.1	52.0	34.9	11.8	1.3	118	.06	.2	3	3	2	26.8	61.8	Clay
42 - 66"	8.4	19.3	13.4	3.4	0.7	36.8	52.5	36.4	9.2	1.9	100	.01	.2	20	15.3	16.4	19.5	43.0	Clay
66 - 84"	6.9	14.3	9.1	2.5	0.4	26.3	54.4	34.6	9.5	1.5	42	.02	.1	5	27.2	25.6	1	40.3	Sandy clay
84-102"	7.5	12.8	10.1	6.0	0.5	29.4	43.5	34.4	20.4	1.7	32	.01	.1	10					

The relatively high pH indicates a certain degree of solonisation, which is common in Queensland red-brown earths formed on alluvial materials. The available phosphate figures are low for the top eighteen inches of soil, and field experiments have shown marked responses to the application of superphosphate.

Lateritic Red Earths (Stephens)—

These soils have been listed under Prescott's Brown Soils of Light Texture. They occur extensively on the mulga country of south-west Queensland extending from St. George westwards to beyond Quilpie and north to Augathella and Adavale. The profile features are set out in Figure 4, and the chemical and mechanical analyses are listed in Table XII. The vegetation at the experimental site is composed chiefly of mulga *(Acacia aneura)* with an occasional box *(E. populnea)* and an under storey of dense "turkey bush" *(Eremophila gilesii* with some *E. bowmani)*. The few grasses present are generally tufts of wire grasses *(Aristida spp.)*.

Normally, the mulga country, which occupies some 86,000 square miles or 55 million acres in the central area of southern Queensland, carries a ground cover of mulga mitchell *(Neurachne* spp.) and wire grasses *(Aristida* spp.) and a wide array of herbage, and the whole provides valuable drought fodder. Following the invasion by turkey bush, the Manager of "Gowrie," Mr. O. W. Smith, treated an experimental area with a heavy tyne ripper in May, 1955, to remove this bush and see if natural regeneration of grasses would take place. Practically no growth of grass took place between May, 1955, and January, 1956, and it was then decided to investigate the plant nutrient requirements of this type of soil.

Table XII

Analysis of Mulga ridge soil, "Gowrie," Charleville

—*Chemical Analysis* (by Agricultural Chemist, Dept. of Agriculture and Stock)

Depth	pH H_2O	Available P_2O_5 *(B.S.E.S.) p.p.m.	Exchangeable metal ions: m.e. per 100 g.					Exchangeable metal ions: Per cent. of Total				Total N %	Organic carbon %	C/N
			Ca++	Mg++	Na +	K+	Total	Ca	Mg	Na	K			
0 - 6"	4.5	16	2.2	0.8	.17	.83	4.0	55.0	22.0	4.3	20.7	.10	1.07	10.7
6 - 12"	4.4	12	2.5	1.2	.08	.59	4.4	57.2	27.5	1.8	13.5	.09	.99	11.0
12 - 18"	4.4	16	2.7	1.1	.10	.42	4.3	62.5	2.55	2.3	9.7	.07	.76	10.6
18 - 30"	4.7	10	3.8	1.7	.24	.29	6.0	63.2	28.2	4.0	4.6			
30 - 36"	5.8	16	3.2	3.5	.50	.25	7.5	43.0	47.0	6.7	3.3			
36 - 42"	6.2	12	2.5	2.2	.64	.23	5.6	44.9	39.5	11.5	4.1			

* B.S.E.S. Bureau of Sugar Experiment Stations method.

Mechanical Analysis (by V. R. Catchpoole)

Depth	Coarse Sand	Fine Sand	Silt	Clay	Texture
0 - 6"	20.5	45.8	10.0	23.7	clay loam
6 - 12"	20.5	45.3	9.7	24.5	clay loam
12 - 18"	21.8	41.8	8.9	27.5	clay loam
18 - 30"	23.9	37.9	8.8	29.4	clay loam
30 - 36"	24.0	37.6	9.2	29.2	clay loam
36 - 42"	26.1	38.3	9.4	26.3	clay loam

It will be noted that the profile is acid throughout, the available phosphorus figure is very low and the exchangeable cation figure is only 4.0 m.e. per 100 grams of soil of nearly 24% clay. There is no textural differentiation throughout the profile.

(a) *Soil Moisture Studies—*

Horne (1955) studied the soil moisture movement in two soil types at "Gowrie." To calculate total storage of both moisture and nitrogen, he determined the "volume weight" of the soils at equivalent depths in the profile, eight replicates being obtained for each depth. The results are shown in Table XIII.

Table XIII

Apparent Specific Gravity and Weight per acre of soil at varying depths.

Soil	Depth (ins.)	Bulk Density	lb. per acre '000
Heavy grey brown soil	0 - 6	0.89	1,220
	6 - 12	1.32	1,790
	12 - 24	1.52	4,140
	24 - 36	1.62	4,410
	36 - 48	1.59	4,320
Red Brown Earth	0 - 6	0.91	1,230
	6 - 12	1.31	1,780
	12 - 24	1.62	4,400
	24 - 36	1.69	4,600
	36 - 48	1.39	3,780

Samples were taken for soil moisture determinations and detailed findings are listed in Appendix I.

At wilting point, the heavy grey brown soil contained 13.3 per cent. moisture and the Red Brown Earth 8.6 per cent. The maximum moisture storage in both soils was at planting on 21/1/55, when the heavy grey brown soil contained 6.5 inches of available water and the Red Brown Earth 4.3 inches in the top four feet of profile. At harvest 89 days later, this moisture reserve was reduced to 2.8 inches in the case of the heavy grey brown soil and 1.3 inches for the Red Brown Earth. The rainfall during the growing period was 18.55 inches, so that a total of 3.7 inches of moisture lost from the soil plus 18.55 inches rainfall = 22.25 inches, must be accounted for in crop growth + evapo-transpiration and run-off. Although the long fallow plots had the advantage of 2.2 inches more of stored moisture at harvest in 1954, the subsequent wet season, when 974 points of rain fell, enabled the short fallow plots to catch up before planting in 1955. The percentage of the rainfall which was conserved in the soil is shown in Table XIV.

Percentage Conservation of Rainfall

Soil Type	Period	Rainfall in period (ins.)	Water Conserved to 4 ft.	% Rainfall conserved to 4 ft.
Heavy grey brown soil	6/1/54 to 21/1/55	32.23	6.1	18.9
	31/3/54 to 21/1/55	23.79	3.3	13.9
Red Brown Earth	6/1/54 to 21/1/55	32.23	3.1	9.6
	31/3/54 to 21/1/55	23.79	1.7	7.2

Denmead (1954), Humphreys (1955) and Catchpoole (1956) have determined the soil moisture figures (Table XV) for a series of long fallow and short fallow plots on a grey brown soil of heavy texture at "Inverness," Muttaburra.

Table XV

Soil Moisture Data, "Inverness," Muttaburra (after O.T. Denmead et. al.).

Depth (ins.)	Relative Density	Field Capacity (F.C.) %	Inches of Water Stored at F.C.	Permanent Wilting Point (P.W.P.)	Inches of Water retained at P.W.P.	Water Storage Availability (F.C.-P.W.P.)
0 - 6	1.3	33.1	2.6	14.9	1.2	1.4
6 - 12	1.3	30.0	2.3	15.7	1.2	1.1
12 - 24	1.2	32.7	4.7	17.6	2.5	2.2
24 - 36	1.2	33.2	4.8	17.7	2.5	2.3
36 - 48	1.2	28.8	4.1	18.0	2.6	1.5
0 - 48			18.5		10.0	8.5

These figures indicate that a miximum storage equivalent to 8.5 inches of rainfall is possible within the top four feet of the soil profile.

The soil moisture determinations made during the succession of seasons 1954-6, together with rainfall and evaporation figures, are given in Appendix II.

The trials have not been in progress long enough to draw any definite conclusions, but some interesting trends have been recorded. It is obvious that evaporation and run-off are two major factors in moisture loss in this period. The very wet early summer of 1955 recorded 22.3 inches of rainfall at "Inverness" for the twelve-week period from planting to harvest. Runoff was heavy and was reflected in the wide flooding which occurred in the Landsborough and Thomson river systems at that time.

(b) *Nitrate Nitrogen Studies* —

Horne (1955) studied the amount of nitrate nitrogen in the two soil types at "Gowrie," Charleville, and the detailed figures are given in Appendix III. The heavy grey-brown soil nitrified under fallow and produced 60.6 lb. of nitrogreen material in the 89-day growing period. The short-fallowed plots gave a yield of 17 tons over the same period. Compared with other heavy grey brown soil areas, the accumulated nitrate has not been high at any stage of the investigations at "Gowrie," and it appears that a very low equilibrium figure is reached. After sampling and analysing these soils, Horne realised that some factor, in addition to the moisture and the nitrate actually present at the time, was operating to produce the increase in yields in the long-fallowed plots. The crop from the short-fallowed plots exhibited the usual pale green colour of nitrogen deficiency, and the plants were shorter and had more slender stems than those of the long fallow plots. It was thought that possibly the rate at which nitrate was made available to replenish that used might differ markedly in the two sets of plots. He decided to investigate the 0-6" and 6"-12" bands of soil immediately after harvest. At that time transpiration would be at a minimum and plant growth static, although the roots were alive.

The results are summarised in Table XVI.

TABLE XVI

Nitrate trends in heavy grey brown soil at "Gowrie," Charleville, in the period immediately after harvest.

Days after harvest	Nitrate nitrogen in p.p.m. in series of 4 plots								
	Zone	0 - 6"				6" - 12"			
3	Long Fallow	3.0,	2.9,	2.9,	2.9	1.5,	1.5,	1.5,	1.5
	Short Fallow	2.9,	4.4,	1.5,	2.9	1.5,	1.5,	3.0,	1.5
Unploughed land									
11	Long Fallow	*3.5,	*3.2,	*4.4,	*2.9	1.5,	1.7,	1.5,	1.5
	Short Fallow	*1.5,	*1.5,	*2.0,	*1.7	1.4,	1.7,	1.5,	1.7

* Although the figures for accumulated nitrate nitrogen are very low, the difference for the 0-6" figures on the unploughed land eleven days after harvest are highly significant. There was no significant difference between the figures for these same plots three days after harvest. The difference in nitrate production in the 0-6" band are equivalent to approximately 18 lb. of sulphate of ammonia per acre in eight days.

