CHEMICAL PROPERTIES AND FERTILITY STATUS OF SOILS OF THE BRIGALOW RESEARCH STATION, CENTRAL QUEENSLAND

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by: A.A. Webb
J.E. Maltby
J.Y. Gill
P.J. Nugent

Agricultural Chemistry Branch,
Research Station, P.O. Box 201,
BILOELA. 4715

DEPARTMENT OF PRIMARY INDUSTRIES, QUEENSLAND

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The soils of the Brigalow Research Station, 32 miles north west of Theodore in Central Queensland, were described and mapped by Webb (1971). A soil association map was produced.

A copy of the survey report and map are included as an appendix to this report.

In this paper some chemical and physical properties of the major soils of the Station and an assessment of their fertility are presented and discussed.

1. METHODS

1.1. Soil sampling

A total of 27 sites were described and sampled to a depth of 150 cm to provide information on the profile characteristics of the dominant soils of the various mapping units (Webb 1971). For consideration of the data the profiles have been grouped into 7 profile classes:- Ug 5, Sw-Db, Db, Dy-Dd, Gn 2, Al-Dd and Dy 3.

The three major soil profile classes on the Research Station are:-

- Ug 5 - cracking clay soils of units Ug and gil Ug
- Sw-Db - loamy duplex soils with moderately thick A horizons ("softwood" duplex soils) of unit Sw-Db
- Db - loamy duplex soils with thin A horizons of units Db and Dy-Db

18 of the sites represented these three major profile classes - 8 from Ug 5, 5 from Sw-Db and 5 from Db. For these 18 profiles, analyses of variance were computed on attribute values for six separate horizons (0-10, 10-20, 20-30, 50-60, 80-90 and 140-150 cm) in order to compare variability among and within the three major profile classes.

At 32 sites, surface samples (0-10 cm) were obtained. At each site five samples were collected over an area of approx 25 m^2. For the three major profile classes these samples were analysed separately to estimate within site variability of attributes. For the other profile classes, less sites were sampled and a composite sample was analysed for each site. Attribute values of surface samples for all profile classes were compared using analysis of variance.

1.2. Methods of analysis

All samples were analysed for pH, electrical conductivity, chloride, acid extractable phosphorus, total nitrogen (surface only), organic carbon (surface only), exchangeable cations and cation exchange capacity (C.E.C.). Profile samples were analysed also for particle size by a pipette method and a modified exchange resin method of Edwards and Brenner (1965).

Electrical conductivity, pH and chloride were measured on a 1:5 soil-water suspension at 25°C. Exchangeable cations were extracted by a leaching method with alcoholic ammonium chloride adjusted to pH 8.5 (Tucker, 1954). Cation exchange capacity was obtained by determination of

exchanged ammonium from the ammonium saturated sample remaining after the leaching for exchangeable cations. After destruction of the alcohol in the leachate and addition of strontium chloride, exchangeable cations were measured using a Techtron AA4 atomic absorption spectrophotometer.

Total nitrogen was determined on a Kjeldahl digest and organic carbon by the Walkley-Black method (Piper 1950). Organic carbon values were not adjusted by the factor of 1.3. Acid extractable phosphorus was obtained with 0.01N sulphuric acid (Kerr and Von Stieglitz 1938) and measured on a Unicam SP 600 spectrophotometer.

Copper and zinc were determined by atomic absorption spectrophotometry after extraction with DTPA (Follett and Lindsay, 1971) while total phosphorus, sulphur and potassium were determined by X-ray fluorescence spectroscopy.

1.3. Nutrient Experiments

Surface samples (0-10 cm) were collected at ten sites representing major soils. The soil from each site was sieved through a 10 mm mesh and thoroughly mixed. In all experiments 1600 g air dry soil was poured into 15 cm diameter polystyrene pots lined with clear polythene bags. To achieve similar bulk density, soil in each pot was lightly tamped at regular intervals. Each pot was watered to field capacity daily with demineralized water. Pots were rerandomized each week in the glasshouse. Lucerne (*Medicago sativa* cv. Hunter River) was selected as the indicator plant. All seeds were inoculated with *Rhizobium*. A week after germination seedlings were thinned to seven per pot.

For each soil a phosphorus rate experiment and a half replicate of a 2^6 factorial nutrient experiment were carried out.

The phosphorus rate experiment comprised seven levels of phosphorus replicated three times. Rates of phosphorus were calculated to be equivalent to 0, 10, 30, 50, 70, 90, 110 kg ha^{-1} P. A basal application of all nutrients used in the factorial experiment was added to each pot.

In the factorial experiments a basal application of phosphorus equivalent to 58 kg ha^{-1} P was added to each pot (.515 g $Na\ H_2\ Po_4\ .2H_2O$ per pot). Two series of factorial experiments were carried out. Factors in Series I (six soils) were the presence and absence of lime, molybdenum, zinc, potassium, sulphur and copper plus boron. In Series II (four soils) they consisted of sulphur, potassium, zinc, molybdenum, copper plus manganese plus iron, and magnesium plus boron. Rates of application and nutrient compounds used are given in appendix I.

Plant tops from 2 cm above soil level were harvested at preflowering, oven dried at 75°C and weighed. Dried plant material from selected treatments was ground in a "Glen Creston" stainless steel mill. In the phosphorus rate experiments plant material from each replicate was bulked for analysis.

Following Kjeldahl digestion of the plant samples nitrogen and phosphorus were determined by Auto Analyser, and potassium by flame photometry. Total sulphur, copper and zinc were determined by X-ray fluorescence spectroscopy.

