PASTURE DEVELOPMENT IN THE WESTERN DARLING DOWNS AND SOUTHERN BRIGALOW, MAY FIELD MEETING, 1967

SPECIES AND MINERAL NUTRITION STUDIES ON DEEP SANDS OF SOLODIC ASSOCIATIONS—A PROGRESS REPORT

by

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SUMMARY

Solodized solonetz soils with sandy A-horizons more than 18 in. deep have produced high yields of Siratro *(Phaseolus atropurpureus)*, Lucerne *(Medicago sativa)*, *Dolichos lablab* and Serradella *(Ornithopus* spp.) in a 25 in. rainfall area.

The mineral fertility of the soils is very low, and deficiencies of phosphorus, calcium, potassium, molybdenum, copper, zinc, manganese and boron have been recorded. The soils are poorly buffered against heavy metal toxicities.

Root knot nematodes *(Meloidogyne* sp.) may cause serious losses in susceptible legume species. Seedling mortality in lucerne is considered the most important problem.

INTRODUCTION

Approximately 4 million acres of solodized soils occur in that part of the 22-26 in. rainfall area of southern Queensland, which is situated to the south and west of the Great Dividing Range. This area receives relatively reliable winter rainfall. The soils and vegetation of the southern portion of this area have been described in detail by Isbell (1957) and Beckmann and Thompson (1960). The solodized soils are generally infertile, with low nitrogen and phosphorus contents. Many members are physically intractable.

They are soils of particular significance because of their proximity to the intensely developed black earth and brigalow soils, and their associated public facilities. In recent years, development pressure has resulted in the production of winter cereals (particularly barley) and forage crops (oats, cowpeas and sorghum) on these soils. Superphosphate usage has been accepted, but nitrogen fertilizers could be used more widely than they are at present (Leslie and Hart, 1967). The main contribution of forage crop development has been the conversion of woolgrowing properties to breeding enterprises.

Continued cultivation results in rapid physical deterioration of the surface soil. Soil erosion, leading to the exposure of the B-horizon, can be devastating. These influences, plus the economic limitations to complete property development for forage crop production, warrant the establishment of permanent or rotation pastures.

Lucerne has been grown successfully for many years on solodized soils timbered naturally with poplar box *(Eucalyptus populnea)*. Establishment and maintenance has required superphosphate treatment, but no detailed studies of the mineral status of these soils have been made. It appears that the poplar box soils on which lucerne has been successful possess a higher calcium status than other soils of the group. Considerable commercial areas of Rhodes grass, buffel grasses and annual *Medicago* spp have also been established.

In 1958, attention was directed at two other soils representative of a large proportion of the total area, and about which no information pertinent to pasture development was available.

Preliminary Studies, 1958-60

Soil 1
Solodized solonetz. Clay loam A-horizon 3-4 in. deep overlying a dense columnar B-horizon. Timber—buloke (*Casuarina lehmanii*) and ironbark (*Eucalyptus crebra*). Location—"Stirling Park", Kogan. Fertilizer experiments were carried out with Biloela buffel grass *(Cenchrus ciliaris)* and phasey bean *(Phaseolus lathyroides)*. Growth of phasey bean was poor, but growth responded to superphosphate and molybdenum. The buffel was a one-year old stand, and growth was increased substantially, only when superphosphate and nitrogen were applied in conjunction (Table 1).

TABLE 1
Yields Biloela Buffel Grass (lb. D.M. per acre)

NP	P	N	O
1274**	389	411	242

O — No fertilizer.
N — 70 lb. per acre nitrogen (as urea).
P — 448 lb. per acre superphosphate.
** N.P. effect highly significant (1% level).

The buffel grasses (Biloela and American) appeared superior to others in species evaluation, but growth of all grasses was well below their normal potential. Snail medic *(Medicago scutella)* and phasey bean made most growth for the range of winter and summer legumes tested. Nodulation difficulties were experienced with *Medicago* spp. and all legumes displayed restricted root development. Roots were generally confined to the A-horizon. Inability of legume roots to gain entry to the B-horizon, in conjunction with a surface soil displaying poor water entry characteristics, made legume establishment and production dependent on rainfall frequency. Perennial grass species were able to develop roots in th B-horizon.

It was concluded that development of persistent grass pastures would demand nitrogen fertilization. At that time, this appeared unlikely to be economically sound, and prospects for development were believed to hinge entirely on legume establishment. The legume situation was not encouraging, with the severe physical limitations to growth which were believed to exist. Work was discontinued on this site in 1960. Since then C.S.I.R.O. have commenced work on these soils* (Russell, 1966) and their early results appear more hopeful.

Another change which may yet have an impact on these soils is the growing use of nitrogen fertilizers for cereal production. It does seem likely that continued nitrogen and phosphorus applications to cereal crops could be used to improve soil nutrient status to the point where grass leys may be reasonably productive for a period.

Soil 2
Solodized solonetz. Sandy A-horizon 30-36 in. deep overlaying a dense sandy clay B-horizon.

Timber—Cypress pine *(Callitris glauca)*.

Location—"Kurrowah", Cecil Plains. (Group 10 soil, Beckmann and Thompson, 1960).

The mineral fertility of this soil appeared substantially poorer than that of soil 1. Establishment of Rhodes grass *(Chloris gayana* cv. Pioneer) and green panic

*C.S.I.R.O. Division of Tropical Pastures, Annual Report, 1965-66.

(Panicum maximum var. *trichoglume* cv. Petrie) and persistence of the buffel grasses demanded nitrogen and phosphorus fertilization. Pot experiments with buffel grass indicated additional deficiencies of calcium, potassium, copper, zinc and manganese (Leslie, 1963).

All legumes sown suffered heavy infestations of root nematodes *(Meloidogyne* sp.) and nodulation problems occurred with *Medicago* spp. The only legume to impress at this stage was *Stylosanthes gracilis,* but this failed to survive the second winter.

While these results were little more encouraging than those at Kogan, it was apparent that pasture production on this soil would not be restricted by physical intractability. Nevertheless, work was shelved in 1960, due primarily to the nematode problem.

Mineral Nutrition and Species Work on Deep Sands since 1963

Following release of the nematode resistant Siratro by C.S.I.R.O., work was resumed at Kurrowah in 1963. Results since then have generated some optimism for pasture developmental possibilities on deep sands.

Mineral Nutrition

Pot experiments were conducted on 0-6 in. soil with Siratro and Hunter River lucerne. These experiments indicated deficiencies of phosphorus, calcium, potassium, boron, molybdenum, copper, zinc and manganese (Tables 2 and 3).

The results suggested that a fine nutrient balance existed, and antagonistic or toxic reactions to nutrient additions were common. Copper nutrition was sensitive to additions of lime, molybdenum and zinc (Table 2) and it would seem that the system is most stable (in the absence of liming) if copper, zinc and molybdenum are applied jointly.

TABLE 2

Interactions of Lime, Molybdenus, Copper and Zinc* on Growth of Lucerne in Pot Experiments

Mean Plant Weight (gm)

	No fertilizer	Zinc	Copper	Zinc & Copper
No fertilizer	0.209	0.162	0.151	0.115
Molybdenum	0.393	0.511	0.456	0.742
Lime	0.646	0.413	0.619	0.919
Molybdenum + Lime	0.454	0.524	0.975	0.975
Least significant difference				
P = 5%	0.264	Main effects of lime, molybdenum and copper highly significant (1% level).		
P = 1%	0.365			

*Lime — Equivalent to 10 cwt./acre
Molybdenum — Equivalent to 1 lb./acre ammonium molybdate
Copper — Equivalent to 14 lb./acre copper sulphate
Zinc — Equivalent to 14 lb./acre zinc sulphate

Both legumes had a requirement for lime on this soil (pH 4.5-5.5), which may be met by relatively low rates of liming— of the order 5 cwt. per acre. The effects of lime appear to be complex and have not been fully clarified. Liming appears to imbue the soil with some buffering capacity to nutrient antagonisms and toxicities. This suggests that fertilizer practices may be easier to manipulate if the soils are limed. At the same time, liming at 10 cwt. per acre has reduced boron and copper availability. Other beneficial effects of lime have been attributed to correction of calcium deficiency, increased molybdenum availability, and elevation of soil pH (Table 4).