The results point to an increased rate of nitrate production in the previously long fallowed plots. This could be due to a greater population of soil organisms built up over the fallowing period, or to the fact that soil nitrogen was no longer locked up in the decomposition of the organic matter in the old stubble and was thus available to the crop.

At "Inverness," Muttaburra, Denmead and Catchpoole made nitrate nitrogen determinations on land under long and short fallow from February, 1954, until May, 1955, involving two crops on the short-fallowed land and one on the long-fallowed land. The results are set out in Table XVII.

Table XVII

Nitrate nitrogen determinations (in p.p.m.)

Heavy grey-brown soil, "Inverness," Muttaburra

Sampling dates

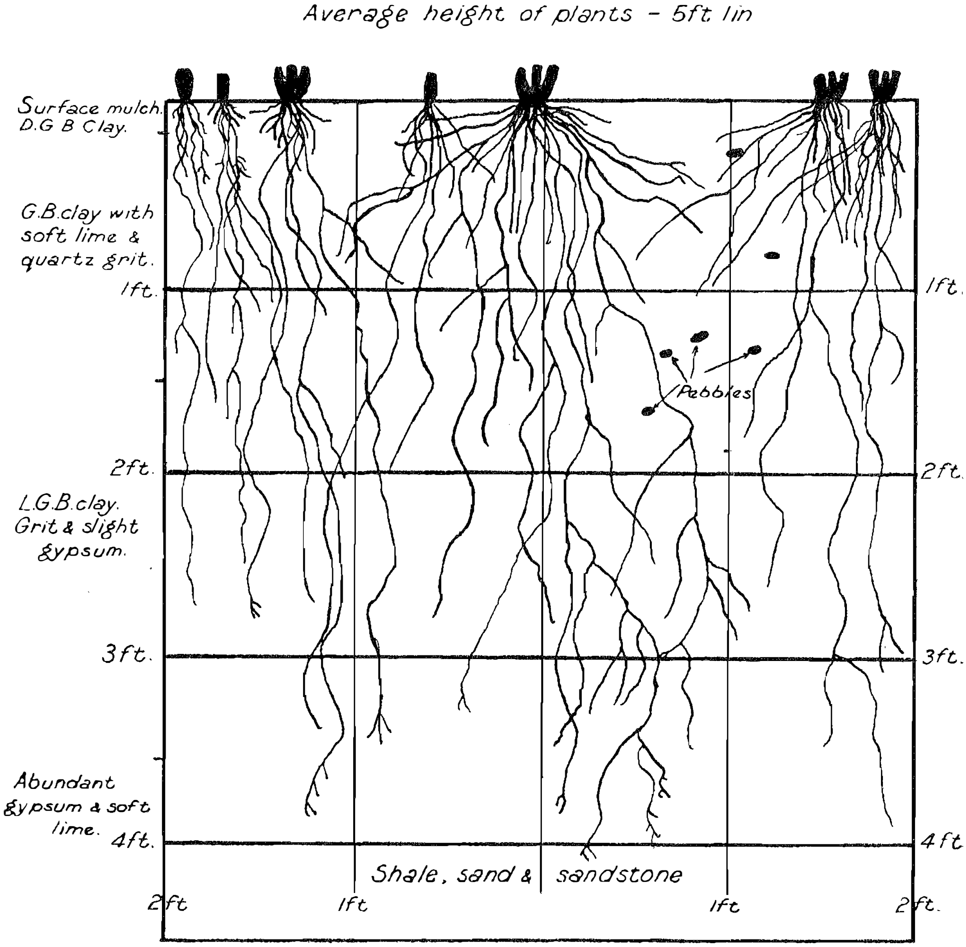
	Depth (ins.)	12/2/54	26/4/54	21/9/54	Planting 7/2/55	Harvest 11/5/55
LONG FALLOW	0 - 6	4	15	22	20	Trace
	6 - 12	3	7	6	12	Trace
	12 - 24	3	4	3	5	
	24 - 36	3	3	3	4	
	36 - 48	3	4	2	2	
SHORT FALLOW		Planting 12/2/54	Harvest 26/4/54		Planting 7/2/55	Harvest 11/5/55
	0 - 6	4	2	3	8	Trace
	6 - 12	3	3	2	6	Trace
	12 - 24	2	2	1	4	
	24 - 36	2	2	1	2	
	36 - 48	2	3	1	2	

It can be seen that nitrate nitrogen production is active in the surface foot of the soil profile and increase is rapid during the bare fallowing period. The growing crop removes nitrogen fairly quickly and there is evidence of considerable production of nitrate nitrogen during the growing period of the crop. Crop residues evidently lock up the nitrogen during decomposition following ploughing after harvest, and nitrate build-up is slow.

(c) *Sorghum Root Distribution—*

Denmead (1954) studied the root development of the sorghum plant by the 'trench-wash' method, exposing the sorghum roots by removing the surrounding soil with a jet of water. He found that during the ten weeks' growth to harvest for silage the Saccaline sorghum roots penetrated to a maximum depth of 4 ft. 2 ins. and spread from 12 to 18 inches from the plant. (Figure 5).

Figure 5



Diagrammatic sketch of the root system of Sweet Sorghum (var. Saccaline)—plants 10 weeks old growing in Grey-Brown soil of Heavy Texture. "Inverness" Muttaburra" (after O.T. Denmead)

(d) *Fallowing Investigations*—

The Western Queensland sheep belt has an average annual rainfall which has always been considered as sub-marginal for cropping. In an endeavour to grow crops in these areas it was decided to investigate a system of dry farming based on a fallowing period. A series of trial areas were selected and the treatments included—

i. a short fallow usually from July-September to the following January or February;
ii. a long fallow of about 18 months extending from July-September through the following calendar year and into January of the next year; and
iii. The addition of sulphate of ammonia to a short fallow treatment to assess the value of the fallow as a source of nitrogen.

Concurrent soil moisture and nitrate determinations were made on two of the trial areas by Denmead (1954), Horne (1955) and Catchpoole (1955).

"Gowrie," Charleville, 1954-6—

A valuable lesson was demonstrated in the initial year when the crops on the heavy grey brown soil, after growing magnificently until near the heading stage, suddenly collapsed through drought, whereas plants on the edge of a fallowed strip continued to grow rapidly and were of dark green colour, indicating adequate soil moisture and nitrate.

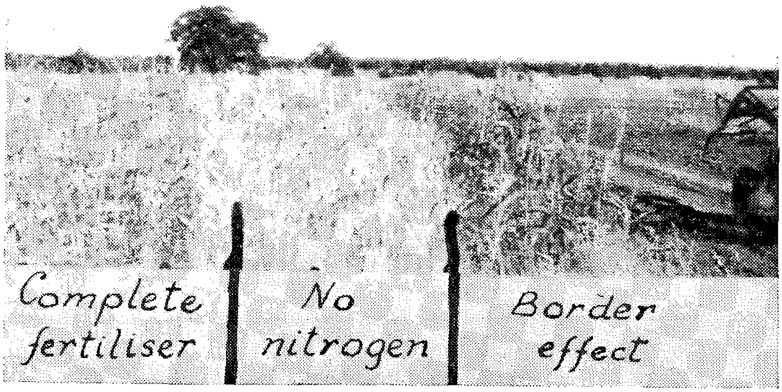


Plate III The initial fertiliser plots, "Gowrie," Charleville, on non-fallowed land. The soil moisture in the plots became exhausted and the plants with their roots tapping the fallowed land continued to grow to give a marked border effect.

Long fallow v. Short fallow—

This trial consisted of four replications of paired plots each 1/10 acre in area, on each of two soil types. The trial design only allows a comparison each alternate year. Results are given in Table XVIII.

Table XVIII

Rainfall and Yields

Year	Rainfall during growth	Grey brown soil		Red Brown Earth	
		Long Fallow	Short Fallow	Long Fallow	Short Fallow
	inches	tons G.M./acre		tons G.M./acre	
1954	8.84	—	2.4	—	1.8
1955	18.55	24.0	17.8	6.1	6.8
1956	16.67	—	11.4	—	not harvested

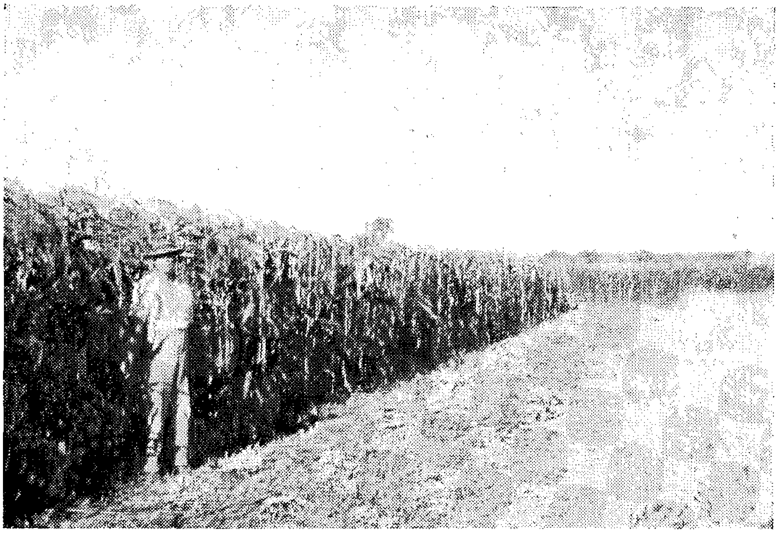


Plate IV A 24-ton per acre crop of Certified Saccaline Sorghum grown on fallowed land, "Gowrie," Charleville.

"Inverness," Muttaburra, 1954-6—

A similar trial was planted here beginning in 1954, with the results shown in Table XIX.