2. SOIL CHEMICAL AND PHYSICAL CHARACTERISTICS

2.1. Soil Profiles

Morphological and analytical data for 27 soil profiles are presented in appendix II. Mean profiles for some attributes for the major soils are presented in figures 1-9.

pH The Ug soils had significantly higher pH than Db and Sw-Db soils in the upper 20 cm ($P < .05$). Below 30 cm the pH of Ug soils decreased and they were strongly acid at depth. Db soils increased in alkalinity to 60 cm, but became acidic deeper in the profile while Sw-Db soils remained alkaline. For the 80-90 cm horizon both Db and Sw-Db soils were significantly higher ($P < .05$) in pH than the Ug group but at 150 cm the Sw-Db soils had higher values than both the Db ($P < .05$) and Ug soils ($P < .01$)

Exchangeable cations Exchangeable calcium values for the Ug soils were moderately high in the upper 20 cm and were significantly higher than those for the Db and Sw-Db soils to 30 cm. For Ug and Db soils, exchangeable calcium decreased with depth but values for Sw-Db did not change greatly below 10 cm.

For exchangeable magnesium, Ug soils had values significantly higher than Db and Sw-Db soils ($P < .01$) in the upper 20 cm, but the latter two profile classes showed a marked increase at depth. Magnesium is the dominant cation below 30 cm in Db and Ug soils and is dominant below 60 cm for the Sw-Db group.

Ug soils had significantly higher exchangeable sodium ($P < .01$) than Sw-Db soils in all horizons except 140-150 cm, and significantly higher values ($P < .05$) than Db soils at 0-10, 10-20 and 80-90 cm depths. The Ug and Db groups show a mean maximum exchangeable sodium percentage (ESP) of about 20% by about 60 cm but this E.S.P. is not reached in the Sw-Db profiles until about 90 cm.

Mean exchangeable potassium profiles for the three major soil groups are not presented as a figure. Some values were extremely low ($< .10$) and precluded the use of mean values. For the Db soils values below the surface were $< .15$ m. equiv./100 g to 50-60 cm and < 0.1 to 150 cm. The Ug soils had a mean of about .30 m. equiv./100 g to 30 cm and about .15 m. equiv./100 g below that. Values for the Sw-Db soils were markedly higher than for the other soils with a mean value of .63 m. equiv./100 g in the 0-20 cm decreasing to .40 m. equiv./100 g in the 80-150 cm zone.

For cation exchange capacity (C.E.C.), Ug soils had significantly higher values than Db and Sw-Db soils throughout the profile.

Salinity The chloride values and electrical conductivity values for the Ug soils were significantly higher than the Db and Sw-Db soils at all horizons except 80-90 cm.

Profile trends for chloride and electrical conductivity are similar to exchangeable sodium for all soils. The Sw-Db soils generally have attribute peaks at a lower depth than the Db soils. This may be due to a deeper A horizon and/or deeper soil water movement in the Sw-Db soils.

2.2. Surface Soils

Mean values for a number of attributes of the top 0-10 cm for seven soil profile classes are presented in Table 1.

