FIELD MEETING IN THE TARA-KOGAN DISTRICT, JUNE 3, 1977
PASTURE DEVELOPMENT ON SOLODIC SOILS

Solodic soils cover approximately five million hectares of south-east Queensland and are at present either uncleared or else cleared but carrying only native pasture. The unfavourable nutritional and physical properties of the solodic soils have been the major limitations to their agricultural and pastoral development and this field day examined progress made in overcoming these limitations.

The first speaker, Mr. T. E. O'Sullivan, discussed the climate, vegetation and land use patterns of the solodic soils while the second speaker, Mr. W. Bott, described the major soil and vegetation types of the Wambo Shire so placing the problems of the solodic soils in regional perspective. Dr. J. S. Russell outlined the research program which he had carried out on solodic soils and showed members around some of the experimental pastures. Two experimental sites were visited, the first on the property of Mr. S. Male at Tara, the second at Mr. C. R. Hayward's property at Warra, in the Wambo Shire.

CLIMATE AND LAND USE OF SOLODIC SOILS IN THE TARA-KOGAN AREA

T. E. O'Sullivan

Queensland Department of Primary Industries, Dalby, Queensland.

Climate

The Tara area is on a similar latitude to Dalby (27° 32'S) and has an average rainfall of 600 mm (23.7") per year. The local view is that Tara is a "dry hole" as rainfall increases to the north and east. The annual rainfall of Tara compared with Dalby is:

Centre	Years of Record	Average (mm)	Highest Recorded (mm)	Lowest Recorded (mm)
Tara	45	600	1056	277
Dalby	87	665	1271	268

In both centres 67% of rainfall occurs in the warmer months (October to March) and 33% in the cooler months. Although rainfall reliability is not very high by world standards it is more reliable than in much of Queensland. The average yearly evaporation is 1611 mm, as measured at Taroom and there are approximately 88 days a year with an average maximum temperature over 32°C (90°F) and 13 days a year with maximum temperature over 38°C (100°F). Light frosting can occur from April to October with heavy frosting usually confined to June, July and August.

Vegetation and Soils

The light textured shallow surfaced solodic soils have a bleached A2 horizon and an A horizon less than 30 cm deep. The predominant tree species is narrow leaf ironbark (*Eucalyptus crebra*) with rusty gum (*Angophora costata*) often present. There is a dense lower tree layer, and if there is more than 30 cm of top soil cypress pine (*Callitris columellaris*) is common. Bull oak (*Casuarina luehmanii*) is frequent where the A horizon is less than 30 cm deep and is heavier. The main grasses are wire grasses (*Aristida* spp.), love grasses (*Eragrostis* spp.), silky browntop (*Eulalia fulva*) and curly windmill grass (*Enteropogon acicularis*, formerly *Chloris acicularis*).

As soils improve down the slopes towards water courses there is a change to loamy-surfaced, texture contrast soils. Poplar box (*E. populnea*) is the dominant tree species often with an understory of wilga and sandalwood. Pitted blue grass

(*Bothriochloa decipiens*) is common on these better soils, though grasses dominant on the lighter soils are also present.

Land use

There has been very little cropping on the solodic soils. Marginal success with barley has been obtained after fertilizing with superphosphate on soils with a deep A horizon. Grazing of natural pastures on the solodic soils has been primarily by sheep with a swing within the earlier years of last decade to replacement of sheep by cattle. However with the poor cattle prices over the last three years there has been some move back to sheep.

Cattle management is fairly low key on many properties with little or no control over mating or weaning. This results in two calving peaks, September and February. Weaning early is often only a drought induced husbandry practice. Native pastures on solodic soils carry a steer to 16–20 ha, which contrasts with the pastures on cleared brigalow which carry a steer to 2.5–3 ha. Furthermore cattle on brigalow soils have an annual liveweight gain of 0.5 kg beast^{-1} day^{-1}, whereas cattle on the solodic soils only gain at 50–75% of this rate.