Table XIX

Rainfall and Yields

Year	Rainfall during growth inches	Long fallow tons G.M./acre	Short fallow tons G.M./acre
1954	4.40	—	3.0
1955	22.35	16.5	10.2
1956	7.39	—	5.5

Although the year 1955 was an exceedingly wet one and soil moisture would not be a limiting factor, the long-fallowed plots outyielded the short-fallowed ones by some sixty per cent. This was probably due to greater nitrification capacity in the plots under long fallow.

Plate V Fallowed and non-fallowed plots, "Inverness," Muttaburra, 1954.

Plate VI—The same plots cropped to sorghum in 1955. Note the greater growth and deeper colour of the crop on the fallowed plots.

"Terrick Terrick," Blackall, 1956—

This trial was laid down in 1955 to compare yields from land which had been long fallowed and land cropped to sorghum each year with the addition of nitrogenous fertiliser. There were four replications. Results are given in Table XX.

Table XX

Planted 11/2/56. Harvested 18/4/56

Treatment	Mean Yield — tons G.M./acre
Saccaline sorghum crop after long fallow	17.7
Saccaline sorghum after a previous crop + 4 cwt./ac. sulphate of ammonia	17.0

There is no significant difference between these yields. The present cost of sulphate of ammonia (August, 1956) is £39/5/- per ton f.o.r. Brisbane, and so the nitrate nitrogen accumulated during the long fallow was worth £7/17/- per acre in terms of sulphate of ammonia. Rail freight and road transport could add as much as £15 per ton delivered to the property.

Plate VII Crop on long-fallowed plot. At right: Crop on short-fallowed land plus 4 cwt./ac. of sulphate of ammonia. "Terrick Terrick" Stud, Blackall, 1956.

The influence of fallowing on feeding value—

Samples of green material were collected by Horne (1955) from the "Gowrie" fallowing trials on the heavy grey brown soil and anlysed. The analyses revealed a significant increase in crude protein in the material from the crop grown on land under long fallow. (Table XXI).

Table XXI

Analyses of Green Sorghum, "Gowrie" Fallowing Trial (on a moisture-free basis).

	Crude Protein	Fat	Fibre	Carbo-hydrate	Ash	Lime	Phosphoric acid as P2O5
	%	%	%	%	%	%	%
Long Fallow	4.25	1.75	36.55	49.31	8.15	0.33	0.22
Short Fallow	3.05	1.26	31.10	57.9	7.2	0.29	0.24

(Analyses by Biochemist, Department of Agriculture and Stock).

(e) ***Fertiliser responses***—

At the outset, it was desired to determine what plant nutrients, if any, were deficient in the soils being investigated, and a series of fertiliser trials designed to give quick results was laid down.

"Gowrie," Charleville, 1954—

A complete fertiliser trial including micro-nutrients was laid down in duplicate on both the heavy grey-brown soil and the Red Brown Earth. In the absence of fallowing prior to this first year's trials, the available soil moisture supply ceased a fortnight before harvest, and general observations only were taken on response. There appeared to be little difference in the treatments except for a marked response to nitrogen in both soil types, and to both nitrogen and phosphorus on the Red Brown Earth, with a positive interaction. The indicator crop was Italian sorghum. Results are given in Table XXII.

Table XXII

	Grey brown soil Mean Yield G.M. in tons/acre	Red Brown Earth Mean Yield G.M. in tons/acre
No fertiliser	4.5	3.7
All nutrients	7.0	8.3
All nutrients except phosphorus	7.0	5.5
All nutrients except nitrogen	4.8	5.1

The effect of a long fallow in providing nitrogen was subsequently studied.

In the same year, a similar trial was laid down at "Inverness," Muttaburra, on the heavy grey brown soil, with treatments only in duplicate. In 1956, a comprehensive 5 x 12 randomised block fertiliser trial was planted at "Gowrie," Charleville, on the lateritic red earth which, under natural conditions, carried mulga scrub. Italian sorghum was used as the indicator crop.

The complete fertiliser dressing consisted of the following mixture per acre—

Superphosphate	2 cwt.	Potassium sulphate	1 cwt.
Lime	2 cwt.	Copper sulphate	7 lb.
Ammonium sulphate	2 cwt.	Zinc sulphate	7 lb.
Molybdenum trioxide	1 oz.	Magnesium sulphate	56 lb.
Borax	3½ lb.	Manganese sulphate	14 lb.

Each of these ingredients was omitted in turn and a nil treatment was used as the control plot. On the heavy grey brown soil, lime was omitted because of the high lime status of the soil. The results are shown in Table XXIII.

Table XXIII

Treatment	Grey brown heavy soil, "Inverness," Muttaburra	Lateritic red earth, "Gowrie," Charleville
	Mean Yield G.M. tons/acre.	Mean Yield G.M. tons/acre.
1. All nutrients except boron	2.0	10.1
2. „ „ „ manganese	2.3	10.0
3. „ „ „ extra lime		9.7
4. „ „ „ molybdenum	2.4	9.5
5. „ „ „ copper	1.9	9.4
6. „ „ „ magnesium	2.2	9.3
7. „ „ „ zinc	2.1	9.3
8. „ „ „ potash	2.2	9.1
9. All nutrients	2.2	8.6
10. All nutrients except nitrogen	1.4	8.0
11. No fertiliser	1.6	4.5
12. All nutrients except phosphorus	2.1	3.9

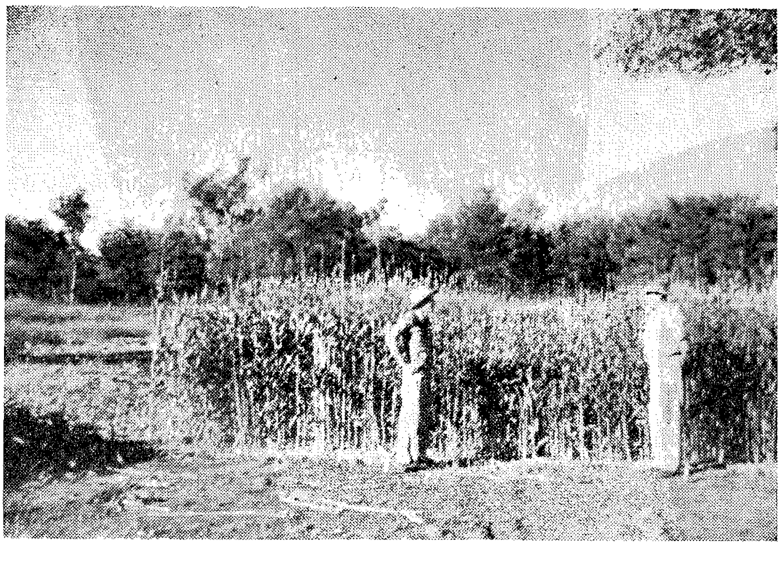


Plate VIII A "no superphosphate" plot (between the two men) on lateritic red mulga soil, "Gowrie," Charleville.

Nitrogen appeared to be the limiting factor at Muttaburra, and subsequent field tests have shown that this can be built up for crop production by fallowing. At P = 0.05, treatments 11 and 12 were significantly poorer than the others at "Gowrie," and superphosphate gave a marked response on this mulga soil. This fertiliser contains calcium, sulphur and phosphorus and pot tests have since shown that phosphorus is responsible for the effect. The most economical dressing of superphosphate will be determined in subsequent field trials.

The mineralisation of nitrogen in this virgin soil apparently provided adequate nitrogen for the initial crop, but it would be expected to be limited in subsequent cropping. It must also be remembered that mulga *(Acacia aneura)* is a legume and could have been effectively nodulated to provide a reserve of nitrogen in the soil.

"Dundee," Richmond, 1956—

A nitrogen fertiliser trial was laid down, including the following treatments

N_0, N_1, N_3, N_6 levels of nitrogen at planting nil, ½ cwt., 1½ cwt. and 3 cwt. of sulphate of ammonia per acre.

S_0, S_2, = side dressings at eight weeks nil and 1 cwt. of sulphate of ammonia per acre.

U_0, U_2, = levels of urea spray at eight weeks nil and the equivalent of 1 cwt. of sulphate of ammonia per acre as a urea spray.

It was intended that the side dressing and the urea spraying should take place six weeks after planting, but weather conditions prevented these operations at that time. The results are given in Table XXIV.

Table XXIV

Treatment	Mean Yield tons/acre	Significance (P = .05)
1. $N_6S_2U_0$	2.9	Signif. exceeds 4, 6, 7, 8 & 9
2. $N_6S_0U_0$	2.8	,, ,, 4, 6, 7, 8 & 9
3. $N_3S_0U_2$	2.7	,, ,, 4, 6, 7, 8 & 9
4. $N_3S_2U_0$	2.1	,, ,, 6 & 9
5. $N_3S_0U_0$	2.4	,, ,, 4, 6, 7, 8 & 9
6. $N_1S_0U_2$	1.8	
7. $N_1S_2U_0$	2.2	,, ,, 6 & 9
8. $N_1S_0U_0$	2.2	,, ,, 6 & 9
9. $N_0S_0U_0$	1.9	

The area had been cropped to sorghum the previous season. The rainfall during the growth of the crop was meagre and the crop suffered moisture stress. The nitrogen at planting gave significant responses in proportion to the magnitude of the dressing. There were no significant responses to side dressing or urea spray under the conditions of the trial. Further experiments under more favourable conditions are required to obtain the true picture of nitrogen response.

3. *Experimental Cropping*—

It was decided that in this low rainfall belt with a summer maximum incidence that short-growing summer crops would give the best performance. Further, the demand on soil moisture could be reduced by harvesting the crop in a comparatively green state for conservation as silage rather than waiting for maturity of the grain. Consequently, most of the cropping for conservation has been confined to the fodder sorghums with occasional attempts at grain production.

(a) *The sorghums*—

1. *Sorghum Variety Trials*—

Seven varieties of the sweet sorghums were tested at each of the four experimental sites in 1955. The layout was a 7 x 4 randomised block and the seeding rate 8 lb. per acre in 14 inch rows. All seed was certified except the commercial strain of Saccaline. The results are set out in Table XXV.