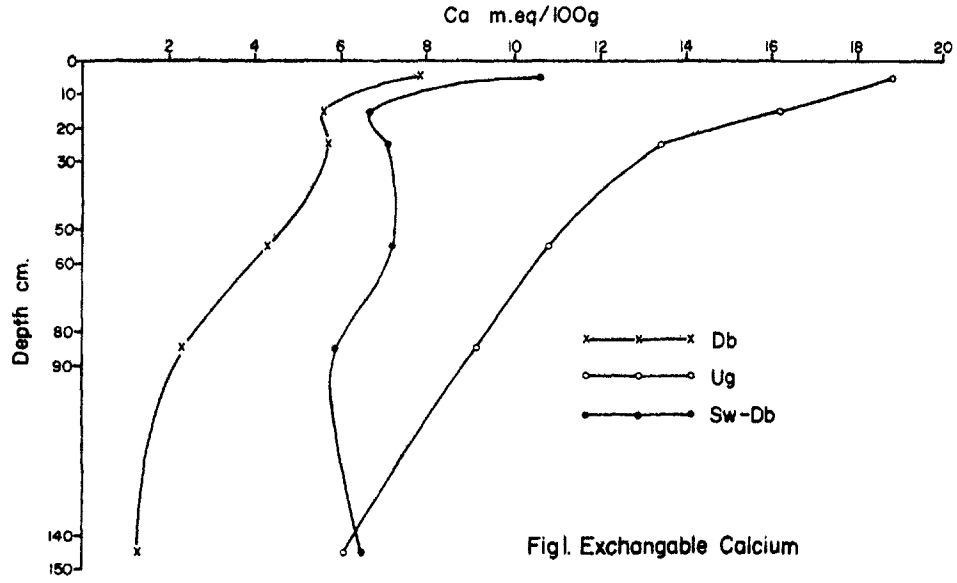

Fig 1. Exchangable Calcium

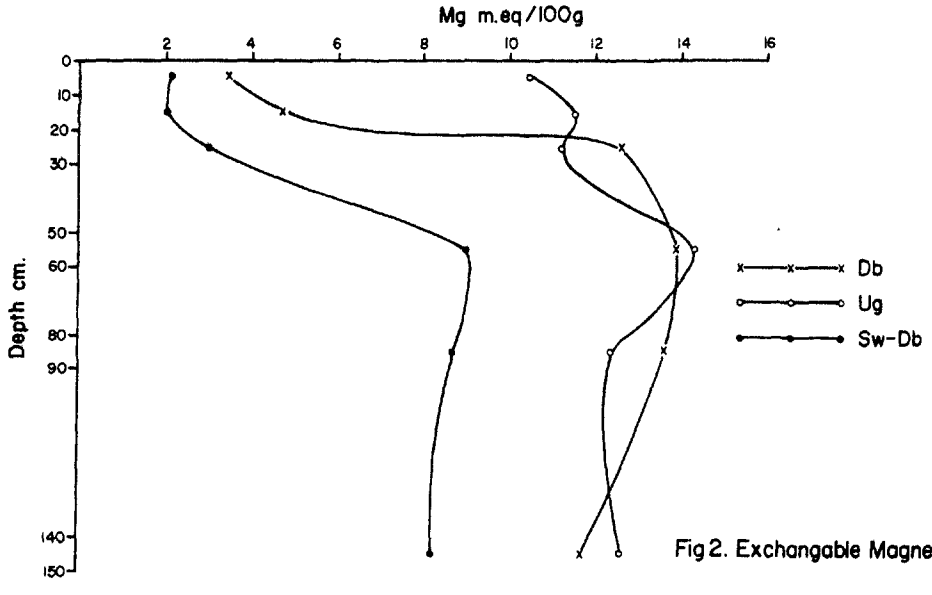

Fig 2. Exchangable Magnesium

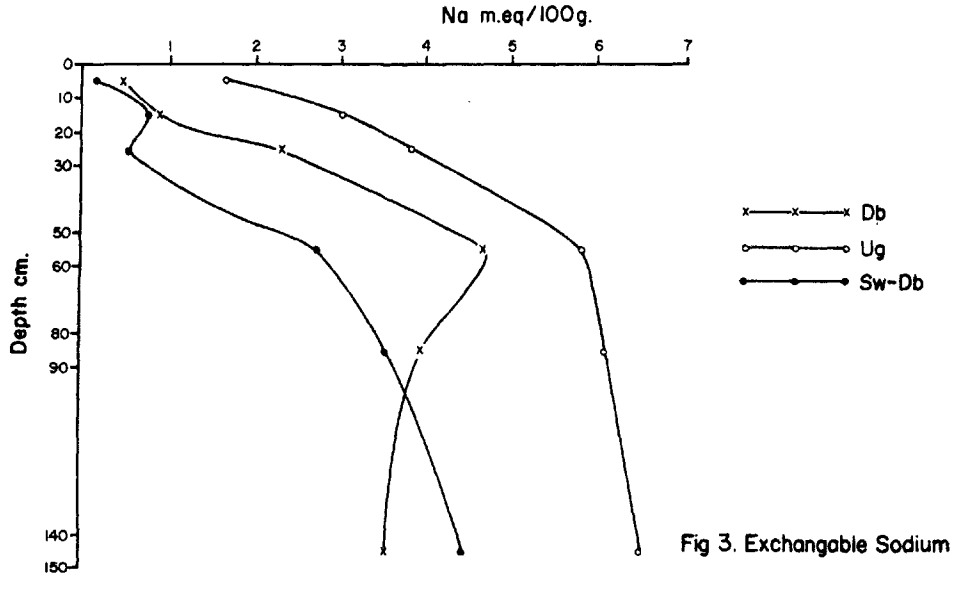

Fig 3. Exchangable Sodium

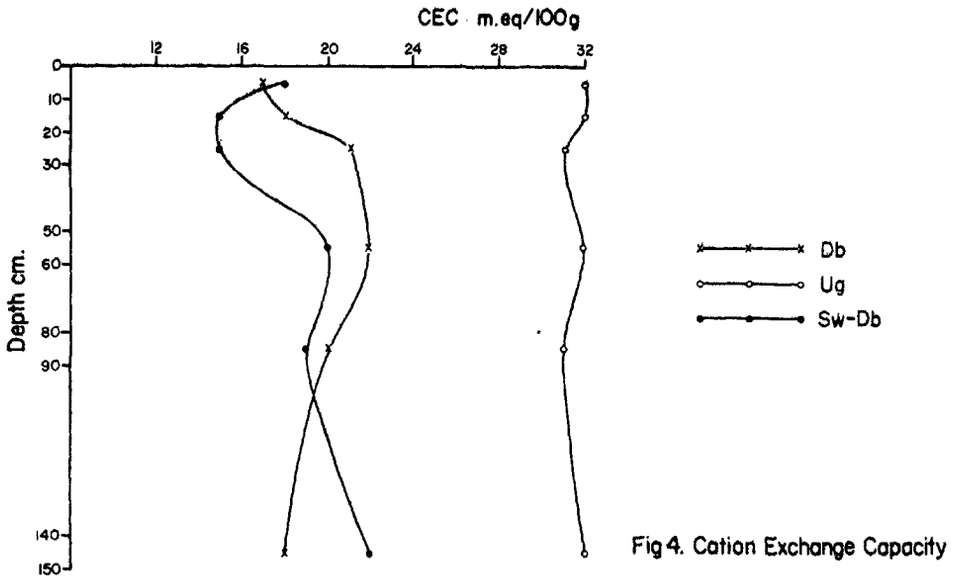

Fig 4. Cation Exchange Capacity

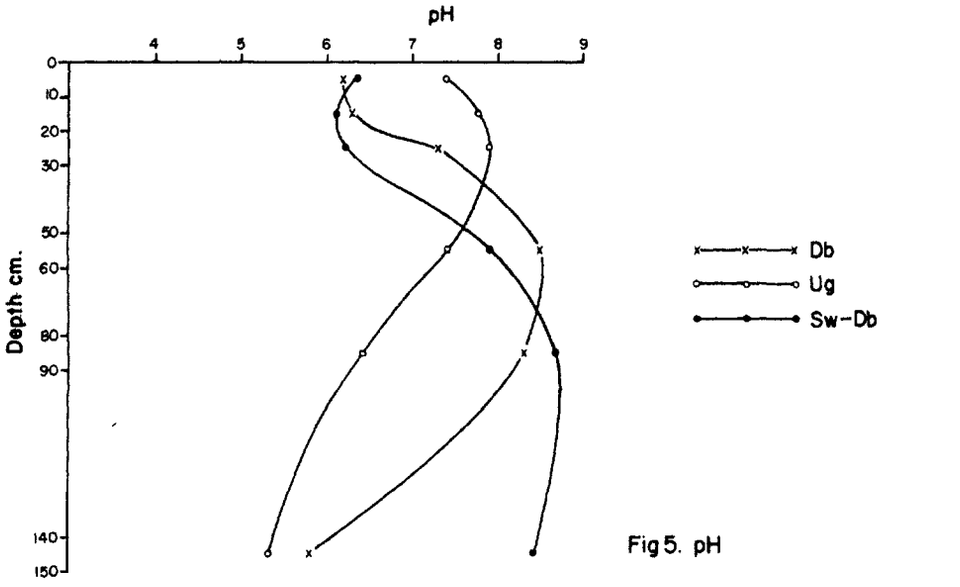

Fig 5. pH