TABLE 3

Interactions of Potassium, Boron and Manganese* on Growth of Lucerne in Pot Experiments

Mean Plant Weight (gm)

	No fertilizer	Manganese	Boron	Manganese + Boron
No fertilizer	0.135	0.191	0.522	0.407
Potassium	0.084	0.287	0.744	0.814
Least significant difference				
P = 5%	0.073 Main effects of potassium, boron highly significant (1% level).			
P = 1%	0.101 Main effect of manganese significant (5% level).			

*Potassium — Equivalent to 2 cwt./acre potassium chloride
Manganese — Equivalent to 14 lb./acre manganese sulphate
Boron — Equivalent to 4 lb./acre boric acid

TABLE 4

Effect of Calcium, Molybdenum and pH on Growth of Lucerne and Siratro

Mean Plant Yield (gm)

Treatment	pH	Lucerne		Siratro	
		+ Molybdenum	— Molybdenum	+ Molybdenum	— Molybdenum
Nil	4.4	0.702	0.580	1.088	0.708
Calcium carbonate —5 cwt./acre	4.4	0.781	0.319	0.919	0.757
Calcium carbonate —3.7 cwt./acre	5.5	1.054	1.098	1.645	1.469
Calcium carbonate —20 cwt./acre	7.6	1.137	1.122	1.892	1.669
Sodium hydroxide —80 p.p.m.	5.5	0.391	0.850	0.930	0.927
Least significant difference P = 5%		0.211		0.291	
P = 1%		0.289		0.398	

Pot studies with lucerne on the A-horizon of a solodized solonetz from Leyburn have yielded positive responses to lime, copper and boron. A response to cobalt has not been confirmed. The action of lime on this soil (pH 6.2) was associated with correction of calcium deficiency and with buffering against nutrient toxicities.

Field experiments commenced at Kurrowah in late 1963.

Factorial fertilizer experiments were conducted with lucerne, Siratro and *Dolichos lablab*. The nutrient treatments were as follows.—

1. P — Superphosphate 0 to 4 cwt. per acre.
2. CaMoK — Lime 0 and 10 cwt. per acre; ammonium molybdate 0 and 1 lb. per acre; potassium chloride 0 and 2 cwt. per acre.

3. Mn — Manganese sulphate 0 and 14 lb. per acre.
4. Cu. — Copper sulphate 0 and 14 lb. per acre.
5. Zn — Zinc sulphate 0 and 14 lb. per acre.
6. MgB — Magnesium sulphate 0 and 2 cwt. per acre; borax 0 and 4 lb. per acre.

The significant effects recorded from these experiments are summarized in Table 5.

TABLE 5

Significance of Main Effects and Interactions in Field Experiments

Species	Harvest Year	Main Effects	Interactions
Lucerne	1965a	P < 1% CaMoK < 1%	P x CaMoK < 1% Mn x CaMoK < 5% P x Zn < 5%
	1965b	P < 1%	P x CaMoK < 1% Zn x CaMoK < 5%
	1966	P < 1% CaMoK < 1%	P x Zn < 5%
Siratro	1964	No significant effects.	
	1965	P < 1%	P x Zn = 6.1%
	1966	P < 1% CaMoK < 1%	Zn x CaMoK < 5%
Dolichos	1965 1966	P < 1% CaMoK = 5.8% No significant effects.	— (nematode infestation)

The Mn x CaMoK and P x Zn effects noted for lucerne refer to toxicities of manganese and zinc. Manganese toxicity was alleviated by the CaMoK treatment, and zinc toxicity occurred in the presence of superphosphate. This latter effect probably indicates little more than the fact that lucerne growth without superphosphate was too poor to be further affected by toxicities.

In view of the pot studies it is believed that the effects of the CaMoK treatment on lucerne may have been due to all three components. No CaMoK response was recorded in Siratro until the third year of growth, and this, plus the development of potassium deficiency symptoms, suggests that potassium deficiency may have arisen with repeated harvests.

TABLE 6

P x CaMoK x Mn x MgB x Cu x Zn — Yields (lbs. D.M. per acre)

Species	Harvest Year	O	P	P x Cu x Zn	
Siratro	1964	642	661	1331	
		O	P	P x CaMoK	P x CaMoK x Zn
	1965	1305	1818	1473	2359
	1966	2632	4079	4939	6658
		O	P	CaMoK	P x CaMoK
Lucerne	1965a	90	1496	384	2163
	1965b	290	491	188	991
	1966	351	983	331	1982
		O	P	CaMoK	P x CaMoK
Dolichos	1965	1036	2911	3742	4197

Table 6 lists the dry matter yields of the three species for some of the pertinent nutrient combinations listed in Table 5. Treatment combinations containing nutrients which produced growth depressions (e.g. zinc and manganese for lucerne) have been omitted in compiling the data.

Further experiments have been established to resolve the nutrient requirements of lucerne and Siratro. In the new Siratro experiment nonsignificant trends have again suggested copper and zinc deficiencies, but no effects of lime, molybdenum, potassium or boron have been measured.

Most attempts to establish lucerne since 1964 have failed.

The nutrient picture of these soils is still far from clear. It is obvious that the minor elements, particularly zinc, should be applied at low rates only, and the attitude to be taken towards lime and potassium awaits resolution.

Until the lucerne establishment problem is resolved, Siratro is the only legume recommended for commercial sowings on deep sands (Mackenzie, 1966). An initial application of 2 cwt. per acre molybdenized superphosphate with copper and zinc may be followed with annual dressings of 1 cwt. per acre superphosphate. A few good commercial stands have been established in this manner.

No attempt has been made to identify sulphur deficiency although it is believed to exist. Substitution of low-sulphur phosphorus fertilizers for superphosphate may be unwise.

Species Evaluation

Siratro has been the outstanding legume and productivity has increased with the age of the stand. Its period of growth extends from December to April, and its seasonal yield has been greatly dependent on the distribution of summer rains. (The vigour of Siratro appears to decrease with decreasing depth of the A-horizon below 18 in. and its performance on shallow surfaced solodics has been poor). Plants survive frost well, but leaf shed occurs soon after the first frosts. Analysis of the frosted mat in August, 1966 (a wet winter) gave 16% crude protein, but stock acceptance of this material was poor.

The restricted growth period of Siratro does not overlap the growth period of most winter annual legumes, and a number of the latter have been evaluated with the idea of combining these with Siratro.

The most promising of these have been the Serradellas—*(Ornithopus sativus* and *O. compressus)*. Experience at Kurrowah has matched in detail the wider experience with Serradella in Western Australia (Cariss and Quinlivan, 1967; Gladstones and Barrett-Lennard, 1964). Two features of these species which are important are the absence of a lime requirement on acid sands, and the ability of their rhizobia to survive the summer months. *O. sativus* produced 4,000 lb. dry material per acre in 1966.

Annual *Medicago* spp. and *Trifolium hirtum* have produced well but survival of their rhizobia has been poor. *Dolichos lablab* and *D. biflorus* showed some promise as pioneer species, but their extreme susceptibility to nematodes makes them very unreliable. *Lotononis bainesii*, although unexpectedly persistent, has produced little forage.

Lucerne Establishment

The productivity of established lucerne stands has been very good. Stands appear to have a persistence normal for the region and nematode infestation of mature plants has been of little consequence.

Lucerne establishment has proved to be extremely fickle. Severe seedling mortalities occur, and stands become very sparse within 2-3 months after emergence.