Table XXV

Variety	"Inverness," Muttaburra		"Gowrie," Charleville	
	Mean Yield G.M. tons/acre	Significance (P = .05)	Mean Yield G.M. tons/acre	Significance (P = .05)
1. White African	32.7	Significantly better than 7	24.2	Significantly better than 7
2. Sugar Drip	30.4	"	18.0	"
3. Early Orange	30.3	"	20.3	"
4. Saccaline	29.9	"	23.9	"
5. Italian	27.1	"	19.3	"
6. Saccaline (Commercial)	26.7	"	20.7	"
7. Sudan grass	12.1		11.0	
	"Terrick Terrick," Blackall		"Dundee," Richmond	
1. White African	8.9	Significantly better than 7	8.2	Significantly better than 7
2. Sugar Drip	9.8	"	9.5	6 + 7
3. Early Orange	9.4	"	8.8	7
4. Saccaline	10.6	6 and 7	10.3	6 + 7
5. Italian	9.6	7	7.1	7
6. Saccaline (Commercial)	9.1	7	9.5	6 + 7
7. Sudan grass	4.2		2.6	

* G.M. = Green Material throughout this Report.

(4) It should preferably be a tall-growing plant with a tendency to climb during its later growth;

(5) The seed should be of a size suitable for sowing through the seed drill with the sorghum.

The 1955 trials were observation plots using some thirty-three legumes obtained from the Queensland Department of Agriculture and Stock and the C.S.I.R.O. The seeds were all inoculated before sowing. Notes regarding performance are listed below—

Guar (Cyamopsis tetragonoloba) 16 varieties — disappointing — sparse foliage, erect, but not tall—to 18 inches badly affected by wilt.

Phaseolus mungo (Black Gram)—very promising—good leaf development, pods heavy, borne amongst the foliage, maturity satisfactory, a little short in growth—to 2ft. 3ins.

Mung bean (Phaseolus aureus) very promising -developed good bushes and an abundance of pods borne at the top of the bush above the leaves—a little early in maturity, height to 3ft.

Poona cowpea—grew very well, not as much foliage as the two previous plants. Matured too early for the sorghum but produced a heavy crop of seed.

Cristaudo cowpea grew very well and reached a height of 4ft. amongst the sorghum, produced a good crop of foliage and well-filled pods. It is a little early in maturity for saccaline sorghum, but would probably combine better with the Italian variety.

Reeves cowpea grew very well and was only slightly inferior to Cristaudo.

C.P.I. 9432 grew very well and was about equal to Reeves.

Black cowpea and Giant cowpea did reasonably well, but did not have the bulk of Cristaudo, Reeves or C.P.I. 9432 and the grain is a little too big for the combine.

Centro (Centrosema pubescens) did not thrive. The plants were very yellow, grew only a few inches high, and were sparsely nodulated.

Nanda soybean and *Clemson Non-Shatter soybean* did not impress; the plants were short with sparse foliage.

Phasey bean (Phaseolus lathyroides)—was disappointing. The plants grew erect but not tall, and produced only a little foliage.

Phaseolus aconitifolius was not suitable for silage purposes owing to its prostrate growth, but grew well, matured early and produced a heavy crop of seed.

Dolichos spp. (4 selections)—did particularly well, produced a good body of leaf, grew erect for two feet and then climbed the sorghum plants. They are very late maturing, beginning to flower when the sorghum was ready for ensiling. The seed is too big for "combine" sowing.

From these preliminary trials, Cristaudo, Reeves and Poona cowpeas, Mung bean, Phaseolus mungo and Dolichos spp. were chosen for further study. Samples of the various plots were collected, air-dried and analysed. The results are set out in Table XXIX.

Table XXIX

Composition on a moisture-free basis

Sample	Protein %	Fat %	Fibre %	Carbo-hydrates %	Ash %	Lime % CaO	Phosphoric acid % P_2O_5
Cristaudo cowpea (inter-row)	10.7	2.6	25.7	50.2	10.8	3.05	0.34
C.P.I. 9432 cowpea (inter-row)	8.4	2.0	26.2	54.4	9.0	3.11	0.26
C.P.I. 9432 cowpea (alone)	9.8	2.6	33.6	44.5	9.5	3.13	0.34
Dolichos 16883 (inter-row)	11.4	2.2	25.7	52.0	8.7	2.99	0.31
Dolichos 16883 (alone)	14.2	2.5	22.0	52.0	9.3	3.10	0.55
Dolichos 16880 (alone)	13.7	2.0	32.8	41.4	10.1	2.97	0.58

(Analyses by Biochemist, Department of Agriculture and Stock).

In addition to their use for admixture with sorghum in silage, legumes could be used for hay, green manure or for grain, the grain supplementing the sorghum silage as a protein-rich food. This legume grain could be picked from the ground by sheep in a similar manner to maize grain and to lupins (in W. Aust.), when used for drought feeding. A 9 x 4 randomised block design was used to test legumes at "Terrick Terrick" in 1956. The yields of green material and grain are listed in Table XXX.

Table XXX

Legume	Green Material tons/acre	Significance (P .05)	Grain bus./acre	Significance (P = .05)
		Signif. exceeds		Signif. exceeds
1. Poona cowpea	3.3		21.7	3 et seq.
2. Reeves cowpea	3.4		20.9	3 et seq.
3. Mung bean	4.0		15.9	4 et seq.
4. Cristaudo	4.0	5, 6, 7, & 8	9.3	8 and 9
5. Clemson Non-shatter soybean	2.0		7.3	
6. Navy bean	1.8		6.4	
7. Tokyo soybean	2.2		4.8	
8. Gaton soybean	1.7		4.6	
9. Nanda soybean	2.3		4.5	

The presence of the legume lifted the protein content from 4.4 to an average of 5.2 per cent. These protein figures are again low and it would appear that a greater proportion of legume would have to be used in mixtures to raise this level to the desired amount.

The interesting observation is that the legume grown alone had a higher level of protein than when grown in association with sorghum. It may be a better plan to grow both legume and sorghum alone in a system of strip cropping, harvesting them in blocks and mixing the material in the trailer and during tipping. In this way, a fallow-sorghum-legume rotation could be initiated to the benefit of both crops.

The 1956 trials with legumes and sorghum were designed to answer some of the above questions. Saccaline sorghum and Poona cowpea were grown alone and in row mixtures of 1 : 1 and 1 : 2 at row spacings of 14", 21" and 35" respectively. The plots were planted on 11/2/56 and harvested on 18/4/56. The treatments were—

1. Saccaline sorghum 14" rows.
2. Saccaline sorghum 21" rows.
3. Saccaline sorghum 35" rows.
4. Poona cowpeas 14" rows.
5. Poona cowpeas 21" rows.
6. Sorghum + Poona cowpea 14" rows 1 : 1 mixture.
7. Sorghum + Poona cowpea 21" rows 1 : 1 mixture.
8. Sorghum + 2 rows Poona cowpea 14" rows 1 : 2 mixture.
9. Sorghum + 2 rows Poona cowpea 21" rows 1 : 2 mixture.

The results (on a moisture-free basis) are given in Table XXXIII.

Table XXXIII

Treatment	Protein %	Fat %	Fibre %	Carbohydrate %	Ash %	Lime % CaO	Phosphoric Acid % P_2O_5	Tons G.M. /acre
1	4.0	1.7	27.3	59.7	7.3	0.40	0.30	5.5
2	4.8	1.7	28.1	57.8	7.6	0.41	0.33	5.0
3	4.2	1.7	26.6	60.0	7.5	0.45	0.34	4.6
4	10.8	2.2	26.8	50.7	9.5	2.17	0.59	2.0
5	11.5	2.5	26.8	49.9	9.3	2.07	0.53	2.5
6	6.7	1.9	30.4	52.8	5.2	0.87	0.44	4.2
7	6.2	1.9	30.1	54.1	7.7	0.53	0.42	4.2
8	6.9	2.1	26.1	56.9	8.0	0.61	0.39	4.7
9	8.1	2.0	29.0	52.6	8.3	0.81	0.48	3.3

(Analyses by Biochemist, Department of Agriculture and Stock).

It will be noted that the protein figure of 8.1 per cent. has been reached by combining one row of sorghum with two rows of cowpeas at the 21 inch spacing. This mixture at full feed would satisfy the requirements of a production ration for sheep. The attainment of this mixture, however, reduces the overall yield by some two tons of green material per acre. Table XXXIV indicates the relative yield of protein per acre under the various cropping treatments.

Table XXXIV

Crop	Row Spacing	Mean Yield tons G.M./acre	% Protein Moisture-free basis	Protein lb./acre
Sorghum alone	14"	5.5	4.0	122
Sorghum alone	21"	5.0	4.8	134
Sorghum alone	35"	4.6	4.2	107
Poona cowpeas	14"	2.0	10.8	121
Poona cowpeas	21"	2.5	11.5	163
Sorghum + Cowpeas 1 : 1	14"	4.2	6.7	156
Sorghum + Cowpeas 1 : 1	21"	4.2	6.2	145
Sorghum + Cowpeas 1 : 2	14"	4.7	6.9	181
Sorghum + Cowpeas 1 : 2	21"	3.3	8.1	152

Plate X—Poona cowpea and Saccaline sorghum growing in alternate rows 14 inches apart, "Terrick Terrick" Stud, Blackall, 1956.

(d) *General Considerations relating to Silage—*
Silage-making in Plastic Bags—

There have been some recent developments in the use of plastics, one of which is the storage of silage in temporary silos made of plastic material. While this trend seems rather unsuitable for bulk storage purposes in Western Queensland, there is a real need for some easy method of experimental manufacture of silage for research work. Some plastic (nyathine) bags of 0.002 in. thickness were obtained and a double bag filled with chaffed green sorghum from a forage harvester. The air was partly removed by a simple water-operated vacuum pump and the bag was tied at the neck with string and stored at room temperature under a building. The silage fermentation proceeded satisfactorily, and after ten weeks' storage, the material was analysed by Dr. J. M. Harvey, who reported as follows—

"*Quality Tests*

pH	4.10
Dry matter	21.0%
Volatile acids (as acetic)	0.82%
Residual acids (as lactic)	0.57%
Ratio lactic/acetic	0.7
Ratio amino acids/volatile bases	1.23

Appearance: Yellow stems and olive green leaves.