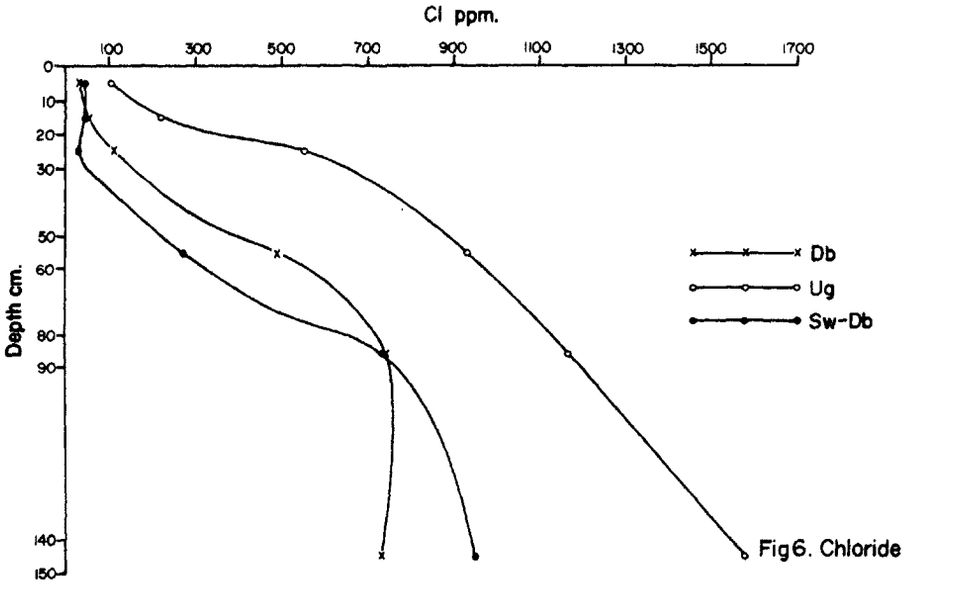

Fig 6. Chloride

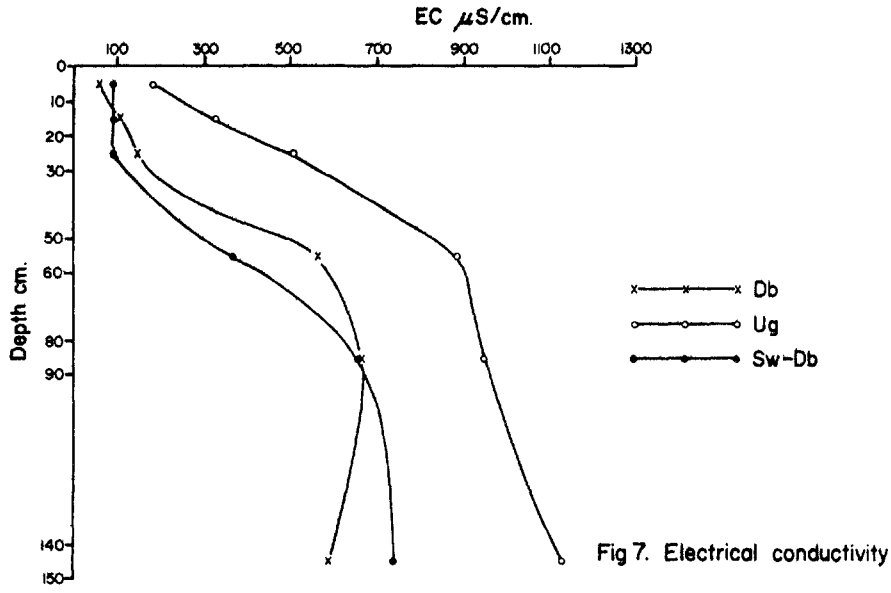

Fig 7. Electrical conductivity

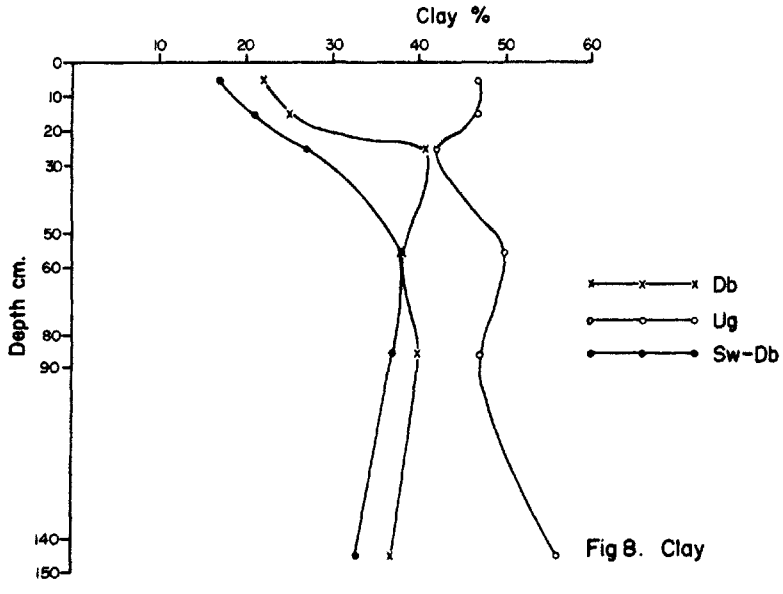

Fig 8. Clay

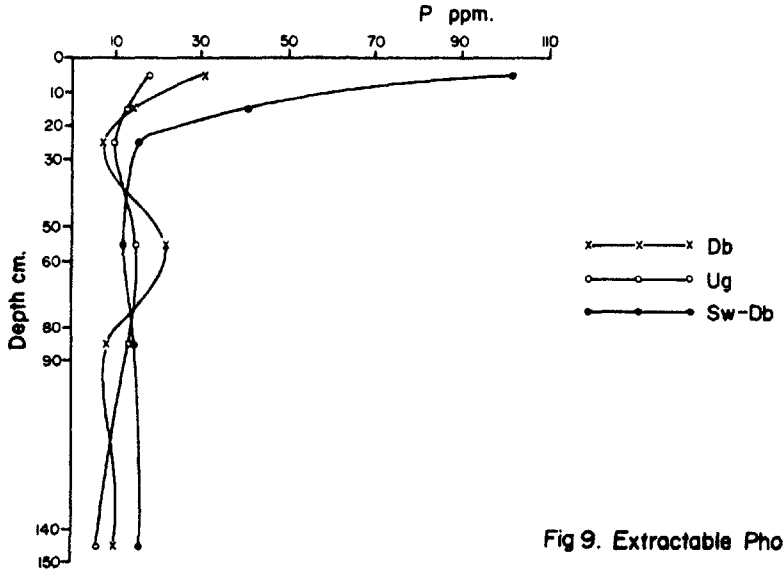

Fig 9. Extractable Phosphorous

TABLE 1: Chemical properties of surface soils (0-10 cm) for major soil profile classes, Brigalow Research Station