Plants which survive this period develop normally even on unfertilized areas. In fact much of the yield differences recorded in Table 6 reflects stand density rather than individual plant size. The recovery and normal development of lucerne plants has been associated with root proliferation into the B-horizon; and seedling mortality is thought to be a problem for plants growing entirely in the A-horizon.

At Kurrowah the sands occur as a mosaic of areas of raw sand (pH 4.5) and darker sands (pH 5.3-5.5). The darker areas have higher organic matter contents and presumably higher base exchange capacity. Lucerne establishment is invariably better on the darker sands. Similar problems have been experienced on other sands in the region where pH has ranged up to 6.2.

Fertilizer additions (including lime) and the use of lime pelleted seed and other techniques for obtaining effective nodulation have given some improvement in seedling vigour but have done little towards ensuring seedling survival. The problem does not appear to be associated with ineffective nodulation.

A percentage of mortalities has been attributed to fungal pathogens and nematodes; but neither agency is considered to be the cause of the repeated failures. Damping off may be severe in wet conditions, and nematodes appear most devastating in sowings made in early Spring.

An experiment at Leyburn in 1966 studied the effects of fertilizers and soil fumigation with methyl bromide. Methyl bromide had a pronounced beneficial effect on establishment, but this could not be ascribed to pathogen, nematode or weed control. Nodulation ratings indicated equal and effective nodulation for all treatments.

Current work is concentrated on this mortality problem, and a number of separate approaches are being explored. Techniques for reliable lucerne establishment would alter the prospects for the deep sands considerably, and lucerne could well replace Siratro and annual winter legume combinations.

General Considerations

One feature of the deep sands which merits attention is that of their water relations. In the first instance the sandy soils allow good growth responses to light falls of rain. Secondly, water retention in these profiles is greatly enhanced by the presence of the slightly permeable B-horizon; and water is virtually ponded above the B-horizon at super saturated levels for quite long periods. With a 30-40 in. depth of sandy A-horizon, direct evaporative loss of this water is evidently slow. Loss of soluble nutrients by leaching is also impeded by the B-horizon.

These features are believed to be reflected in the levels of productivity attained at Kurrowah, and presumably explain successful wheat production over a number of years, on similar soils north-west of Goondiwindi. In this sense, the sands are considered to have real potential in the semi arid areas in which they occur.

The work on the deep sands has been directed towards the production of pure legume stands. This attitude originated, as explained earlier, from the need to raise soil nitrogen status considerably before persistent grass or grass-legume pastures could be produced. It was also based on the idea that the sands could be used to produce "islands" of high protein forage to supplement the native grasses of adjacent, shallower surfaced solodic soils. A more detailed appraisal of the solodic soils indicates that the "island" principle would be applicable to relatively few properties. More commonly, properties contain either large areas of deep sand or patches too small and numerous to be treated separately.

At the same time, paddock or property development for the region will have to be applicable to complex soil associations, varying particularly in the depth of A-horizon. The research objective now is to develop a full pasture technology for deep sands. It is hoped that parallel developments on shallow surfaced solodics may allow selection of blanket development procedures for these complex associations.

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DISCUSSION

Why not delay application of fertilizer to Siratro until the third year when a better response could be expected following its build up?

Mr. McKenzie: This could be a point worth considering with regard to potassium. The big problem in the first two years is one of competition from couch.

What was the seeding rate used for Siratro? I should imagine that this could profoundly affect the establishment and yield of Siratro in the first years.

Mr. McKenzie: This is so. We have found the higher seeding rates best. In this respect we have used 4 lb/ac and still this is not perhaps enough.

With reference to the non wetting of sand could the fumigation responses be related to the killing of water repellant fungi contained in the surface soil hence allowing better water penetration?

Mr. Leslie: I don't think so here but it could be the case at Leyburn where there is more clay.

Would deep ripping and thus breaking the B-horizon, aid lucerne establishment?

Mr. Leslie: This is being tested. It is possibly of use but one must avoid bringing up the B-horizon to the surface.

PROPERTY OF Mr. D. BLIGH — CONDAMINE PLAINS

MR. N. D. YOUNG

Development work began in the area several years ago. The country was originally timbered with poplar box (*Eucalyptus populnea*) growing on solodized soil with a clay loam of 4" - 6" overlaying a massive clay layer. The timber was pushed and cleared.

Initially barley and linseed were cropped for 5 - 7 years with several applications of 1 cwt of superphosphate per acre applied over this period. Yields were initially satisfactory but commenced to decline after 4-5 years despite added superphosphate. Surface soil structure also deteriorated. At this point sward Hunter River lucerne was tried.

H.R. lucerne (2 lb/ac) was sown with barley at 24 lb/ac in August, 1965. Superphosphate at rates from 1 - 7 cwt/ac was applied at sowing. Barley responded up to 4 cwt of superphosphate and lucerne up to 2cwt of superphosphate per acre.

Twelve inches of rain in December, 1965, 5 months after sowing, caused heavy waterlogging of these solodic soils, and the lucerne was very severely affected, but recovered. It is now 2 years old. The depth of the soil above the clay is a critical factor in establishing lucerne in this environment. It seems important to get fair lucerne root development before these roots reach the tight clay layer.

Grazing: The first grazing occurred 8 months after sowing. Stocking management consists of heavy intermittent grazing. Five grazings, each with about 100 head for 2 - 3 weeks occurred in 1966. Two grazings, each of 3 weeks have been achieved so far in 1967. Recently, 1 cwt of Mo super was applied from the air.

DISCUSSION

Is there much regeneration of lucerne from seed drop?

Mr. Young: Seedlings have been observed but it is doubtful if they survive.

Is there a problem with witches broom disease?

Mr. Young: It has only been seen here in the second year, and then only slightly. The seasons have mostly been too dry so it is hard to predict for the future. Its importance is perhaps over-rated.

Was the lucerne inoculated?

Mr. Young: Yes. There were no problems with nodulation however, though no trials were done. The seed was inoculated with the commercial inoculum, not lime pelleted. Annual medics grow well in this area also.

Have any other lucerne varieties been tried?

Mr. Young: African lucerne seems to be initially promising. Snail medic has also done well.

Do you intend growing grain crops again after the lucerne?
Is pasture renovation likely to be necessary?

Mr. Grice: Yes, we hope to crop again after 4 - 6 years of grazing lucerne, when it becomes grassy. I don't think renovation is likely to be applicable in this country. I prefer to let native pastures invade and eventually plough out and return to cropping.

SUPPLEMENTARY LUCERNE GRAZING FOR WOOL PRODUCTION IN SOUTH-EAST QUEENSLAND

by

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The work described in this paper is being carried out in the Traprock region of South-East Queensland. The main block of this country in Queensland occupies a rough triangle of about 400 square miles west of the Stanthorpe-Wallangarra granite belt. A line from Cobba-da-manna on the Inglewood line to Texas would form a rough western boundary. This country stretches across the border (Dumeresq-Severn river) into New South Wales. The soils are mostly shallow and skeletal in nature and akin to the Podsolized and Solodized Red Brown Earth Associations described by Hallsworth and Gibbons (1951). Evidence to date indicates that the problems of livestock production, plant nutrition and species definition conform to those of the general solodic group of soils under discussion.

Grazing for wool production is based on native pastures dominated by summer growing perennials among which blue grasses (*Bothriochloa* and *Dichanthium* spp.) and spear grasses (*Aristida* spp) are prominent. Average annual rainfall ranges from 22 to 26 inches — 65% of which falls during October-March. Annual evaporation is approximately 70 inches being highest in December-January and lowest in June-July. Monthly mean maximum temperatures range from 90° in January to 64° in July. The corresponding minima are 67° and 42°. The carrying capacity of the pasture is limited during winter and early spring by the absence of new growth on the native grasses, and the senescence and frost damage of standover forage which limits intake by sheep. In July the overall crude protein content of the forage available reaches a minimum of about 3.2%.