Smell: Very sweet with no marked deterioration on exposure to air for three days.

These tests indicate a fair quality silage. The pH is very good. The ratio of lactic acid to acetic is not ideal, due to the rather low concentration of lactic acid. It is suggested that this may have been due to the method of manufacture.

Stock Food Analysis—

Moisture percentage 79.0. The composition on a dry matter basis is given in Table XXXVI.

Table XXXVI

Protein %	Fat %	Fibre %	Carbohydrate %	Ash %	Lime Ca O. %	Phosphoric Acid (P_2O_5) %
8.3	1.5	34.3	43.6	12.3	0.32	0.38

This indicates a good quality product equivalent to prime oaten chaff. Provided the digestibility of the protein is good, which could only be determined by a digestibility trial, this silage should supply maintenance plus some production."

The result shows that plastic bags would be valuable for experiments into time of cutting and quality tests, in tests with additives, and in handling small to medium-sized samples for feeding trials. The plastic used was not satisfactory in a single thickness as the sharp ends of the cut silage punctured two of the single-thickness bags used before the double bag was tried. A thicker and stronger grade of plastic bag (Visqueen) is now available in thicknesses up to 0.008 ins.

Pests and Vermin

The Rat Problem—

During the past two years, rats have affected the crops of sorghum in the Richmond area, the 1956 plague being serious. The rats attack the lower internodes causing the plant to fall to the ground where it is subjected to further damage. A rat plague traversed this north-western zone at the close of the very wet 1950 year and the damage to vegetation aggravated the severe drought which developed in this area in 1951-2. Dr. C. M. Dunnett, of the Wild Life

Section of C.S.I.R.O., visited the area near the end of the plague and has tentatively identified the rat as *Rattus villosissimus*, a burrower and a poor climber, and suggested that netting fences might offer some protection to crops. However, more research is necessary in connection with this problem. An inspection of trenches which had been filled with silage and covered with two feet of soil revealed that the rats had not attacked the silage.

Plate XI—Rat damage to the lower internodes of sorghum, "Dundee," Richmond, 1955.

Grasshoppers

The Mitchell grass downs are known breeding areas for the plague grasshopper, particularly *Chortoicetes terminifera*, and damage has been caused to crops in some years, necessitating three plantings in one instance. Sudan grass appears to be more attractive than sweet sorghum, and severe defoliation has occurred in some crops.

Birds

It is very difficult to mature a crop of sorghum for grain in the Mitchell grass downs areas because of the depredations of galahs *(Kakatoe roseicapilla)* and corellas *(Kakatoe sanguinea)*. The former are more plentiful in the southern half of the area and corellas are more common in the north. These birds usually do not attack the grain until it is hardening up and so crops for silage usually escape attack.

There would appear to be a good case for research on bird control.

Miscellaneous trials and commercial cropping—
"Gowrie," Charleville

A simple "yes-no" experiment in which complete fertiliser was tried against no fertiliser was tested on the Lateritic Red Earth previously under mulga, using Gayndah strain buffel grass *(Cenchrus ciliaris)*, green panic *(Panicum maximum var trichoglume)*, Birdwood grass *(Cenchrus setigerus)*, guinea grass *(Panicum* *maximum)*, evening primrose *(Oenothera* sp.) and Townsville lucerne *(Stylosanthes sundaica)*. The response to the complete fertiliser was spectacular in all cases except with Townsville lucerne, a legume which is tolerant of low fertility.

Plate XI Turkey bush *(Eremophila gilesii)* infesting mulga *(Acacia aneura)* country at Charleville.

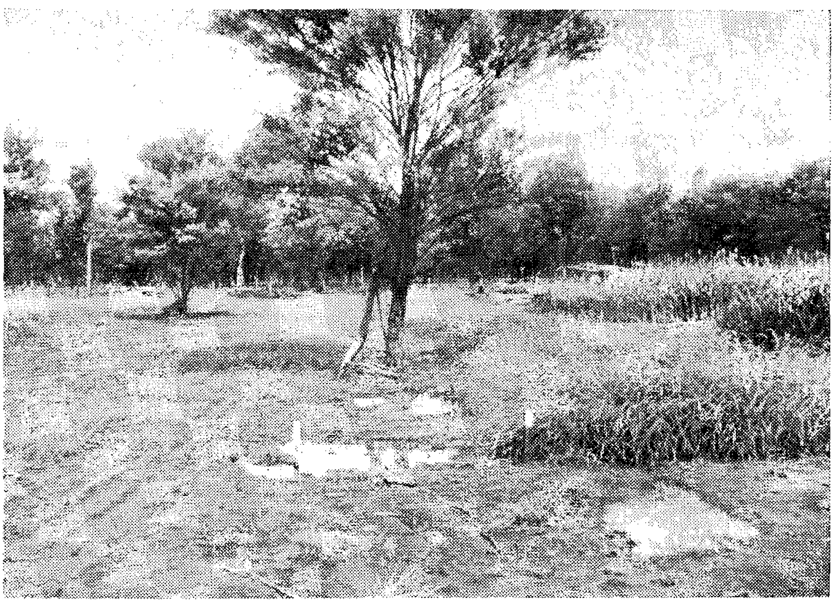


Plate XII —Buffel grass *(Cenchrus ciliaris)*—Gayndah strain on mulga country at "Gowrie," Charleville.
Unfertilised plot left: Complete fertiliser (including 2 cwt./ac. superphosphate) applied to plot at right.

On the alluvial levee soil of the Warrego floodplain for which available phosphate figures were satisfactory, buffel grass, green panic and Townsville lucerne were successfully introduced into a native bunch spear grass *(Heteropogon contortus)* and forest blue grass *(Bothriochloa intermedia)* pasture by broadcasting behind a scalloped disc harrow.

Commercial crops of Algerian and Richland oats have been grown in each of the three seasons 1954-6 on this alluvial levee soil with the addition of 2 cwt. of sulphate of ammonia per acre each year. This soil contains adequate phosphorus, but nitrogen is deficient and a good response was obtained with the sulphate of ammonia.

A native legume *(Psoralea eriantha)*, known as Bullamon lucerne, has been spreading naturally along this alluvial levee soil. It is a prostrate vine with a well-developed tap-root and is highly palatable and nutritious. It appears to have a place in the alluvial levees of many of our western rivers.

Further work on these plants is in progress.

Machinery for Silage Manufacture and Excavation—

Forage Harvesters—

The conservation of silage in large quantities has been made possible by the recent introduction of the forage harvester which cuts, chaffs and delivers the material from a standing crop to trailers or trucks, eliminating hand operations.

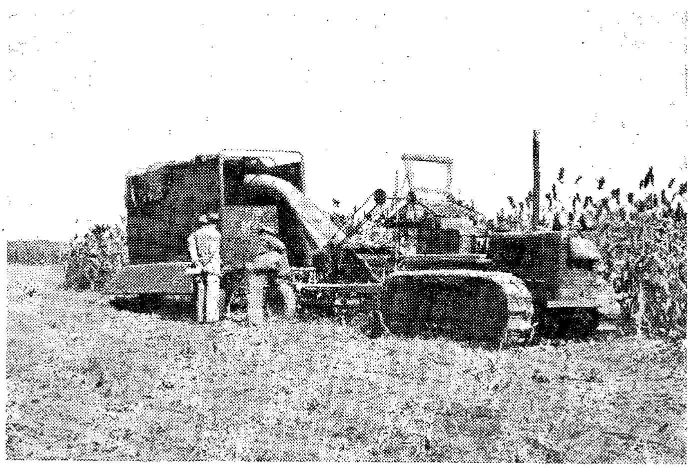


Plate XIII A 65.5 H.P. crawler tractor, cutter bar forage harvester, and side-tipping trailer harvesting a crop of sorghum at "Terrick Terrick" Stud, Blackall, 1955.

However, harvesting machinery for the large crops of sorghum which are being grown still constitutes a major problem, the bottle-neck being the width of cut at each passage of the machine, and mechanical difficulties in handling the tall crops. There are four classes of machines now available -the cutter-bar, the row-crop, the recently introduced hammer types, and the rotary cutter.

The cutter bar machines fall into two general categories, those with an overhead reel which over-tops the crop and feeds it back to the platform, and those which have a low reel pushing the crop forward to allow the cutter bar to sever the stalk near the ground, after which it is fed to the platform, butt end first. Difficulties with the first type occur when the reel cannot over-top tall crops or where the length of the stalk exceeds the platform length, and breaking and loss of material occurs in the process. Lengthening the platform by 3 ft. has improved this machine, but the alteration is costly. The low reel machines do their best work in shorter crops such as lucerne, wheat, etc., but in tall thick crops they can also perform well, provided there is sufficient body in the crop to push the material through, when they are capable of large capacity. In a lightly-populated crop, the stalks often receive a second cut with a consequent loss of heads.

The row crop machines were specially designed for tall crops grown in rows, and they have no problem regarding height of crop or of chaffing capacity, and would appear to be the best type of machine for smaller acreages. Three problems arise with this type, namely, the rate of cutting is slow because it handles only one row at a time; in weedy land, inter-row cultivation of the growing crop is necessary, and with coarser growth of stalks in the wider rows the material would need to be chaffed to a shorter length to make the silage attractive to sheep. Two-row machines now coming on the market will speed up harvesting operations.

The new hammer types of machine depend on cutting or shredding action performed by suspended metal units travelling at speed vertically about a rotating shaft. One type cuts with a narrow blade suspended at each end by short chains; the other uses dual metal strips attached directly to the shaft simulating the action of a hammer mill. Both machines do good work in short crops in a continuous sward, but the volume of tall crops makes hard work of harvesting for these low clearance machines, and in thin crops where ground cover is not complete there is a tendency to throw dirt into the shredded material.

The rotary cutting type has a series of horizontal blades rotating at high speed which chop the crop and deliver it to a blower. It also does good work in short crops, but finds difficulty in handling a bulky crop such as sorghum.