Soil Profile Classes		Ug 5	Db	Sw-Db	Dy-Dd	Gn 2	Al-Dd	Dy 3
No. of Sites		6	6	5	7	2	3	2
pH	Mean	7.8	6.4	7.5	7.1	7.3	6.5	6.5
	S.E.	*0.1*	*0.1*	*0.1*	*0.2*	*0.1*	*0.2*	*0.1*
Cl (%)	Mean	0.0116	0.0048	0.0066	0.0056	0.0090	0.00 [illegible]	0.0025
	S.E.	*.0012*	*.003*	*.0009*	*.0007*	*.005*	*.006*	*.005*
E.C. (mS cm^{-1})	Mean	188	86	143	135	170	120	54
	S.E.	*13*	*8*	*13*	*22*	*70*	*55*	*28*
Extr. P (ppm)								
Dilute Acid	Mean	34	24	92	46	86	111	8
	S.E.	*3*	*2*	*13*	*7*	*38*	*18*	*2*
Exch Cations (m. equiv/100 g)								
Ca^{++}	Mean	18	8	12	8	8	12	4
	S.E.	*1*	*1*	*1*	*1*	*2*	*2*	*1*
Mg^{++}	Mean	9	2	3	3	2	5	1
	S.E.	*0.3*	*0.2*	*0.2*	*0.3*	*0.5*	*1.6*	*0.1*
Na^{+}	Mean	1.7	0.2	0.3	0.4	0.1	0.7	0.1
	S.E.	*0.20*	*0.03*	*0.04*	*.07*	*.12*	*.20*	*.10*
K^{+}	Mean	0.53	0.12	1.16	0.51	0.63	0.77	0.11
	S.E.	*0.06*	*0.03*	*0.17*	*.10*	*.23*	*.22*	*.10*
C.E.C.	Mean	31	14	20	16	17	23	7
	S.E.	*1*	*1*	*2*	*1*	*1*	*2*	*1*
Total N (%)	Mean	0.121	0.094	0.178	0.111	0.136	0.152	0.059
	S.E.	*.008*	*.008*	*.013*	*.007*	*.060*	*.008*	*.002*
Org. C (%)	Mean	1.62	0.97	2.04	1.57	1.54	1.58	0.57
	S.E.	*0.11*	*0.08*	*0.17*	*.23*	*.48*	*.14*	*.11*
Total P (%)	Mean	.027	.046	.096	.050		.098	
	S.E.	*.0026*	*.0033*	*.0182*	*.0053*		*.0125*	
Total K (%)	Mean	.34	.18	.48	.37		1.52	
	S.E.	*.07*	*.04*	*.17*	*.07*		*.06*	
Total S (%)	Mean	.021	.020	.031	.023		.031	
	S.E.	*.0020*	*.0014*	*.0081*	*.0024*		*.0064*	
D.T.P.A. Cu (ppm)	Mean	2.4	1.6	1.3	1.4		1.7	
	S.E.	*.1*	*.2*	*.1*	*.3*		*.1*	
D.T.P.A. Zn (ppm)	Mean	.23	.4	1.5	.52		2.03	
	S.E.	*.1*	*.1*	*.6*	*.1*		*.2*	

TABLE 2: Variability of selected attributes for three soil profile classes

Soil Profile Class and Site No.		pH		E.C.* microS/cm		Exchangeable cations: Ca m. equiv/100g		Mg m. equiv/100g		Na m. equiv/100g		K m. equiv/100g		C.E.C. m.equiv/100g		Total N %		Organic C %		Acid Extr. P ppm	
		Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
Ug 5	34	7.5	.3	204	14	20.8	1.2	9.0	.6	1.1	.11	1.05	.14	34	3	0.197	.022	2.2	.2	48	7
	35	8.2	.2	156	26	17.4	.9	11.4	.2	1.5	.15	0.50	.06	32	1	0.106	.008	1.2	.1	32	5
	21	8.2	.1	152	5	22.6	1.8	8.6	.7	1.0	.14	0.39	.06	29	2	0.105	.014	1.2	.1	31	7
	19	7.1	.4	214	42	12.8	1.2	9.4	.9	2.0	.27	0.32	.11	28	1	0.117	.007	1.7	.1	15	2
	20	8.5	.0	153	8	23.8	.5	6.6	.2	1.6	.17	0.68	.08	34	1	0.092	.008	1.2	.2	44	4
	25	7.4	.2	250	44	11.0	.3	10.0	.6	3.1	.68	0.26	.12	27	2	0.110	.015	2.2	.2	35	3
LSD P <.05		.7		83		3.3		1.7		.9		1.29		5		0.042		.5		14	
LSD P <.01		.9		113		4.5		2.3		1.3		0.40		7		0.057		.6		19	
Sw-Db	26	6.9	.2	109	30	8.8	2.0	2.6	.4	.4	.09	0.65	.19	26	4	0.130	.020	1.3	.1	56	8
	22	7.4	.2	92	22	7.8	1.5	2.0	.3	.2	.09	0.36	.22	12	2	0.130	.018	1.7	.3	36	8
	17	7.4	.1	162	30	8.0	1.1	2.2	.5	.4	.10	1.24	.23	16	1	0.165	.021	2.2	.2	78	24
	33	7.8	.1	203	10	22.0	0.7	3.6	.2	.1	.10	1.25	.25	27	2	0.258	.023	3.1	.5	115	14
	16	7.8	.1	149	20	14.8	1.6	3.0	.4	.2	.02	2.3	.09	22	3	0.211	.021	2.0	.2	173	29
LSD P <.05		.5		69		4.3		1.2		.2		0.71		7		0.061		.9		55	
LSD P <.01		.6		94		5.8		1.6		.3		0.97		9		0.082		1.2		75	
Db	7	6.7	.2	58	19	11.6	2.9	2.4	.2	.2	.04	0.07	.06	16	2	0.118	.014	1.3	.2	34	8
	36	6.4	.1	79	17	7.2	1.2	1.9	.1	.2	.04	0.06	.05	13	2	0.084	.011	1.4	.1	23	4
	4	6.1	.1	103	21	6.0	0.6	2.1	.6	.4	.13	0.06	.05	15	1	0.099	.010	1.0	.1	24	4
	9	6.0	.0	66	7	4.0	0.6	2.0	.5	.2	.03	0.01	0	10	1	0.088	.003	.8	.2	12	1
	37	6.3	.2	83	5	6.4	0.5	1.1	.3	.1	.04	0.22	.09	10	2	0.077	.010	.6	.2	22	3
	8	6.8	.3	129	24	12.2	2.2	2.5	.5	.2	.02	0.28	.10	16	2	0.120	.015	.7	.2	29	5
LSD P <.05		.5		50		4.8		1.2		.2		0.19		5		0.033		.5		14	
LSD P <.01		.7		68		6.6		1.6		.2		0.26		7		0.045		.7		19	