SOILS AND LAND USE IN THE WAMBO SHIRE

W. Bott

Queensland Department of Primary Industries, Dalby, Queensland.

Introduction

Wambo Shire of 575,000 ha is situated on the western slopes of the Great Dividing Range about 180 km north west of Brisbane. The principal town is Dalby. There are 1075 rural holdings covering 493,000 ha. Of this total area 240,000 ha is cultivated, 20,000 ha is sown to improved pastures and 233,000 ha remains under native pasture. The climate of the shire is similar to that described for the Tara-Kogan region, with an annual average rainfall of 665 mm at Dalby. This paper describes the major soils and land use patterns in the shire and emphasises the relative poverty of the solodic soils.

Soils and land use

There are three major land use zones: the central plain which is well suited to agriculture, an upland area to the north-west with mixed farming potential and areas of solodic soils with limited pastoral value to the north and south-west. The plains soils are generally fertile with good water holding capacity, the uplands soils are fertile with mediocre water holding capacity and the solodic soils are poor in both respects.

There are six main ecological units which have been listed below in descending order of productivity based on carrying capacity when developed for native pasture. Such development involves clearing of scrub, or judicious thinning of woodland, and provision of appropriate fencing and stock water.

Ecological Unit	*Natural Vegetation*	*Carrying Capacity*
Plain	Open grassland	1 beast to 1.5–2.0 ha
Undulating brigalow	Brigalow, belah, softwood scrub	1 beast to 2.0–2.5 ha
Brigalow plain	Brigalow, belah, wilga, ti-tree	1 beast to 2.0–2.5 ha
Basaltic uplands	(a) Softwood scrub	1 beast to 2.0–2.5 ha
	(b) Mountain coolibah woodland	1 beast to 3.0–4.0 ha
Box plain	Poplar box woodland	1 beast to 4.0–5.0 ha
Solodics	Mixed forest and woodland	1 beast to 10–20 ha

The Plain

The open treeless plain naturally carries a grassland dominated by Queensland blue grass (*Dichanthium sericeum*) on a self mulching dark grey clay soil of great depth. Most of the plain is now cultivated. Continuous cropping appears to have had little adverse effect on soil physical condition and a stable cropping system involving the use of fertilizers, without the need for a pasture ley, has developed.

The Undulating Brigalow

The undulating brigalow generally occupies the lower foothills between the range and the plain. Soils are mainly clay loams to loams overlying clay subsoils. Vegetation on heavy soils is mainly brigalow, belah and softwood scrubs while on the lighter soils and higher situations scrub gives way to mixed woodland of poplar box, narrow leaf ironbark and cypress pine. About two thirds of this soil type is cultivated and the remainder offers considerable scope for pasture improvement.

The Brigalow Plain

The brigalow plain is virtually flat, the original vegetation being mainly brigalow and belah scrub. Some two-thirds of the estimated 26,000 hectares of brigalow plain is cultivated.

The Basaltic Uplands

The topography ranges from mountainous to undulating with a range in soils from loams and clay loams on the upper slopes to clays on the valley floors. The mountain coolibah woodland soils are generally more elevated, coarser in texture and less fertile than the scrub soils. This landscape pattern is well suited to mixed farming.

The Box Plain

The plain is mainly flat with levees and depressions associated with major water courses, the main tree being poplar box. About three-quarters of this soil type is currently used for grain growing.

The Solodics

There is a range in topography in the solodic areas from hilly through gently undulating to flat plain. Soils vary from shallow stony sands on hill tops to deeper sandy and loamy top soils overlying deep impenetrable clay subsoils. Half the solodic woodland areas are held as state forest. Little native pasture development has taken place on these soils because of the cost of timber treatment and regrowth control, limited productivity and, in undulating areas, the soil erosion hazard. There is very little cropping on these soils. All these points emphasise the vast difference between the solodic soils and the plains or uplands soils.