Trucks and Trailers for forage harvesters

Two schools of thought exist with regard to the collection of cut forage from the blower of the forage harvester. In one case, two tip-trucks which are driver-operated continuously operate a shuttle service from crop to trench with the material being delivered to the trucks driving parallel to the machine. Where adequate labour and money for the purchase of trucks are available, this system speeds up operations.

The second system operates with two trailers, one of which is towed behind the forage harvester with the tractor pulling both harvester and trailer. When the trailer is full, it is disconnected and taken to the trench by a separate power unit after a second trailer has replaced it behind the machine. This system requires only one man to attend to the trailers. A modification exists whereby the tip-truck can be trailed behind or beside the forage harvester and then unhitched and driven off under its own power when full. In this case, the truck is trailed from behind the forage harvester or from an extended drawbar of the tractor for side delivery of the material.

A side-tipping trailer operated by a winch has been developed by the McClymont Brothers of "Inverness," Muttaburra, and "Kensington," Longreach. The trailer cabin is built on a separate floor on top of the trailer table, and, when lifted from the side to an angle of 28°, discharges its load into the trench through hinged side doors swinging from the roof. In this case, the winch is operated from the gear box of the station truck which tows it, but hand-operated winches are also used.

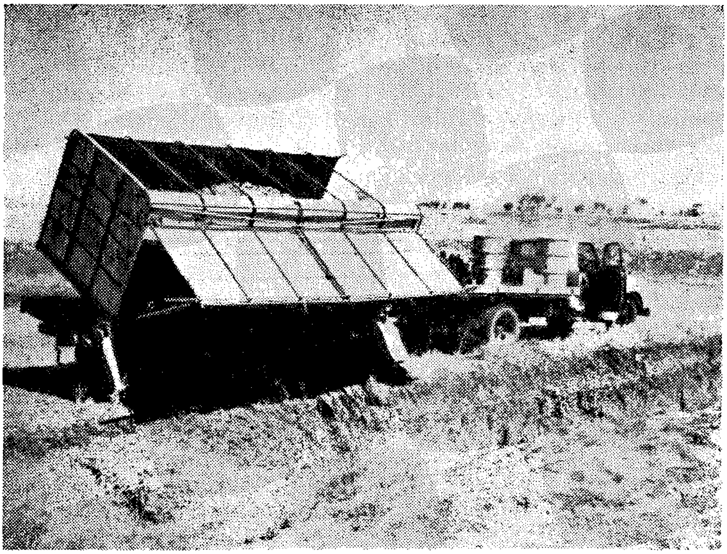


Plate XIV—A side-tipping trailer discharging its load. The lifting winch is driven from the gearbox of the towing truck. "Inverness," Muttaburra.

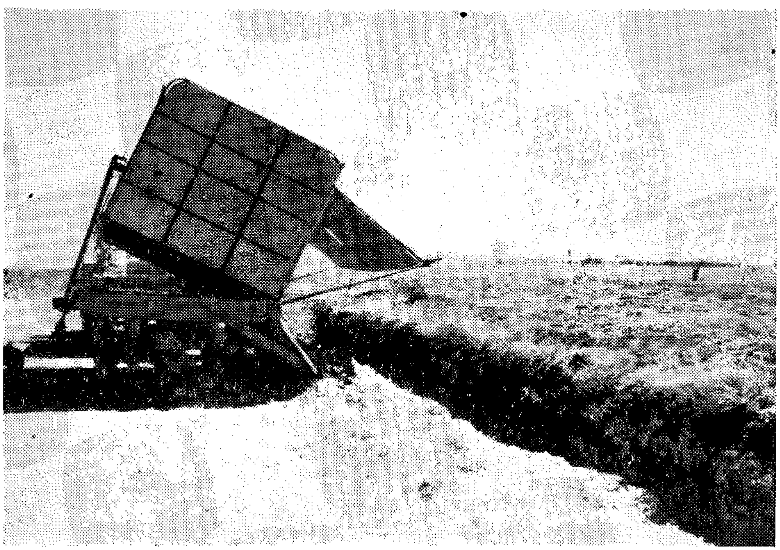


Plate XV Rear view of side-tipping trailer showing winch in operation.

Excavating Machinery

One of the deterrents to trench silage practices is the doubt about the ease of excavating and handling the silage at feeding time, and consideration is being given to this aspect. Excavating machines are available in America based on the principle of loosening a face of silage in a trench with rotating blades operating hydraulically in a vertical arc, the loose material dropping into the mouth of an elevator which delivers it to waiting trucks. A machine of this type is being made locally and will soon be available for testing.

The cost of Trench Silage in the "under 20 inch" Sheep Belt—

Figures for the cost of growing and ensiling a sorghum crop have been obtained for two properties, based on early 1955 costs. Both are privately owned, and the owners, with the application of mechanical knowledge, have cut costs on some machinery by home building and fitting.

Costs for these two properties have been drawn up and set out in Table XXXVII.

Table XXXVII

Item	"Inverness," Muttaburra			"Dundee," Richmond		
		£	£		£	£
Plant	Tractors (2)	2470			2232	
	Plough	290			—	
	Disc harrows	130			161	
	Harrows	96			146	
	Combine	386			440	
	Forage harvester	1180			1215	
	Trailers }	500		Two hoists	262	
	3-ton Truck }	1700				
	Dozer blade	200			900	
	Rippers				286	
	Total Plant	£6952		Total plant	£5642	
	Depreciation at 10%		£695	Depreciation at 10%		£564
Trenches		321			458	
	Depreciation at 10%		37	Depreciation at 10%		45
Seed			143			372
Labour			372			552
Fuel			339			980 (and vehicle costs)
Repairs			346			380
Misc.						53
5% Interest on Capital			365			305
Total Cost			£2297			£3251
Cost per acre cultivated			£4 18 7			£6 10 0
Estd. Silage Stored			1600 tons			2000 tons
Estimated Yield			4 tons per ac.			app. 4 tons per ac.
Cost per ton			£1 8 8			£1 12 6

It would be legitimate to add to the above costs a rental for the land.

Discussion

1. *Silage—*

The principles involved in silage manufacture have been known since early times, but the adoption of the practice in Australia, and particularly in Queensland, has been very slow. The reasons for this would seem to lie in a number of causes, chief of which may be listed a general lack of knowledge of the simplicity of the operation, labour problems, lack of finance, and the heavy work previously involved in handling the green crop. In Western Queensland, the risk of crop failure could be added.

These barriers to conservation of fodder as silage have been largely removed. The first major onslaught on the problem was the introduction of the forage harvester, which mechanised the cutting and loading, and streamlined the process to eliminate labour and cut down time.

Knowledge of the procedure has been spread by demonstrations at field days on properties, in which this University has played a leading part.

The financial barrier has been made less burdensome by the far-sighted legislation providing 20% depreciation on machinery and taxation concessions for the value of fodder stored, although the initial outlay is still considerable.

Silage manufacture fits in well with the known characteristics of the Mitchell grass areas in Western Queensland where the soils are of high moisture-holding capacity and of good fertility under fallow. The short summer monsoonal season can supplement the moisture already stored in a fallow to give a reasonably high expectancy of crops. Further, silage requires the harvesting of the crop in the immature state, thus saving soil moisture, largely removing the hazard of bird attack on the grain and lessening rat damage. If the young crop faces a soil moisture shortage it can be ensiled at any stage to prevent crop loss. Silage is not subject to a fire hazard, and storage trenches involve little capital outlay.

Silage is the best type of home grown roughage available in these Western downs areas, being superior in feeding value and in succulence to bush hay. Its ability to remain in storage with little deterioration over several years adds to its value in drought mitigation and permits the good seasons to provide food for the leaner years. This storage then becomes a 'bank,' protecting the owner against drought losses in sheep, lambs and wool; heavy agistment or replacement burdens; and stabilises his carrying capacity. Present stocks of silage stored underground on some thirty properties in the Queensland sheep belt must now approach the 80,000 ton mark. At 3 lb. of silage per head per day, plus supplement, this would support some 160,000 sheep for a full year's drought feeding.

2. (a) *Costs of Production—*

Figures have been given in Table XXXVII for the cost of ensiling sorghum on two grazing properties in Western Queensland as £1/8/8 and £1/12/6 per ton respectively. These costs were based on the early years results representing yields of only 4 tons of green material per acre. The highest yields so far obtained have been 32.7 tons per acre in small experimental plots hand-harvested, and 24 tons per acre for larger plots. Several yields have ranged from 8 to 12 tons per acre. The higher the yield, the less will be the cost per ton of green material, and a figure of 4 tons per acre may be considered low. However, on a year-in-year-out basis, taking into consideration years when no crop is planted or a very poor crop is grown because of drought conditions, such a yield as 4 tons per acre could well be a reasonable figure.

This cost of approximately 30/- per acre is remarkably cheap in relation to the cost of landed fodder purchased from the recognised farming areas. Moule has shown comparative costs per lb. of energy-producing foods in recognised foodstuffs in Table III. Sorghum silage with a digestible crude protein content of 1.5% gives a cost per lb. of energy-producing foods of $\frac{3}{4}$d., compared with 5d. for maize grain, 5$\frac{1}{2}$d. for lucerne hay and 1$\frac{1}{2}$d. for Mitchell grass hay. Freight charges by rail and road would considerably increase the listed price, as most properties must inevitably be removed from both rail and serviced roads. In a normal year, lucerne hay might sell at £12 ton in Brisbane, but in a drought year it has often reached £50 a ton. The rail freight from Brisbane to Longreach is £11/13/6 ton (October, 1956), and to this must be added road transport to the property.

(b) *Feeding Value and Cost of Feeding*—

Sorghum silage is palatable and succulent, well-supplied with vitamins, and fairly well-supplied with energy-forming foods. It is, however, a little deficient in protein when the crop is cut at the normal stage for ensilage (medium dough stage).

Hewitt (1953) gives the maintenance requirement for sheep per week per hundred pounds live weight as 4 lb. of starch equivalent and 0.4 lb. of protein equivalent.