In conjunction with Mr. I. A. F. Murray, "Kelso", a grazing trial was initiated near Texas in 1962 to examine the effects of stocking rate and supplementary grazing lucerne on sheep and native pasture productivity. Four treatments are involved. (1) Native pasture plus lucerne at 0.67 acres/sheep. (2) Native pasture plus lucerne at 1 acre/sheep. (3) Native pasture at 1 acre/sheep. (4) Native pasture at 2 acres/sheep. In (1) and (2) 1/6 of the grazing area is planted to lucerne to which the sheep have access whenever grazing is made available. Three replications give twelve paddocks. Each paddock is set stocked with seven Merino x Corriedale wethers. Results for 1962-65 have been presented by Lee and Rothwell (1966).

These results suggest stocking rate is the principal factor in maximising wool production per acre. The 3-year totals for greasy wool production per acre range from 15.48 lb at 2 acres/sheep to 43.70 lb at 0.67 acres/sheep with lucerne. By comparing treatments 2 and 3 over the 3 years 16% more greasy wool per acre was produced at the 1 acre/sheep level of grazing when lucerne was used. Body weight gains per acre reflected both stocking rate and feed quality. They were the same at 0.67 acres/sheep with lucerne and 1 acre/sheep with lucerne (105 lb). These two treatments gained about 38% more live wt/acre than native pasture at 1 acre/sheep, which in turn was 61% better than native pasture at 2 acres/sheep. The results since February, 1965 have not yet been reported. The trial is now conducted by Mr. J. Nation, Senior Sheep and Wool Adviser, and myself.

1965 was a serious drought year with a total of only 7 inches of rain at the trial site for the eleven-month period January-November. No supplementary lucerne grazing was available during this period. At the 1966 shearing 2 acres of native pasture/sheep yielded 4.8 lb greasy wool/acre and 1 acre/sheep with lucerne yielding 8.0 lb/acre. On two of the treatments, i.e. 1 acre of native pasture/sheep and 0.67 acres/sheep with lucerne, it was necessary to feed a supplementary ration for survival. At 1 acre/sheep with lucerne the animals had accumulated sufficient body weight reserves to survive a serious drought with an average weight loss per head for the year of 14 lb. At 2 acres of native pasture/sheep the animals showed a nett gain of 3 lb/head for the drought year.

Following the February, 1966 shearing the original flock was disposed of and the trial re-stocked with two-tooth Merino x Corriedale wethers. Wool yields for the following year (ending February, 1967) are related to stocking rate only. Average greasy fleece weight on all treatments was between 10.3 and 10.9 lb/head. No response occurred to supplementary lucerne grazing on the relevant treatments for four months from mid-October. Differences in body weight gain are relatively small ranging from 49 lb/head at 1 acre/sheep with lucerne to 41lb/head at 1 acre native pasture/sheep. These data indicate that the quality and utilisation of the summer growing native pastures, following heavy and uniform defoliation during the drought year, were such that supplementary lucerne at the level used had little or no effect. This is supported by the recorded yields of available native pasture during the year, which are low on all treatments, and the fact that the overall crude protein levels of this largely unused (but harvestable) material are up to 2% higher than any recorded since the beginning of the trial. The responses to supplementary lucerne recorded during the first three years of the trial are associated with higher available pasture yields and lower nitrogen content of this surplus material. It could, therefore, be argued that long term responses in wool production to this level of lucerne supplementation will occur only with a system of underuse of the native pastures.

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PASTURE RESEARCH IN THE SOUTHERN BRIGALOW REGION

by

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Today we are to see some of the problems of research and development in two very different types of country that occur throughout the brigalow region. It is essential to realise that the brigalow region is not an unbroken belt of brigalow land, but that it is a mosaic of many different types of land. Within this mosaic brigalow occupies perhaps half of the total area. This is the central fact behind the discrepancies in assessment of total area for brigalow country between such authors as Skerman (1953) who gave a figure of 23 million acres and Isbell (1962) whose figure was 11.7 million acres of brigalow land in Queensland.

A substantial amount of the non-brigalow portion of this region is occupied by soils which may be described broadly as "solodic"; Dr. Russell will shortly give further details about these soils. For the moment we can contrast them with brigalow land by pointing out that they are very infertile sandy soils carrying eucalyptus forest whereas brigalow land is composed of fertile clay soils carrying brigalow and its associated communities in which eucalyptus is generally infrequent. Isbell (1962) and Johnson (1964) have described the soils and the vegetation respectively of the brigalow lands.

As yet we have no comparable general account of the soils and vegetation of the solodic lands although Isbell (1957) includes them in his general survey of the southern brigalow region.

These solodic soils, which include the types discussed yesterday by Mr. Leslie and his colleagues, extend eastwards beyond the brigalow region, northwards beyond Townsville and southwards through New South Wales. The Queensland Regional Soils Group of the Division of Soils, C.S.I.R.O., estimates that there are 15 million acres of solodic soils in Queensland south of the tropic and east of the 20-inch isohyet of mean annual rainfall. They can now be regarded as a major source of virgin land suited to development when the necessary research has progressed far enough. Research on them is necessarily slow for several reasons.

Dr. Russell and Mr. Leslie's group are already showing that correction of their infertility is complicated by physical characteristics that are often related to residual effects of the salinity that is prominent in many of them. Again, they are a diverse group of soils with sufficient variation to require field experiments at quite a number of sites. Finally, they occur in a region of highly variable rainfall where the scientist continually faces the risk of losing experiments through drought. Dr. Russell will shortly be quoting some figures to indicate variability. The situation can be summarised in the fact that any month of any year may be the start of another drought lasting from 3 months to 3 years.

This problem of variability of rainfall is also the greatest long-term difficulty with the brigalow land that you will be seeing this afternoon. At one of our field stations on brigalow land in one summer period (November-March inclusive) there was 29 inches of rain in 5 months; in the following summer there was 2 inches in the same period. At another centre all summer experiments started by 3 Research Scientists were lost through drought for 3 summers in succession. This is not a plea for sympathy, but a statement of the reason that some of the experiments you will be shown have not yet produced any clear results. Finally, on the subject of rainfall in the southern brigalow region there is the interesting paradox that in a region of predominantly summer rainfall the most reliable rainfall is in winter. For this reason you will notice today a strong interest in winter growing annual temperate legumes in contrast to the dominant interest in tropical legumes that is a feature of most meetings of this Society.

This morning you will be shown experiments on some of the soil types that help to make the range of solodic soils, and also some of the large-scale development of land that is being based on these experiments. This afternoon we will move to gilgaied brigalow land. Problems of distance prevent us from taking you to research areas on brigalow land and so we will show you an example of property development where the results of research are being incorporated into land management.

The close association that you will see today between research worker and landowner is something that we hold precious. We owe much to the generosity of landowners such as Mr. Hayward and Mr. Savill for the direct support that they provide for our work, but we also owe them a large debt of gratitude for the courage with which they involve their own resources in early application of research findings. The step from the plot to the paddock is by no means automatically successful, but by taking it at their own risk such landowners as these often show us important gaps in our knowledge. They contribute largely to a very important symbiosis between research and application.

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ASPECTS OF PASTURE GROWTH ON SOLODIC SOILS

by

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INTRODUCTION

Background information on the environment at "Tong Park" and "Stirling Park" is as follows —

Climate

The annual rainfall of this area is about 26 inches. Broad distribution pattern on a seasonal and yearly basis (from the 72-year record at Warra) is

Frequency (No. of years)	10%	30%	50%	70%	90%
November-March (inches)	21.80	18.78	16.43	11.65	8.24
May-September (inches)	11.47	8.59	6.09	4.60	3.16

In the past summer 10.18 inches of rain were recorded in November-March which means that this was a 1-in-5 year drought. Low temperatures and frosts are common in winter. Mean monthly minimum night temperatures recorded at this site were

1966				1967		
Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
45.8	52.3	59.5	64.0	69.6	67.8	62.2

This indicates the extent to which low night temperatures occur beyond the main summer months and are likely to limit the growth of tropical legumes.