RESEARCH ON SOLODIC SOILS IN SOUTH-EAST QUEENSLAND

J. S. Russell

C.S.I.R.O., Division of Tropical Crops and Pastures, St. Lucia, Queensland.

Introduction

The marked contrast between plant yields and other factors (such as land prices) on solodic and the more fertile soils described in the previous papers indicates that the main limitations of the solodics are due to soil properties and the interaction of soil properties and climate.

The research program on solodic soils has been orientated towards the identification of these soil limitations and their possible amelioration through the application of amendments. The interaction between climate and soil has also been studied and the ultimate aim has been to develop stable grass-legume pastures which can be used productively.

Since 1964 CSIRO's experiments have been concentrated at two sites, the properties of Mr. S. Male, "Gelou", Tara and of Mr. C. R. Hayward, "Tong Park", Warra. The main findings of the earlier work have been as follows:

(1) The solodic soils are deficient in several nutrients. Phosphorus is highly deficient and any improvement must involve some addition of phosphate. Soils are also highly deficient in nitrogen and require nitrogen addition either as inorganic fertilizer or by use of legumes. Trace element deficiencies of copper, zinc and molybdenum have been shown for legumes but not for grasses. Sodium and magnesium levels are high and calcium, and sometimes potassium, levels are low.

(2) Rainfall variability is such that there is no certainty of adequate moisture being available for plant growth at any time of the year. The solodic subsoils are dense, almost impervious and this limits waterholding capacity and root growth. The occurrence of frosts also limits the species that can be used.

(3) Marked responses by summer legumes and particularly winter growing annual medics to large amounts of lime have been obtained with up to two tonnes ha^{-1} of hydrated lime. Hydrated lime has been more efficient than ground limestone in improving legume growth—possibly due to its greater solubility.

(4) Suitable species have been defined. The annual winter medics grow well particularly after addition of lime. Once established, the medics regenerate from seed and grow during the winter and early spring when competition from grasses is low. Of the tropical legumes, Siratro will persist in pastures particularly on the deeper soils and in some cases when they are deep chiselled to 50 cm. Grasses that can tolerate the high sodium content of the soil are at an advantage. Rhodes grass has this capability and is the most aggressive and productive grass on these soils. Pangola grass and *Panicum coloratum* both tolerate the soil conditions once established. Buffel grass growth is less certain. The acidity of the surface soils and the low potassium status may be reasons for the variable performance of this grass.

Current experimentation at Tara

The current plots were designed to give more detailed information on calcium requirements, grass/legume compatability and the possibility of potassium deficiency.

Eight fertilizer treatments were applied to four grass treatments, with and without addition of potassium fertilizer. The experiment was sown in 1975.

The eight fertilizer treatments were:

1. Nil
2. 750 kg ha^{-1} hydrated lime
3. 2000 kg ha^{-1} hydrated lime
4. 1000 kg ha^{-1} ground limestone
5. 3000 kg ha^{-1} ground limestone
6. 750 kg ha^{-1} hydrated lime + 1000 kg ha^{-1} gypsum
7. 1000 kg ha^{-1} ground limestone + 1000 kg ha^{-1} gypsum
8. 50 kg ha^{-1} nitrogen year^{-1} as urea

The four grass treatments were:

1. Rhodes grass cv. Pioneer at 3 kg ha^{-1}
2. *Panicum coloratum* cv. Bambatsi at 3 kg ha^{-1}
3. Buffel grass cv. Nunbank at 3 kg ha^{-1}
4. Mixture of (1 + 2 + 3) at 1 kg ha^{-1} of each species.