This amount would be provided by the following mixtures at the listed cost—

Daily Ration	Starch Equivalent (lb.)	Protein Equivalent (lb.)	* Cost per 1000 sheep/ month
Daily requirement	0.57	0.057	
7$\frac{1}{2}$ lb. sorghum silage	0.675	0.052	£200
3$\frac{1}{2}$ lb. sorghum silage + 2 ozs. meat meal	0.575	0.054	£178
6 lb. sorghum silage + 1 oz. cowpea	0.583	0.054	£194

* Based on sorghum silage at £2 ton, meat meal at £50 ton (40% protein) and cowpeas (£1 per bushel and 25% protein).

Moodie (1956) fed sheep at Blackall on a daily ration of 7$\frac{1}{2}$ lb. of silage and the sheep were alive after seven months' feeding in yards without access to other food. The sheep were, however, very weak at the end of this period.

Moule (1954) fed sheep of about 70 lb. live weight at Muttaburra with a ration of 3 lb. of sudan grass silage plus 2 oz. of meat meal per day in yards without access to other foods and they were maintained in reasonably good condition for the two months' trial period.

Home-grown legumes could be utilised as a supplement to the silage to provide the extra protein required. Experiments in utilising these supplements are in progress within the University Department of Animal Husbandry. In addition, concentrated nitrogenous materials including urea, ammonia, ammonium sulphate and ammonium nitrate are under trial. If satisfactory, these materials will be considerably cheaper sources of protein nitrogen for drought feeding purposes.

3. *Feeding methods*—

The method of handling silage for feeding purposes has not yet received much attention because of the good seasons experienced in these Western areas since conservation commenced. One grazier fed the silage in small heaps along an earth road to ewes and young lambs for a fortnight, and these sheep ate the silage readily and quickly. Heavy rains were then received and hand feeding ceased.

It is thought that such a method of feeding will be satisfactory provided that the heaps are sufficiently small for quick consumption without fouling. Troughing is expensive.

Supplements could be added from a tank or hopper mounted over the elevator leading from the excavator to the distribution trucks or trailers.

4. *Integration with Station Management*—

The introduction of cropping and conservation as silage means some reorganisation of station management. The system has been sufficiently proved to start off with an area large enough to warrant the appointment of an experienced farmer and the purchase of equipment to handle at least 300 acres of crop each year. This frees the owner of the immediate labour problem involved and the normal station labour can be called in to support the farmer during the busy periods of planting and harvesting.

The silage conserved can be used—

(a) for drought mitigation;

(b) for special seasonal feeding.

(a) *Silage for drought mitigation*—It is generally considered that stocks of conserved fodder should be sufficient to carry the stock through a two years' drought. It is unlikely that the whole of the stock on the property would be fed. An early effort would be made to unload surplus stock and the young breeding ewes would certainly be retained to rebuild the flock. The grazier must decide then when he has sufficient silage to carry his selected flock through a reasonable drought period. Feeding at 3 lb. of silage per day requires approximately a ton for every 750 per day, or 40 tons per 1,000 per month. For a flock of 5,000 sheep, this would require a storage of approximately 5,000 tons of silage to tide it over the two-year period. At a heavier daily rate of feeding of 6 lb., the amount would be 10,000 tons. The attitude of the stock towards silage should be cultivated so that when drought feeding commences little difficulty will be experienced in getting the sheep to eat. Sheep are notoriously timid feeders, and it would be a good plan for every grazier intending to feed silage during drought to teach a small training flock to eat it during the good seasons so that they will readily lead others to it when drought feeding commences in earnest.

(b) *Silage for special feeding*—While the prime aim in conserving silage would normally be for drought mitigation, silage could very well form the basis for special feeding at critical periods of the year. Beneficial results should accrue from feeding both ewes and rams just before and at joining, and ewes before and after lambing.

Gunn, Sanders and Grainger (1942) have shown that vitamin A is essential for Merino rams for spermatogenesis, and it is present in adequate amounts in young grass, green forage and silage. In addition to the lack of vitamin A in these areas, Gunn (1942) showed that temperatures in excess of 95°F lead to seminal degeneration in rams, so that mating during this extreme heat period would result in low lambing percentage. Moule (1950) has pointed out that there is a closed area in the Mitchell grass downs belt between Winton, Richmond and Kynuna, and extending towards Cloncurry, where mean monthly maximum temperatures exceed 95°F from October to March inclusive. It should be possible with adequate stocks of silage on hand to permit joining in the cool months of the year, when semen quality is high and most of the ewes are in oestrus, and lamb on silage if other succulent feed is scarce. In this way, it is probable that the low lambing percentages common in these areas could be lifted.

Such practices would require stocks of silage in addition to those set aside for drought feeding, and a succession of good seasons would be required to build up adequate stocks. In the meantime, sorghum stubble and regrowth can, and has already filled in during these critical periods, thus adding to the general success of cropping in these Mitchell grass downs areas.

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REFERENCES

BIRD, A. R., 1953 A Study of the Factors Responsible for the Fluctuations of Sheep Numbers in the Charleville District of South Western Queensland, 1939 49. **Pap. Dept. Agric. Univ. Qd. 1 (2): 43-85.**

CARNEY, J. P., 1951—Regional Studies of the Australian Woolgrowing Industry. 2. Longreach Blackall District, Queensland.—**Bur. Agric. Econ., Canberra.**

CATCHPOOLE, V. R., 1956 Personal communication.

DAVIDSON, D., 1954 —The Mitchell Grass Association of the Longreach District.—**Pap. Dept. Bot. Univ. Qd. 3 (6): 46-59.**

DENMEAD, O. T., 1953 Honours Thesis University of Queensland.

DAVIES, J. G., SCOTT, A. E. and KENNEDY, J. F., 1938—The Yield and Composition of a Mitchell Grass Pasture for a period of Twelve Months. **J. Coun. Sci. Industri. Res. Aust. 11 (2): 127-142.**

EDYE, L. A., 1953 Honours Thesis, University of Queensland.

EVERIST, S., and MOULE, G. R., 1952 Studies in the Environment of Queensland. 2. The Climatic Factor in Drought. **Qd. J. Agric. Sci. 9 (3): 185-299.**

EWER, T. K., 1955—Personal communication.

FARMER, J. N., EVERIST, S. L., and MOULE, G. R., 1947—Studies in the Environment of Queensland. 1. The Climatology of Semi Arid Pastoral Areas.—**Qld. J. Agric. Sci. 4 (3): 21-59.**

FRANKLIN, M. C., BRIGGS, P. K., and McCLYMONT, G. L., 1955—The Utilisation of Low Quality Pasture. **J. Aust. Inst. Agric. Sci. 21 (4): 216-228.**

GUNN, R. M. C., SANDERS, R. N., and GRANGER, W., 1942 Studies in Fertility in Sheep. 2. Seminal Changes Affecting Fertility in Rams. **J. Coun. Sci. Industr. Res. Aust. Bull. 148: 5-134.**

HARVEY, J. M., 1952—The Nutritive Value of Some Queensland Fodders. **Qd. J. Agric. Sci. 9 (3): 169-183.**

HEWITT, A. C. T., 1950 Feeding Farm Animals. Angus and Robertson Ltd., Sydney.

HORNE, W. R., 1955—Personal Communication.

HORNE, W. R., and DENMEAD, O. T., 1954— A Modified Colorimetric Method for the Field Determination of Soil Nitrate. **J. Aust. Inst. Agric. Sci. 21 (1): 34-6.**

HUMPHREYS, L. R., 1955—Private Communication.

MARRIOTT, S., and HARVEY, J. M., 1951—Bush Hay Conservation in North Western Queensland.—**Qd. Agric. J. 73 (5): 249-255.**

MOULE, G. R., 1950 —Some Problems of Sheep Breeding in Semi-Arid Tropical Queensland. **—Aus. Vet. J. 26 (2): 29-37.**

MOULE, G. R., 1954 Private Communication.

PIERCE, A. W., MOULE, G. R., and JACKSON, M. N. S., 1955—The Effect of Thrice Weekly Ingestion of Urea on Wool Production by Grazing Sheep.—**Qd. J. Agric. Sci. 12 (4): 107-117.**

PRESCOTT, J. A., and THOMAS, J. A., 1949 The Length of the Growing Season.—**Proc. roy. Geog. Soc. Aust.** (S.A. Branch), Vol. 50.

ROE, R., 1941 Studies on the Mitchell Grass Association in South-Western Queensland. 1. Some Observations on the Response of Mitchell Grass Pasture to Good Summer Rains Following the 1940 Drought. **J. Coun. Sci. Industr. Res. Aust. 14 (4): 253-9.**

ROE, R., and ALLEN, G. H., 1945—Studies on the Mitchell Grass Association in South-Western Queensland. 2. The Effect of Grazing on the Mitchell Grass Pasture. **J. Coun. Sci. Industr. Res. Aust. Bull. 185. 4-27.**

Appendix I

Soil Moisture Determinations (% on oven-dry weight basis) Heavy grey brown soil, "Gowrie," Charleville (after W. R. Horne)

Sampling dates

	Depth	6/1/54	27/2/54	31/3/54	24/9/54	4/12/54	Planting 21/1/55	1/4/55	Harvest 20/4/55
LONG FALLOW	0—6"	15.2	14.9	11.9	16.6	11.1	25.0	13.7	16.2
	6—12"	13.9	19.8	16.2	23.2	20.0	24.5	16.2	19.0
	12 24"	12.7	22.8	20.3	23.4	20.9	25.0	18.1	17.2
	24—36"	14.6	20.6	19.4	22.0	20.2	22.2	19.7	16.8
	36—48"	14.0	14.8	15.8	18.4	15.8	20.0	18.1	17.4
SHORT FALLOW	0—6"	Planting 12.9	12.9	Harvest 7.7	17.9	10.9	Planting 25.6	14.2	Harvest 14.3
	6—12"	14.4	15.8	11.2	22.3	20.2	25.3	17.9	18.8
	12 24"	13.7	18.9	12.5	19.6	20.7	25.4	19.2	17.4
	24 36"	14.7	17.0	13.8	17.7	18.1	21.7	20.3	17.2
	36—48"	14.0	11.2	13.7	15.8	14.6	17.9	16.2	15.4

Wilting Point 13.3%

Soil Moisture Determinations (% on oven-dry weight basis) Red Brown Earth, "Gowrie," Charleville.