Soils

The soils can be broadly classified as solodic, which implies past influences of salinization and subsequent solodization. The latter process results in the removal of soluble salts from the surface soil over a long period of time and thus they are generally not a problem as regards plant growth. However, residual, exchangeable sodium levels are frequently high in the sub-soil, affecting soil structure, water entry and possibly plant growth. Magnesium is generally high but calcium and potassium low.

Variations in surface texture from sand of varying depths over clay to sandy clay surface soils occur. The surface is usually acid; in some soils (soloths) the profiles are acid throughout; in others (e.g. solodized-solonetz) the sub-soils are alkaline. The characteristics of the soils studied are given in Table 1.

TABLE 1.

Characteristics of the soils of the "Tong Park" and "Stirling Park" experimental areas.

Soil Characteristic	Tong Park						Stirling Park	
	Predominantly Cypress Pine (*Callitris glauca*)			Predominantly Box (*Eucalyptus populnea*)			Type 1	Type 2
	0 - 4"	9 - 14"	20 - 35"	0 - 4"	10 - 18"	25 - 34"	0 - 5"	0 - 5"
pH	5.6	6.4	8.3	5.4	5.8	6.6	4.6	5.8
Soil nitrogen (%)	0.046			0.101			0.088	0.161
Available Phosphorus (parts per million)	4	2	4	10	5		10	26
Copper (ppm)	3	4	5	4				
Zinc (ppm)	7	11	13	4				
Manganese (ppm)	35	17	23	17				
Boron (ppm)	5	5	4	5				
Total Soluble Salts (%)	0.008	0.005	0.09	0.03	0.08	0.13		
Exchangeable sodium (me/100 gram)	0.15	0.31	4.3	0.76	3.3	4.7		

Vegetation

The natural vegetation is correlated with soil type, e.g., Cypress pine (*Callitris glauca*) is generally associated with some depth of sand over clay; buloke (*Causuarina leuhmannii*) with shallow soils, compact sub-soils and poplar box (*Eucalyptus populnea*) with heavier soils on lower slopes.

OBJECTIVES

Work has been in progress at Mr. G. F. Male's property "Gelou", Tara since 1963 and Mr. C. R. Hayward's properties "Tong Park" and "Stirling Park", Warra since 1965. The main objectives are —

Fertility. Identification of chemical and physical soil factors limiting growth and their amelioration, if possible.

Species. The search for suitable legumes and associated grasses which can grow and persist under the difficult climatic and soil conditions.

Management. The development of techniques of land utilization based on pastures which are economic, conserve the soil and result in a rising plane of soil fertility.

Initial Results

Research in a semi-arid sub-tropical environment with variable rainfall needs to be carried out over a period of years before a true assessment of the merits of some practices can be determined. Nevertheless indications from preliminary research provide a guide to future work and the initial results presented here can be considered in this light.

Fertility

Phosphorus. Soil analysis, glasshouse studies and field experiments on both tropical and temperate legumes and grasses have shown phosphorus to be low. However, responses to superphosphate appear to be proportionately greater when temperatures are low. Oats (Benton) and undersown legumes (mainly lucerne and annual *Medicago* spp.) cut at three times at "Stirling Park" in 1966 show this effect (Table 2).

TABLE 2.

Responses of oats and seeded legumes to superphosphate.

Pasture	Superphosphate cwt/acre		
	0	2	4
	Yield (lb dry matter/acre)		
Cut 29 - 30 June —			
Oats	130	360	350
Legume	20	50	70
Cut 24th August —			
Oats	520	2050	2100
Legume	150	200	260
Cut 28th September —			
Oats	2680	5290	5660
Legume	175	230	320
	Phosphorus content %		
Cut 29 - 30 June —			
Oats	0.15	0.25	0.29

These results can also be compared with responses to superphosphate obtained with summer growing species (Table 3).

TABLE 3.

Response of seeded grasses to superphosphate.

Pasture	Site	Year	Superphosphate cwt/acre			
			0	2	4	8
			Yield (lb dry matter/acre)			
Nunbank buffel (1 harvest)	Tara	1965	250	330	485	780
Nunbank buffel (2 harvests)	Tara	1966	1020	1600	1800	2600
Predom. *S. almum*	Warra	1966	1930	2700	—	2800
Predom. native grass + some Nunbank buffel	Warra	1966	1890	2650	—	3100

Annual application of superphosphate appears to be better than heavy infrequent dressings. Also, while 2 cwt/acre appears to give maximum responses with winter growing species such as oats responses to higher rates of application have obtained with summer growing species (Tables 2 and 3).

The benefits which superphosphate appears to have on these soils are (i) legumes can establish and potentially improve soil nitrogen status; (ii) the more productive grasses such as Rhodes and buffel grass with their much longer growing periods than the summer growing native grasses can persist and make use of out-of-season rainfall; (iii) plant growth is markedly affected during winter when forage deficiency is most acute; and (iv) plant P content is increased.

Nitrogen. Although the nitrogen level of these soils is low cultivation over a period of time appears to release considerable amounts of available nitrogen. At "Stirling Park" in 1966 there was little response in iats to applied nitrogen even though yields above 6,000 lb dry matter were obtained in some plots. At the final harvest the above ground material in these plots approached 60-70 lb nitrogen per acre. Nevertheless, nitrogen deficiency is very evident at certain times and appears most frequently on established grass swards, under conditions of adequate rainfall in summer, under conditions of continued cropping and where the period of cultivation is short.

In spite of the low rainfall at "Tong Park" this summer responses of Rhodes and buffel grass were obtained to applications of nitrogen fertilizer. Yield of Rhodes grass was almost doubled by 80 lb N per acre applied as urea even though the rainfall between application and first harvest was only 4 inches spread over a 2-month period. Effects on both Rhodes and buffel grass were as follows in Table 4.

TABLE 4.

Response of Rhodes and buffel grasses to nitrogen fertilization.

Grass	Nitrogen as urea lb N/acre			
	0	20	40	80
	Yield (lb dry matter/acre)			
Commercial Rhodes —				
1st Cut	760	990	1340	1470
2nd Cut	375	510	555	582
Total	1135	658	1895	2052
Nunbank Buffel				
1st Cut	840	1568	980	980
2nd Cut	703	1500	758	977
Total	1543	910	1738	1957

These results emphasize the importance of nitrogen even when rainfall is low but since nitrogen fertilizer is unlikely to be economic in the near future there is a need for suitable legumes to complement the grasses.

Trace elements and lime. Solodic soils contain low amounts of essential elements such as copper, zinc and boron (Table 1). However, the plant growth effects of these elements are complex and appear to be influenced by species, soil type and possibly seasonal conditions. Differences between plant responses obtained under glasshouse and field conditions have also been observed. Responses to copper, zinc and boron have been obtained under glasshouse conditions but these deficiencies appear to be chronic rather than acute. Under field conditions legumes such as lucerne appear more sensitive than buffel grass or oats.

Further work on trace elements is continuing in relation to species and in the application of lime. Studies on the causes of differences between glasshouse and field experiments on the use of lime are also in progress. Recent work suggests that the time-lag in field response to lime may be longer than is usual in temperate soils. This may be related to the low number of wet days per year as rainfall tends to come in fewer larger falls and the surface soil is frequently dry.

Species

The main need is a long term glass-lucerne pasture, which can persist under the climatic extremes, which is productive and can maintain and increase soil fertility. Of the two the legume presents the greater difficulty. Lucerne is the only perennial which presently appears to withstand the extremes of climate and yet make growth when moisture is available. Other legumes being studied include perennial and annual tropical legumes and annual temperate legumes.