Basal superphosphate at 540 kg ha^{-1} was applied in 1975, with copper, zinc and molybdenum. Two of the four blocks in the experiments receive maintenance superphosphate. A mixture of Jemalong, Cyprus, Harbinger and snail medics was sown over all plots in May 1975, snail being sown at 1 kg ha^{-1} and the other cultivars at 3 kg ha^{-1}. Siratro and phasey bean, each at 2 kg ha^{-1} were sown in November 1975 with the summer grasses. The experiment is crash grazed by sheep twice a year, in autumn and spring. The botanical composition and yield of the different pastures is being measured four times a year.

The application of calcium containing amendments is having a marked effect on medic yield and frequency, as shown in Table 1. The beneficial effect of nitrogen application on medic growth suggests that the role of calcium amendments may be one of improving nitrogen fixation. Cyprus medic is proving to be the most productive of the four medics sown and snail medic the least. There has been no response to potassium.

TABLE 1

Yield and frequency of annual medics as affected by fertilizer treatments.

	Medicago spp.		
	Yield dry matter kg ha^{-1} Sept. 1976	Frequency Sept. 1976	Frequency March 1977
Control	84	27†	10
750 kg ha^{-1} hydrated lime	265	68	29
2000 kg ha^{-1} hydrated lime	393	81	22
1000 kg ha^{-1} ground limestone	273	56	21
3000 kg ha^{-1} ground limestone	332	71	16
750 kg ha^{-1} hydrated lime + 1000 kg ha^{-1} gypsum	229	61	20
1000 kg ha^{-1} ground lime + 1000 kg ha^{-1} gypsum	295	62	18
50 kg nitrogen ha^{-1}	228	51	19

†A frequency of 27% indicates that medics were present in 27 out of every 100 quadrats of 0.5 × 1 m thrown in this pasture.

Rhodes grass has been the most productive grass but *Panicum coloratum* is improving (Table 2). Siratro has only given low yields and it may be that the combination of the dry Tara environment and the adverse properties of solodic soils will prevent Siratro from being a useful legume.

TABLE 2

Yield and frequency of summer grasses and legumes.

Species	Plots	February 1976 Yield kg DM ha^{-1}	February 1976 Frequency %	February 1977 Yield kg DM ha^{-1}	February 1977 Frequency %
Rhodes grass	in Rhodes grass alone plots	888	99·7	1094	99·7
P. coloratum	in *P. coloratum* alone plots	285	90·3	507	98·7
Buffel grass	in Buffel alone plots	231	74·7	454	85·3
Rhodes grass	in combined grass plots	895	95·6	918	100·0
P. coloratum		82	55·7	69	28·5
Buffel grass		48	45·0	7	2·2
Siratro	all plots	26	22·8	18	6·4
Phasey bean		70	41·1	2	1·8

Current experimentation at Warra

The establishment of a grazing experiment on a large area of solodic land on the property of Mr. C. R. Hayward, "Tong Park", Warra, is the culmination of ten years research in the area. In this experiment the findings from the smaller experiments are being tested on a large scale with grazing animals. The soils are solodic (15–18 cm loamy sand to sandy loam over dense yellow grey to grey brown clay). The area is 145 ha and 84 Hereford steers graze the pastures continuously. There are 28 paddocks and three beasts per paddock. Stocking rate is altered by adjusting the area of paddocks. The fourteen treatments are listed in Table 3.

TABLE 3

The effect of different fertilizer and sown species on liveweight gain from August 1974-April 1977 expressed on an annual basis.

No.	Treatment	Stocking rate beasts ha^{-1}	Liveweight gain kg ha^{-1} yr^{-1}	Liveweight gain kg $beast^{-1}$ yr^{-1}
1.	Native pasture control	0·25	40	161
2.	Grass + 250 kg ha^{-1} super	0·63	78	126
3.	Grass + 250 kg ha^{-1} super + 125 kg ha^{-1} super annuallyr	0·63	80	129
4.	Grass + 500 kg ha^{-1} supe	0·63	74	119
5.	Grass + 500 kg ha^{-1} super + 125 kg ha^{-1} super annually	0·63	77	124
6.	Grass + P + 112 kg N ha^{-1} annually	0·63	102	165
7.	Grass + P + 112 N ha^{-1} annually	1·24	203	164
8.	Grass + P + TE + medic	0·63	71	114
9.	Grass + P + TE + medic + Ca	0·63	99	160
10.	Grass + P + TE + medic + Siratro	0·63	105	170
11.	Grass + P + TE + medic + Siratro + subsoiling	0·63	95	154
12.	Grass + P + TE + medic + Siratro + Ca	0·63	102	164
13.	Grass + P + TE + medic + Siratro + subsoiling + Ca	0·63	110	178
14.	Grass + P + TE + medic + Siratro + subsoiling + Ca	0·83	110	134