* E.C. = Electrical Conductivity

The clay soils of the Ug groups generally have significantly higher values than do the other soil groups for chloride, electrical conductivity and exchangeable cations. The soils with "softwood" communities, Sw-Db and Gn 2 groups, and the Al-Dd soils have higher extractable phosphorus values than the other soils.

For pH the Ug 5 soils had higher mean values ($P < .01$) than the Db, Dy 3, Al-Dd and Dy-Dd soils. The Sw-Db soils had a higher mean ($P < .05$) than Db, Dy 3 and Al-Dd soils, and the Gn 2 and Dy-Dd soils had higher values ($P < .05$) than the Db soils.

In general the Sw-Db soils had higher exchangeable potassium, total nitrogen and organic carbon than the other soils except Al-Dd soils.

There were significant differences among the surface means for total phosphorus, total potassium and extractable zinc. The Al-Dd and Sw-Db soils again had higher levels of nutrients than the other soils.

The Al-Dd and Sw-Db soils had significantly higher total P values ($P < .01$) than the other three groups while the Dy-Dd and Db soils also had significantly higher means than the other soils.

For total K the Al-Dd soils had significantly higher mean values ($P < .01$) than the other soils and Sw-Db had a higher mean ($P < .05$) than the Db soils.

There was no significant differences among means for total sulphur and extractable copper.

2.3. Variability

Within site means (mean of 5 sub-samples) for attributes of the surface 0-10 cm for a number of sites in Ug, Sw-Db and Db soil groups are presented in Table 2. There were significant differences for each attribute between sites in each soil group. (Table 2)

Within site variability for pH is very low for each of the three major soil groups (Table 2). For most of the other attributes variability differs markedly from site to site.

For exchangeable potassium, total nitrogen and available phosphorus the S.E. associated with the means of several sites, particularly those in the Sw-Db group, are higher than desirable and an increase in the number of sub-samples per site is required for a reliable estimate of the mean.

3. NUTRIENT EXPERIMENTS

3.1. Soil Analysis

Soil analytical data for the ten soils used in the pot experiments are shown in Table 3. Chloride levels were less than .001% and are not shown.

3.2. Phosphorus Experiments

Yield and plant nutrient concentrations for the soils used in the phosphorus rate experiments are shown in Table 4.

TABLE 3: Analytical Data for the Ten Soils (0-10 cm) used in Pot Experiments

(18) (14) (28) (21) (27) ✓ ✓ ✓ (26) (25) ← IN TEXT

Soil Site No.	13	9	23	16	22	38	36	39	21	20
Mapping Unit	AlDd	Db	Dd	SwDb	DyDb	TsDy	Db	gil Ug	Ug	Ug
Principal Profile Form	Dd 1.43	Db 1.43	Dd 1.43	Db 1.43	Dy 2.43	Dy 3.43	Db 1.43	Ug 5.2	Ug 5.16	Ug 5.14
Particle Size (%)										
C.S.	10	31	40	18	45	36	28	20	21	18
F.S.	46	40	34	31	40	31	44	23	26	20
Si	23	13	9	15	6	16	14	13	12	14
C	21	16	17	36	9	17	14	44	41	48
pH	6.7	6.6	6.3	7.6	7.5	6.5	6.6	8.0	7.8	8.0
E.C. (mS cm^{-1})	97	39	47	210	174	39	83	246	183	291
Extr. P (ppm)										
Dilute Acid	182	16	19	98	61	16	19	24	25	40
Bicarb.	99	13	13	76	29	10	10	18	18	39
Exch Cations (m. equiv/100 g)										
Ca^{++}	12	4.7	4.5	9.8	5.0	4.4	6.8	25	20	22
Mg^{++}	2.5	2.4	3.1	4.2	0.9	4.0	1.6	8.2	7.8	7.2
Na^{+}	0.2	0.2	0.2	0.3	<0.1	0.1	<0.1	1.2	0.5	0.8
K^{+}	1.0	<0.1	0.4	2.2	0.5	0.7	0.2	0.6	0.6	0.9
C.E.C.	22	12	15	21	10	14	12	31	29	30
Total N (%)	0.22	0.08	0.13	0.19	0.10	0.10	0.09	0.11	0.09	0.09
Org. C (%)	3.14	0.84	2.37	1.69	1.22	1.29	1.3	1.6	1.1	1.2
Total P (%)	.121	.047	.054	.101	.058	.034	.033	.035	.026	.036
Total K (%)	1.60	0.12	0.31	0.60	0.17	1.46	0.11	0.26	0.23	0.30
Total S (%)	.044	.018	.029	.033	.023	.012	.023	.030	.022	.025
D.T.P.A. Cu (ppm)	1.6	1.1	1.5	1.8	0.7	0.9	1.0	2.0	2.0	2.0
D.T.P.A. Zn (ppm)	2.5	0.4	0.6	1.9	0.5	0.7	0.3	0.3	0.2	0.3