Of the tropical legumes Siratro appears to persist satisfactorily but its short season of maximum growth coupled with the uncertainty of rainfall reduce its potential usefulness. Some early strains of Townsville lucerne are also being investigated.

Because of the occurrence of some winter rainfall in this region temperate legumes from the genera *Medicago, Trifolium, Trigonella* and *Vicia* have been screened. The sandy surface texture of many Solodic soils results in light falls of rain being more effective during winter. The most successful species have been barrel medic (173 and Woodside), Cyprus medic (*M. truncatula*) and Harbinger medic (*M. littoralis*). These have regenerated over three seasons now. Even if these species do not grow every year the evidence suggests that they are able to persist and, in favourable seasons, make some contribution to both winter growth and nitrogen fixation.

In the case of the grasses soil type appears to be of some importance. Buffel grass (*Cenchrus ciliaris*) grows well and persists on some of the soils with light textured surfaces. The most satisfactory cultivars have been Nunbank, Tarewinnabar and Molopo all of which appear comparable in production and persistence. Rhodes grass (*Chloris gayana*) is readily established and is moderately persistent. Other promising grasses are Makarikari grass (*Panicum coloratum* var. *Makarikariensis* cv. Burnett), green panic (*P. maximum* var. *trichoglume* cv. Petrie) and *Sorghum almum* for short term growth.

Management

Establishment of grasses and legumes poses problems on these soils due to the erratic rainfall, high soil temperatures and rapid drying of the surface soil in summer. It has been found that these difficulties can be reduced to some extent by autumn sowing and using oats as cover crop. This method is satisfactory for lucerne and temperate legumes as well as for Rhodes grass and *S. almum*. Less success has been achieved with tropical legumes and some of the grasses, particularly buffel grass.

Fertilization is obviously important in allowing more desirable grasses and legumes to grow and persist. Much has still to be learnt about the most satisfactory methods and rates of application coupled with other measures such as renovation to maintain and improve pasture growth.

Finally, grazing management must consider the plant as well as the animal. Unlike native pastures there is no surety that recovery of sown pasture species after heavy and successive grazing will occur. Light grazing during early establishment appears to be particularly important.

PROPERTY OF Mr. HAYWARD — "TONG PARK" AND "STIRLING PARK"

C. R. HAYWARD and J. S. RUSSELL

Management of livestock and pasture is very complex. Establishment of sown pasture is the most difficult problem of all in this country.

In the past, improved pasture referred to country on which the timber had been killed and natural grass had established. Following the killing of the timber there is a period of high soil fertility for about two years which can be exploited if seasonal conditions permit. In the long term livestock performance is seasonal with loss of body weight commencing from April into the winter months.

In bridging this gap by growing fodder crops it has been found that superphosphate gives a marked response in crops and in the stock grazing them. Evan when paddocks have been subsequently allowed to revert to native pasture the grass seems to be better and the livestock to do better than on the untreated land. One effect of superphosphate has been to delay the onset of livestock weight loss due to the effects of winter.

The next stage is to seek out new plant species in place of the native grasses. It has been established over the past 10 years that the potential of this soil is considerable for crop production. Such crops have included Japanese millet, white french, panicum, sorghum, cow peas, winter oats and barley. The cropping phase however should lead to establishment of permanent pastures of buffel grass which appear to be the most suitable pasture grass for this area. The immediate problems associated with such a sequence are the regeneration of suckers and seedlings from the timber and the hazard of dust and soil erosion. It is important to evolve a farming system which enables the water to get into the soil for maximum use by fodder and grain crops.

There are some important factors governing this development, namely—(1) financial resources to initiate the programme; (2) deriving income from the work done; (3) servicing the loans, commission agents, transport charges, fertilizer costs, insurance companies and equipment; (4) making a profit on the investment; (5) combating regrowth; (6) establishing sown pasture species—i.e. Buffel grass and inoculation and establishment of lucerne.

Timing of these factors is of great importance to the economy of the operation. Thus, it is possible to recoup the capital expenses of clearing, ploughing and seeding in one year, but then it could take ten.

Development Plan

The plan is to put annually 2,500 acres under the plough over a five-year period. This will be sown as follows— 500 acres sudan grass for autumn feeding, 1,500 acres oats or barley for winter feeding, and 500 acres sudan grass again for early summer feeding. Fodder crops are the prime consideration at this stage because of the interference of sticks, stumps and stones with some intensive forms of cultivation. The profitability of this operation rests on rainfall, technique and skill in buying and selling of livestock.

Costs

Pulling — 2D9's @ $80 per hour. Cost per acre, depending on density of timber, varies from $1.20 to $3.00; raking and burning $6.00 to $7.50 per acre. Seed bed preparation — tandem discing, seeding and fertilizing costs vary according to rate of fertilizer, seed and variety used.

This year 2,500 acres of heavy green iron bark and wattle country was pulled in January, burnt 8 weeks later and now (April) some of this area is ready for ploughing. This will be fodder cropped for two years and on the third sown down to a pasture of lucerne, Rhodes grass, green panic and buffel grass.

I am very impressed with buffel grass and look forward to thousands of acres of buffel grass covering these rocky ridges and gravelly slopes.

Inspection of Pastures

"Tong Park" pasture

One hundred acres of this pasture were sown eight years ago using lucerne, barrel medic (173 and snail), Rhodes grass and green panic. Where the ashes from the burn were thick the growth of the pasture was spectacular. This paddock was heavily grazed and then reploughed for sucker control and this led to the actual disappearance of sown pasture plants.

The present pasture was established, in July, 1965. It was sown to 1 lb each of Rhodes grass, green panic and lucerne together with 10 lb of oats, in dry conditions on a well worked seed bed. Covering harrows followed the combine to cover the seed. Fertilizer applied was superphosphate, urea and lime with copper and zinc added by hand, the total being 2 cwt per acre. Prior to sowing, the lucerne seed was wetted with molasses and water and inoculated and lime coated. This was spread mixed with additional lime within a few hours of pelleting.

Subsequently, the pasture appeared to be a failure as it became completely overgrown by natural love grass the following summer. However, by late summer when stocked with cattle and sheep the stock did very well. With winter rains a surprising amount of lucerne established to make it a fair Rhodes grass — lucerne stand.

The fertilizer applied this year (1967) was 1 cwt nitro super and there has been one fall of rain since. Before this the pasture was heavily grazed. A renovation treatment for June/July with superphosphate also is suggested. The estimated carrying capacity is 1 head to 4 acres.

"Stirling Park" — experimental pasture and adjacent grazing oats

Dr. Russell explained that these experimental plots were sown in April, 1966 with oats as a cover crop. The species sown included *Sorghum almum,* Hunter River lucerne, and the annual medics Barrel 173, Cyprus and Harbinger. The oats responded markedly to superphosphate (Table 1) and gave high dry matter yields. However, there was no response to nitrogen fertilizer possibly because of the moderate soil nitrogen content (0.08 - 0.16% N) and the long period of cultivation prior to sowing.

At about the same time (April, 1966) the surrounding area was sown to barley as a fodder crop and grazed throughout the winter. This year the area was cultivated again and resown to oats for grazing. In both cases the cereals were sown with a basal dressing of superphosphate.

DISCUSSION

Do you take precautions against seed harvesting ants when you sow?
Mr. Hayward: No.

What about pasture renovation?
Mr. Hayward: It is possibly a useful procedure to promote increased water intake by the soil. Water is readily shed by these soils.

The oat germination appears patchy; is this due to shortage of soil moisture; was the seed dry planted?
Mr. Hayward: Yes, the patchiness is due to differences of soil moisture due to differences in soil type and run-off. The oats should recover if we get rain, and supposing the ants have not removed the ungerminated seed.

Do you think the Key line system of renovation would have a place here?
Mr. Hayward: Any aid to the maximum use of rainfall must be considered.