(TE = trace elements added)

Establishing the experiment

The whole area had been cleared some three years before sowing. The annual medics (1 kg ha^{-1} each of Jemalong, Cyprus and Harbinger) were sown in May 1973 into treatments 8 to 14. In November 1973, treatments 11, 13 and 14 were subsoiled to 50 cm using a D7 with three chisels one metre apart. In December and January 1974 the remaining seed and establishment fertilizers were applied.

The grasses were sown into all but treatment No. 1 at the rate of 2 kg ha^{-1} Rhodes grass, 0.5 kg ha^{-1} *Panicum coloratum* (Bambatsi) and 0.5 kg ha^{-1} *Panicum maximum* (green panic).

Superphosphate was applied at 250 kg ha^{-1} to treatments 2 and 3, and at 500 kg ha^{-1} to treatments 4 to 14. Treatments 6 and 7 both received a total of 112 kg ha^{-1} of nitrogen as urea, 70% being applied in October and 30% in January.

The medic treatments had the trace elements molybdenum, copper, zinc and boron (0.045, 1.35, 1.20, 0.7 kg ha^{-1} respectively) added with the superphosphate. Treatments 10 to 14 were also sown with Siratro (2 kg ha^{-1}) *Lotononis bainesii* (0.06 kg ha^{-1}) and phasey bean (1 kg ha^{-1}). Gypsum (1250 kg ha^{-1}) and 1250 kg ha^{-1} hydrated lime had been added to treatments 9, 12, 13 and 14.

Cattle management

Hereford steers were put onto the experiment in August 1974. Weather conditions during the first year were generally favourable. The pastures were grazed continuously with steers for 39 weeks from 29 August 1974 to 26 May 1975. A second group of Hereford steers was put onto the experiment in May 1975 and replaced by a third group in June 1977. Cattle are weighed every three weeks.

Results

The best animal performance was achieved from the sown grasses with applied superphosphate and nitrogen fertilizer (Table 3), emphasizing the role of nitrogen in increasing plant yield on these soils. In the treatments that include legumes, the good growth of legumes resulted in greater total plant growth and improvements in animal production over the grass and phosphorus treatment.

Studies of pasture composition showed that the medics as winter legumes and Siratro as a summer legume combine together quite effectively. The calcium amendments (hydrated lime and gypsum) had a marked effect on the yield of the medics and on their frequency in the pasture. Siratro yield has also been influenced by the calcium amendments but to a lesser extent. The effect of the calcium amendments on the grasses is possibly indirect, related to the nitrogen fixed by the legumes.

The experiment will be continued for at least another two years as many treatment differences are becoming more noticeable. The beneficial effect of lime and gypsum on medic growth is, for example, showing up more with time as there is an increasing effect on grass vigour from the extra nitrogen fixed by the increased medic growth. Also there is evidence that failure to apply maintenance superphosphate is weakening Rhodes grass vigour leading to ingress of native grasses.

In proposing a vote of thanks to the speakers, Mr. Ross Tait acknowledged that there is no current likelihood of pasture improvement on the solodics due to the cost/price squeeze. However he was optimistic that favourable financial conditions for pasture improvement would return, in which case research projects like that investigated meant the technology and 'know how' would be available for development of successful pastures.