TABLE 4: Mean Yield and Nutrient Concentration of *Medicago sativa* Grown in Pots at Different Phosphorus Application Rates

Treatment	Soil 18			Soil 14			Soil 28			Soil 21			Soil 27			Soil 38			Soil 36			Soil 39		
Phosphorus kg ha^{-1}	Mean O.D.* Yield (g pot^{-1})	P %	N %	Mean O.D. Yield (g pot^{-1})	P %	N %	Mean O.D. Yield (g pot^{-1})	P %	N %	Mean O.D. Yield (g pot^{-1})	P %	N %	Mean O.D. Yield (g pot^{-1})	P %	N %	Mean O.D. Yield (g pot^{-1})	P %	N %	Mean O.D. Yield (g pot^{-1})	P %	N %	Mean O.D. Yield (g pot^{-1})	P %	N %
0	2.69	.36	4.06	0.74	.24	4.40	1.67	.20	3.40	2.81	.31	3.89	1.47	.31	4.30	1.05	.19	3.65	0.47	.17	4.32	2.33	.26	3.71
10	2.56	.40	4.06	1.39	.24	3.77	2.75	.28	4.16	3.01	.32	3.89	2.62	.31	4.00	1.82	.26	3.93	1.14	.19	3.42	2.54	.29	3.68
30	2.60	.47	3.93	2.08	.33	4.01	4.01	.32	3.65	2.96	.38	3.99	2.92	.35	4.04	2.53	.42	4.53	1.92	.25	4.00	2.66	.42	3.61
50	2.71	.46	4.17	2.43	.39	3.81	4.68	.41	4.01	3.25	.39	3.99	2.93	.39	3.77	2.80	.45	4.20	2.24	.32	4.16	3.12	.36	3.71
70	2.96	.51	4.33	1.76	.44	3.71	4.77	.45	4.13	3.32	.41	4.01	2.50	.40	3.98	2.70	.45	3.77	2.32	.38	4.04	3.16	.40	3.74
90	2.58	.51	4.09	1.99	.47	4.09	4.63	.46	4.36	3.33	.43	4.69	3.07	.42	3.88	3.02	.49	3.94	2.16	.40	3.89	2.74	.42	3.94
110	2.68	.51	3.99	2.21	.46	3.89	4.70	.51	4.23	3.36	.44	3.98	2.95	.43	3.95	2.46	.49	3.89	2.20	.41	3.89	3.17	.42	3.71
Necess. 5% diff. for signif.	+			0.52			0.51			+			0.85			0.36			0.29			0.56		
1%	+			0.72			0.71			+			1.12			0.51			0.41			0.78		

* O.D. - Oven Dried

\+ Not significantly different plant dry matter yields on addition of phosphorus

TABLE 5: Main Effects of Treatments on Dry Matter Production of *Medicago sativa* Grown on Ten Different Soils (g pot^{-1})

	SOIL							SOIL			
Series I	18	14	28	21	27	38	Series II	36	39	26	25
S_0	1.99	1.49	2.43	2.27	2.23	1.92	S_0	1.96	4.08	3.70	4.50
S_1	3.31**	2.70**	3.64**	3.01**	2.61**	3.31**	S_1	3.17**	4.93**	4.38*	5.58**
$Lime_0$	2.70	1.80	2.92	2.69	2.43	2.45	$Mg\text{-}B_0$	2.52	4.56	4.10	5.05
$Lime_1$	2.60	2.39**	3.16	2.58	2.41	2.78*	$Mg\text{-}B_1$	2.61	4.45	3.99	5.03
K_0	2.79	2.20	3.31	2.67	2.55	2.73	K_0	2.56	4.51	3.86	4.99
K_1	2.51	1.99	2.77**	2.60	2.28	2.50	K_1	2.57	4.49	4.22	5.09
Zn_0	2.67	1.97	3.09	2.58	2.38	2.60	Zn_0	2.57	4.39	4.07	4.74
Zn_1	2.63	2.22	2.99	2.69	2.45	2.63	Zn_1	2.57	4.61	4.02	5.34**
Mo_0	2.69	2.17	2.94	2.63	2.31	2.52	Mo_0	2.53	4.54	4.23	5.04
Mo_1	2.61	2.02	3.14	2.65	2.53	2.71	Mo_1	2.61	4.46	3.85	5.04
$Cu\text{-}B_0$	2.55	2.18	3.12	2.66	2.50	2.65	$Cu\text{-}Mn\text{-}Fe_0$	2.60	4.54	3.99	4.88
$Cu\text{-}B_1$	2.75	2.02	2.96	2.62	2.34	2.58	$Cu\text{-}Mn\text{-}Fe_1$	2.53	4.47	4.09	5.20
Necess. 5% diff. for signif.	.41	.26	.28	.44	.35	.29		.16	.25	.51	.38
1%	.59	.37	.40	.62	.50	.42		.22	.35	.73	.55

* mean yield of treated plants significantly different to that for untreated plants at $P < .05$

** mean yield of treated plants significantly different to that for untreated plants at $P < .01$

Six of the eight soils exhibited a significant increase in plant dry matter production on the addition of phosphorus.