What percent of your total area do you plan to have in pasture?
Mr. Hayward: Pastures may only be down for three years initially because of the regeneration of trees by suckers and seedlings. About 50% of the area would be in oats.

Have you considered stand-over crops such as "Sugar Drip"?
Mr. Hayward: We haven't used them although *Dolichos lab lab* could be very useful.

Are you bound by regulation in your clearing programme as with the brigalow scheme ballotees?
Mr. Hayward: No. Our property is freehold so we can clear as we like. Thus, we won't remove all the trees.

Is there danger of wind erosion?
Mr. Hayward: No. Water is the main factor in erosion here. It is easy to lose soil to the depth of cultivation.

Is there much moisture holding capacity?
Mr. Hayward: No. We cannot depend on growing a crop on stored moisture.

PASTURE PRODUCTION AND LAND MANAGEMENT ON BRIGALOW LAND IN THE SOUTHERN BRIGALOW REGION

by

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INTRODUCTION

The programme to develop improved pastures for the brigalow region in Queensland has involved the establishment of small field stations at seven sites south of the tropics where variation in the range of soils and climate could be sampled. In addition experiments on particular problems have been located elsewhere. The programme has progressed through the testing of many species in small plots to the final evaluation of a limited number of successful species through animal production on mixed pastures.

The species testing which began in 1957 led to the establishment of the first of these grazing trials in 1962 at "Tarewinnabar," the property of Sir William Gunn, 40 miles north of Goondiwindi, and 30 miles south-west from "Talinga". Other grazing trials are currently in progress at Meandarra (gilgai soils), Taroom (alluvial soils) and Banana (sedentary clay soils).

During the visit to "Talinga" the meeting inspected three paddocks each involving some practical aspect of research findings from the two major experiments discussed below.

THE "TAREWINNABAR" GRAZING TRIAL

Design

The site originally carried a forest of belah (*Casuarina cristata*) and brigalow (*Acacia harpophylla*) which was burned, stick-raked and ploughed in 1961. The soil was classified by Isbell (1957) as a "weakly solonized brown clay loam". Suckering of brigalow was light and this was eliminated in most of the paddocks that were ploughed in preparation for the sowing of the pastures in February, 1962.

The six pastures listed below were replicated in three randomized blocks —

1. *Sorghum almum* cv. Crooble.
2. Buffel grass cv. Nunbank.
3. Commercial Rhodes grass cv. Pioneer.
4. Green Panic cv. Petrie.
5. Nature Pasture. Chiefly species of *Chloris, Paspalidium, Dicanthium* and *Eragrostis*.
6. Native Pasture plus oats.

Each sown pasture included lucerne.

Each paddock of sown pasture was 4.6 acres and each paddock of native pasture was 9.2 acres. In the case of treatment 6 one-third of each paddock was cultivated and sown annually to oats for grazing. This proportion of one-third was calculated to provide continuous grazing from May to October for the two bullocks in each of the paddocks concerned.

Each paddock was continuously grazed by two steers with extra cattle added occasionally when there was surplus grass. Grazing commenced in February, 1963. Each grazing cycle started with yearling shorthorn steers of 500 - 600 lb liveweight which were replaced one year later at which time they had reached 1,000 to 1,100 lb. The cattle were weighed at monthly intervals after fasting overnight. The annual cycle was interrupted when the individual treatments were destocked during the drought of 1964-1965 after the cattle on them had continuously lost weight for four weeks. By this time all the pastures were reduced to stubble less than two inches high.

Results

The experiment can conveniently be split into two periods —

(a) 1963 and 1964 before drought severely affected the growth of the pastures.

(b) The recovery of the pastures in 1965-66 from drought.

Rainfall for the three years concerned is listed below.

1963	17.5 inches
1964	12.8 inches
1965	7.8 inches

The long term mean annual rainfall is 24 inches.

The mean cattle weight gains are given in Table 1.

TABLE 1.

Mean cattle weight gain (lb/steer) per treatment.
Means of 6 animals.

	Sorghum almum	Native	Native † oats	Green panic	Rhodes grass	Buffel grass	SE
1963	462	415	390	393	386	319	24
	a*	a	ab	ab	ab	b	
1964	†	424	681	315	332	257	30
		b	a	bc	bc	c	
1963 and 1964		838	1071	707	717	575	43
		b	a	bc	bc	c	
28/1/65 – 11/5/65		81	54	53	24	21	19
24/9/65 – 4/2/66		141		9		189	

† The *S. almum* pastures were destocked during this year and did not recover.
* Figures with differing subscripts (a, b, etc.) differ significantly (P=0.05) by Duncan's multiple range test.

The seasonal cattle weight gains are shown in Table 2.

TABLE 2.

Seasonal weight gains (lb/steer/day)
Means of 6 animals.

1963		1964	
Summer/Autumn —		Summer/Autumn —	
(Feb., '63 – June, '63)		(Dec., '63 – June, '64)	
S. almum		S. almum	
Buffel	1.4	Native	
Native		Green panic	
Green panic		Rhodes	2.1 – 2.2
Rhodes	1.1 – 1.2	Buffel	1.6
		Winter —	
Winter/Spring —		(June, '64 – Sept., '64)	
(July, '63 – Dec., '63)		Oats	2.3
S. almum		Native	
Native		Green panic	0.0
Oats	1.0	Rhodes	—0.2
Green panic		S. almum (loss)	
Rhodes	0.7 – 0.8	Buffel	—0.5
Buffel	0.4	Spring —	
		(Sept., '64 – Dec., '64)	
		Oats	3.4
		Native	2.5
		Green panic	
		Rhodes	
		Buffel	1.3 – 1.6

All the pastures gave good weight gains in 1963 with *S. almum* and native pastures (the latter at half the stocking rate of all the others) giving significantly ($P<0.05$) greater gains than the others. It is interesting to note that in this year of moderate rainfall the cattle on buffel grass showed the lowest gain.

In 1964 the onset of the 1964-66 drought began to affect all the pastures. The *S. almum* pastures (now in their third year) had to be permanently destocked in the latter part of the year. Between December, 1963 and June, 1964 the cattle on all treatments except buffel grass gained just over 2 lb/head/day. Thus, although the pastures were short (6 to 9 inches high) the feed presented was of high quality The gains of 2.3 lb/day (winter) and 3.4 lb/day (spring/early summer) on oats were especially good.

All the pastures were destocked from May, 1965 until September, 1965 due to the drought. Rhodes grass and *S. almum* died out and did not recover in the absence of cultivation. The green panic thinned out but the buffel grass recovered well and these pastures became as vigorous as before.

One of the important findings from this experiment was the fact that during a major drought sown pastures stocked at twice the intensity of native pastures supported the stock for equally as long as the native pastures. Buffel grass in particular proved to be very drought resistant and recovered quickly after drought-breaking rains.

It should also be noted that during the first year of this experiment the pastures were understocked as judged from our later experience with similar pastures elsewhere in the brigalow region.

DEPTH OF PLOUGHING FOR CONTROL OF BRIGALOW SUCKERS

From measurement of 2,400 clumps of suckers it was shown that in over 90% of clumps the depth from the soil surface to the centre of the parent root was less than four inches. This suggested that shallow ploughing might be adequate for the control of brigalow suckers and so an experiment was carried out to compare the effectiveness of ploughing to depths of four inches and eight inches. The experiment was sited on gilgaied land (where suckers are most difficult to control) near Meandarra in the southern part of the brigalow region (Coaldrake, 1967).

After four ploughings in two years both treatments gave an identical kill of 80% of suckers that were 21 months old when the experiment started. A final overall ploughing at four inches increased the kill to 91%; these figures include the new suckers that developed between ploughings. In another experiment quoted in the paper mentioned above it was shown that deep ploughing gave no better establishment of sown pastures than shallow ploughing. Finally, shallow ploughing avoids the risk of bringing to the surface the very saline and very acid clay that is common at no great depth in gilgai soils under brigalow forest.