	Depth	6/1/54	27/2/54	31/3/54	27/9/54	4/12/54	Planting 21/1/55	1/4/55	Harvest 20/4/55
LONG FALLOW	0—6"	9.3	7.6	4.9	6.6	4.1	10.6	5.7	7.0
	6—12"	12.2	13.5	12.3	15.4	14.3	15.0	10.2	10.1
	12—24"	9.9	12.8	13.7	16.2	14.3	15.0	10.5	9.3
	24—36"	8.4	12.3	12.8	14.2	12.5	15.1	11.2	11.2
	36—48"	10.3	10.2	11.4	14.2	13.4	15.9	12.1	12.1
SHORT FALLOW	0—6"	Planting 8.7	4.0	Harvest 4.7	6.0	4.3	Planting 15.0	5.6	Harvest 7.8
	6—12"	8.7	10.5	7.4	14.8	14.1	17.7	10.1	11.7
	12—24"	8.3	10.2	8.2	15.1	13.2	15.2	10.9	11.7
	24—36"	8.2	9.2	9.0	12.2	11.1	13.3	13.0	10.8
	36—48"	10.0	9.8	11.2	13.3	10.6	14.0	12.1	12.6

Wilting Point 8.6%

Moisture, expressed in inches, available for plant use on heavy grey brown soil at "Gowrie," Charleville (after W. R. Horne)

Sampling dates

	Depth	6/1/54	27/2/54	31/3/54	24/9/54	4/12/54	Planting 21/1/55	1/4/55	Harvest 20/4/55
LONG FALLOW	0 6"	.1	.8	—	.2	—	.6	—	.2
	6 12"	—	.5	.2	.7	.5	.8	.2	.4
	12—24"		1.7	1.3	1.8	1.4	2.1	.9	.7
	24—36"	.2	1.4	1.2	1.7	1.3	1.7	1.2	.7
	36—48"	.1	.3	.5	1.0	.5	1.3	.9	.8
	Available to 4 ft.	.4	4.7	3.2	5.4	3.7	6.5	3.2	2.8
SHORT FALLOW	0 6"	Planting —	—	Harvest —	.2	—	Planting .7		Harvest
	6 12"	.1	.2	—	.6	.5	.8	.3	.4
	12 24"	.1	1.0	—	1.1	1.3	2.2	1.1	.7
	24—36"	.3	.7	.1	.8	.9	1.6	1.4	.8
	36—48"	.1	—	.1	.5	.1	.9	.5	.4
	Available to 4 ft.	.6	1.9	.2	3.2	2.8	6.2	3.3	2.3

Moisture, expressed in inches, available for plant use on Red Brown Earth at "Gowrie," Charleville (after W. R. Horne)

Sampling dates

	Depth	6/1/54	27/2/54	31/3/54	24/9/54	4/12/54	Planting 21/1/55	1/4/55	Harvest 20/4/55
LONG FALLOW	0—6"	—	—	—			.1		
	6—12"	.3	.4	.3	.5	.4	.5	.1	.1
	12 24"	.2	.8	1.0	1.5	1.1	1.2	.4	.1
	24 36"	.4	.7	.8	1.2	.8	1.3	.5	.5
	36—48"	.3	.3	.5	.9	.8	1.2	.6	.6
	Available to 4 ft.	1.2	2.2	2.6	4.2	3.1	4.3	1.6	1.3
SHORT FALLOW	0—6"	Planting —	—	Harvest —	—		Planting .3	—	Harvest —
	6—12"		.2	—	.5	.4	.6	.1	.2
	12—24"		.3		1.2	.9	1.3	.4	.6
	24—36"	—	.1	.1	1.2	.5	.9	.9	.4
	36—48"	.2	.2	.3	.8	.3	.9	.6	.7
	Available to 4 ft.	0.2	0.8	0.4	3.7	2.1	4.0	2.0	1.9

APPENDIX II

Soil Moisture Determination (as % oven-dry weight) — Heavy grey-brown soil, "Inverness," Muttaburra (after O.T. Denmead).

Sampling Dates

	1954 (Fallowed)						1955 (Cropped)						1956 (Fallowed)					
Depth	Pltg. 12/2/54	Harv. 26/4/54	Moist. Loss	Ins. Loss	Grow. Period Rainfall	Evapo-trans. + runoff	Pltg. 7/2/55	Harv. 11/5/55	Moist. Loss	Ins. Loss	Grow. Period Rainfall	Evapo-trans. + runoff	Pltg. 29/1/56	Harv. 13/4/56	Moist. Loss	Ins. Lost	Grow. Period Rainfall	Evapo-Trans. + run-off
LONG FALLOW																		
	%	%	%						%						%			
0 - 6"	31.1	20.8	10.3	.8			33.1	16.7	16.4	1.2			28.7	21.0	7.7	.6		
6 - 12"	32.4	24.6	7.8	.6			30.0	18.9	11.1	0.8			29.1	25.8	3.3	.2		
12 - 24"	30.1	25.4	4.7	.7			32.7	18.0	14.7	2.1			30.0	27.0	3.0	.4		
24 - 36"	27.3	26.8	0.5	.1			33.2	20.3	12.9	1.9			30.3	29.2	1.1	.2		
36 - 48"	21.3	24.0	+ 2.7	+ .4			28.8	25.3	3.5	0.5			26.0	26.8	+ .8	+ .1		
48 - 60"	16.2																	
60 - 72"	14.5																	
Inches to 4ft.	15.6	14.6		1.8	5.4"	7.2"	18.3	11.8		6.5	22.3"	28.8"	16.9	15.6		1.3	7.4"	8.7"
SHORT FALLOW		1954 (Cropped)						1955 (Cropped)						1956 (Cropped)				
0 - 6"	31.6	15.4	16.2	1.2			32.8	16.4	16.4	1.2			26.9	17.6	9.3	.7		
6 - 12"	31.8	20.3	11.5	.8			30.6	19.5	11.1	.8			27.8	21.2	6.6	.5		
12 - 24"	29.0	19.7	9.3	1.3			32.9	18.8	14.1	2.0			28.0	24.7	3.3	.5		
24 - 36"	28.2	25.0	3.2	.5			29.9	23.5	6.4	.9			28.2	27.1	1.1	.2		
36 - 48"	20.1	22.1	–2.0	+.3			29.9	26.4	3.5	.5			28.0	26.8	1.2	.2		
48 - 60"	15.5	16.1																
60 - 72"	16.4	15.0																
Inches to 4ft.	15.9	12.4		3.5	5.4"	8.9"	18.1	12.7		5.4	22.3"	27.7"	16.5	14.4		2.1	7.4"	9.5"

The evapo-transpiration figures for the three periods during which the crops were growing have been arrived at by averaging the figures for Winton and Blackall. These are as follows—

1954 season (3 months) 14.49"   1955 season (3 months) 17.33"   1956 season (3 months) 14.00"

Appendix III

Nitrate nitrogen in heavy grey brown soil at "Gowrie," Charleville
Figures in parts per million except where otherwise stated—(after W. R. Horne)
Sampling dates

	Depth	6/1/54	27/2/54	31/3/54	24/9/54	4/12/54	Planting 31/1/55	1/4/55	Harvest 20/4/55
LONG FALLOW	0 —6"	4.8	4.7	5.0	9.0		2.3	2.2	1.9
	6—12"	3.6	3.3	2.8	4.7		3.8	1.8	1.5
	12 24"	2.8	3.0	2.7	3.1		4.4	1.5	1.5
	24—36"	3.1	3.6	2.5	3.7		3.4	1.9	2.2
	36—48"	2.9	1.8	1.6	2.8		1.7	1.7	1.9
	Total in lb. N per acre to 4 ft.	5.3	47.8	40.2	60.6		50.3	27.8	29.1
SHORT FALLOW	0 6"	Planting 4.6	2.8	Harvest .8	5.3		Planting 2.9	1.1	Harvest 1.8
	6—12"	3.1	2.7	1.3	2.7		2.2	2.3	1.5
	12—24"	2.8	2.2	.8	1.8		3.8	1.5	2.6
	24—36"	3.1	2.5	1.0	2.0		3.0	2.0	1.9
	36—48"	3.2	2.0	.8	1.0		2.7	1.7	1.5
	Total in lb. N per acre to 4 ft.	50.5	37.2	15.2	32.0		50.0	27.8	30.5

Nitrate Nitrogen in Red Brown Earth at "Gowrie," Charleville
Figures in parts per million except where otherwise stated
Sampling dates

	Depth	6/1/54	27/2/54	31/3/54	24/9/54	4/12/54	Planting 31/1/55	1/4/55	Harvest 20/4/55
LONG FALLOW	0—6"	4.9	3.2	2.5	7.3		3.7	.7	1.3
	6 12"	5.1	2.4	1.6	3.0		5.4	1.0	2.8
	12 24"	6.0	2.4	1.6	5.9		4.0	3.3	2.8
	24—36"	7.3	9.3	5.6	10.1		17.3	6.0	8.1
	36—48"	9.9	17.0	8.0	15.1		19.3	10.7	8.5
	Total in lb. N per acre to 4 ft.	112.6	126.1	69.0	141.8		184.9	85.2	88.4
SHORT FALLOW	0—6"	Planting 4.0	1.1	Harvest .9	5.5		Planting 2.9	1.2	Harvest 1.7
	6 12"	3.7	1.8	.6	1.8		3.4	1.9	1.4
	12 24"	2.8	1.6	.6	1.9		3.5	1.9	1.4
	24—36"	6.1	11.1	6.7	7.2		14.6	7.1	2.8
	36—48"	11.8	18.0	11.2	13.5		22.9	10.1	9.3
	Total in lb. N per acre to 4 ft.	96.8	130.9	78.5	101.5		179.2	84.2	58.9