REFERENCES

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FARM TOUR OF "TALINGA", MOONIE DISTRICT PROPERTY OF Mr. and Mrs. COLIN SAVILL

Property details

Area: 21,782 acres. Of this 12,000 acres is brigalow-belah with clay soils of good fertility. The balance is sandy country of very low fertility carrying cypress pine, buloke, poplar box, etc.

Clearing: 6,000 acres pulled, burnt and now in use for pasture and crop. 6,000 pulled — to be burnt in sections as property management system allows newly burnt land to be dealt with completely by ploughing soon after burning.

Cultivation: 4,000 acres has now been cultivated and is used as follows —

1,000 acres for sown pastures;

1,000 acres for fodder crops (chiefly oats and sudax).

1,300 acres for wheat.

Balance temporarily under natural pasture.

Rainfall

Annual mean 24 inches

Year	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total
1964	190	35	0	219	210	58	235	102	249	495	135	552	26.90
1965	335	10	0	65	40	20	317	75	130	88	136	437	16.53
1966	195	298	163	111	90	276	0	524	42	190	275	208	23.72
1967	130	170	355										

Stop 1

Forage oats as a nurse crop. Shallow ploughing for sucker control.

Paddock history

This area consists mainly of strongly gilgaied soil with hollows up to six feet in depth and formerly carried a forest of brigalow-wilga with some belah. It was pulled and burnt in 1958 and produced a dense stand of brigalow suckers. It was given no further treatment until 1965 when the suckers were eight feet high. It was ploughed twice in January-February, 1965 at a depth of four to five inches and sown immediately to oats for grazing. In 1966 it was again sown to forage oats after only one ploughing.

In 1967 it was again given one ploughing and sown in March to a mixture of oats, lucerne (cv. Hunter River) and barrel medic (cv. 173). At the time of the inspection the oats was about nine inches high and the lucerne and medic were well established underneath.

In 1965 dry weather until the end of June (see Table above) reduced production from the oats and it could only be stocked at two-thirds bullock per acre. In 1966 with very good rainfall throughout the winter the stocking rate was one and one-half bullocks per acre from approximately May to October inclusive.

Thus, four ploughings to a depth of four to five inches in three years have eliminated tall dense suckers on gilgaied land while the land was returning good profits from grazing oats.

DISCUSSION

What will be the management of the paddock after the oats have gone?

Mr. Coaldrake: We are still experimenting and will work that out as we go along. The general principle will be some form of rotational grazing governed by the amount of feed available from the lucerne and medic. It may also be possible to oversow with oats if there is enough rainfall.

How was the seed mixture sown?

Mr. Savill: The seed was mixed and sown in one operation with a combine drill.

Has any attempt been made to level this paddock?

Mr. Coaldrake: No. It has been ploughed only. Many gilgais are saline at 18 inches and one risks exposing this if levelling is attempted. It is a difficult task to carry it out successfully.

Do the presence of gilgais have any effect on establishment?

Mr. Savill: Oats are better in the gilgais to begin with but the difference later on is not great. There are more weeds in the hollows.

If this country were levelled how long would it be before the gilgais reformed?

Mr. Coaldrake: It would be a long time, and it is partly dependent on the seasons experienced. With wet seasons it would probably be more rapid. The persistence of salinity in areas exposed by any levelling operation would also depend a lot on the nature of the subsequent seasons. These are aspects worth studying more closely.

Stop 2

Sown pastures on non-gilgai soil.

Paddock history

This area consists of Isbell's "weakly solonized brown clay loam" and formerly carried forest of brigalow-belah and belah-brigalow. It was burned early in 1964 and ploughed to a depth of four inches during April to June. Thereafter different portions of the paddock were given different treatments as follows:

May, 1964—100 acres sown to oats and lucerne for grazing.

October, 1964—500 acres sown to *S. almum* (cv. Crooble), Rhodes grass ("Commercial") and lucerne (cv. Hunter River).

September, 1965—200 acres sown to *S. almum*, Rhodes grass and lucerne.

The management technique of ploughing a few months after burning has given good control of suckering which was not so dense here as at Stop 1.

Production

1964—300 bullocks on the 100 acres of oats in July and August. 150 head for remainder of the year.

1965—In March, 340 drought-stricken cattle (all in very poor condition) were placed on the 500 acres of sown pasture. Eleven animals died, most of them soon after arrival, while the remainder progressed to fair store condition. The animals remained on this pasture throughout the year; the only supplementary feed used was 4 x 44 gallon drums of molasses and 5 "Protojen" blocks.

1966-67—Stocking continued from 1965 at 150 to 250 bullocks until August, 1966, when the number was increased to 400. The whole paddock (800 acres) was stocked with 400 head from August, 1966 to mid-March, 1967 and the animals were in forward store condition when removed.

DISCUSSION

Why did lucerne not persist in the "Tarewinnabar" trial?

Mr. Smith: There was a poor initial strike, and the stand obtained began to die out after about one year under the continuous grazing practised on this experiment.

Does buffel grass regenerate readily?

Mr. Smith: Yes, it seeds well and the stand can be thickened up by this self-seeding process. With *Sorghum almum* it appears that if it is allowed to set and drop seed every two or three years it will re-establish strongly if some cultivation is given. This could overcome the disadvantage of the poor persistence of *S. almum* which we have had in the grazing trial.

What would you recommend as the desirable native pasture/oats ratio?

Mr. Smith: It is difficult to say, but perhaps this may be 3:1 on the better soils.

Could you comment on the poor winter feed production from buffel grass?

Mr. Smith: It is not so much the feed production as the winter quality which is the critical factor. It does not bridge the winter trough of low feed quality and poor animal performance at that time.

What would you estimate the true carrying capacity of native pastures to be—e.g., do you think they could carry one beast to two or three acres?

Mr. Smith: Native pastures could do this for only a short period in the summer. For the rest of the year it would be much lower.

Were the Rhodes grass and buffel grass paddocks undergrazed?

Mr. Smith: Yes. In its second year (i.e., the first year of experimental grazing) the pasture could have carried a beast to one acre. It follows from this that the growth curves for the animals' weight gains in 1963 reflect the animals ability to produce rather than the pastures'.

Do stock eat buffel grass readily in larger areas?

Mr. Smith: Yes, and often prefer it to other grasses especially in spring.

How was the area here at Stop 2 prepared?

Mr. Savill: The area was pulled, burnt and ploughed. If the burn is a good one ploughing should be done quickly to get a better control of suckers. Thus the burn should be delayed until one is able to plough.

Can suckers be controlled by establishing a vigorous pasture?

Mr. Savill: We can't control suckers here with Rhodes grass. Some argue it can be done.

How was this pasture sown?

Mr. Savill: Some of it was sown with the combine; on the rest the seed was ploughed in with the Shearer "Acremaker" plough.

Stop 3

Shallow ploughing for sucker control.

Paddock history

This area is one of strongly gilgaied clay that formerly carried a forest of brigalow-belah. It now carries a moderate stand of brigalow suckers (approximately 500 to 800 clumps per acre) five to six years old.

Mr. Coaldrake gave an outline of the experiment on control of brigalow suckers by shallow ploughing (see above) and Mr. Savill demonstrated the technique with the Shearer "Acremaker" plough operating at a depth of four to five inches (see Figure 1).

DISCUSSION

Is this type of ploughing really going to beat the suckers?

Mr. Coaldrake: Brigalow suckers root close to the surface. The horizontal parent root is generally within four inches of the surface. It is therefore only necessary to plough to get that root; there is little point in going deeper. It is necessary to have a plough which is flexible to negotiate the gilgais. This is where the Shearer "Acremaker" plough is so suitable. It will plough 2½ acres per hour and costs $1.50 per acre to operate. Hormone sprays are still not satisfactory for sucker control on large areas of tall suckers.