In soils 14, 28, 38 and 36 yield response was marked and reached 90% of maximum after addition of between 30 and 50 kg P ha^{-1}, while soil 27 attained near-maximum yields between 10 and 30 kg P ha^{-1}. In soil 39 the response was less marked and near maximum yield was reached at 50 kg P ha^{-1}. On soils 18 and 21 yield was not significantly increased on P addition. Plant phosphorus concentrations for nil phosphate treatments on soils 14, 28, 38, 36 ranged from 0.17 to 0.24%. The suggested critical value is 0.24% phosphorus (Andrew and Robins 1969a). The remaining two soils 27 and 39 which responded to P addition had plant phosphorus concentrations for nil P treatment of 0.31% and 0.26% respectively, which is above the suggested critical concentration. Soils 18 and 21 (non-responsive) had P concentrations for nil P treatments of 0.36% and 0.31% respectively.

3.3. Factorial Experiments

Treatment main effects on plant yield for the factorial experiments are shown in Table 5.

Significant two factor interactions based on yield data are shown in Table 6.

Sulphur Effect A significant increase in plant dry matter production occurred on the addition of sulphur to all soils. Plant sulphur concentration for nil sulphur treatments ranged from .10 to .21% compared with .24 to .47% for plus sulphur treatments. This indicates deficiency and sufficiency respectively when compared with the suggested critical concentration of 0.21% (Andrew, 1975).

Application of sulphur increased plant nitrogen concentration on all soils (mean 3.69% N for nil sulphur treatments and 4.49% N for plus sulphur treatments).

A sulphur x molybdenum interaction occurred on soil 28 (a solodic soil). A significant increase in plant yield was achieved from molybdenum addition after sulphur had been applied (Table 6).

TABLE 6: Significant two factor interactions

Soil	Interaction				Necessary Difference P <.05
14	S x Zn	S	Zn_0	Zn_1	.367
		0	1.496	1.485	
		1	2.446	2.963	
28	S x Mo	S	Mo_0	Mo_1	.396
		0	2.490	2.380	
		1	3.394	3.891	
39	S x Zn	S	Zn_0	Zn_1	.353
		0	4.155	3.999	
		1	4.628	5.226	
25	S x Zn	S	Zn_0	Zn_1	.544
		0	4.418	4.593	
		1	5.073	6.079	

Zinc and Lime Effects A positive zinc response occurred in soil 25 (a clay). After correction for sulphur deficiency plant zinc concentrations in nil zinc treatments ranged from 6.0 to 11 ppm which is below the suggested critical level of 15 ppm (Melsted *et al* 1969). On plus zinc treatments plant zinc concentrations ranged from 14 to 19 ppm.

Sulphur x zinc interactions occurred on soils 14, 39 and 25 (Table 6). In each case a response to zinc addition occurred after addition of sulphur.

Liming significantly increased yields on soils 14 and 38. Mean soil pH values were increased by liming from 6.5 to 6.8 (soil 14) and 6.3 to 6.6 (soil 38). Plant zinc concentrations were markedly reduced on liming of soil 14. After correction for sulphur deficiency, plant zinc concentration for nil zinc treatment was 24 ppm and for plus zinc was 27 ppm on unlimed soils. This contrasts with 12 ppm and 17 ppm for limed soils.

Potassium and Copper Effects Soil 28 exhibited a significant yield depression on addition of KCl. In the presence of sulphur plant potassium concentrations in nil potassium treatments for soil 28 ranged from 1.95 to 2.47% which is higher than the suggested critical value of 1.2% (Andrew and Robins, 1969b). In potassium treatments concentrations ranged from 3.08% to 3.42%. Plant chloride concentrations for nil KCl treatments ranged from 0.3 to 0.5% while those in KCl treatments were 0.6 to 0.9%.

The yield depression on KCl addition in soil 28 is thought to be due to chloride toxicity. Fergus (1962) in studying the nutrient response of some "brigalow" soils suggested that an observed growth depression could be caused by excess chloride iron. Other workers (Andrew and Robins 1969c, Hall 1971, and Smith 1971) have reported damage to legumes with high application rates of KCl. Rominger *et al* (1976) obtained herbage yield reduction at plant concentrations of 1.5% and 0.96% Cl in two consecutive years of lucerne growth.

The copper-boron treatment did not have a significant effect on plant yield on any soil. Plant copper concentrations for nil copper treatments ranged from 10 to 24 ppm. This is above the suggested critical level of 7 ppm (Melsted *et al* 1969), and higher than the 5 ppm value suggested as marginal for legumes (Andrew and Thorne 1962).

4. FERTILITY ASSESSMENT

Extractable phosphorus and values in the surface of the Db and Dy 3 and some of the Ug 5 soils are low and are considered to be in the deficiency range. Kerr and Von Stieglitz (1938) suggested a critical value of 17 ppm phosphorus (0.01 N H_2SO_4 extract). In Tables 1 and 2, four Db, one Ug and the two Dy 3 soils had extractable phosphorus values near this value.

Results of the pot experiments indicated that phosphorus and sulphur were the major nutrients limiting growth in the surface of these soils. On five out of the six responsive soils acid extractable P levels indicated that a response could be expected with values in the range 16 to 24 ppm. Non responsive soils had values of 98 and 182 ppm.

Total soil phosphorus is not usually well correlated with plant growth. Despite this, results showed (Table 3) that responsive soils had relatively low levels of total P (330 to 580 ppm) whereas non-responsive soils had much higher values (1010 to 1210 ppm).

Yields of plant material for nil phosphorus pots was regressed against both bicarbonate and acid extractable phosphorus for the eight soils used in the phosphorus rate experiments. In both cases the regression was significant ($P < .05$). The equations for each regression are shown below.

$$Y = .977 + .02x_1 \qquad r = .79$$

$$SE_b = .0065$$

and

$$Y = .1078 + .01x_2 \qquad r = .71$$

$$SEb = .004$$

where Y = yield of lucerne per pot (g)

x_1 = bicarbonate extractable phosphorus (ppm)

and x_2 = acid extractable phosphorus (ppm)

Bicarbonate extractable phosphorus and acid extractable phosphorus were also highly correlated ($r = .96$).

Plant growth response is poorly correlated with total soil sulphur. However the mean total sulphur level of 259 ppm for these soils could indicate a deficiency when compared with the values of Andrew *et al* (1974). They quote a mean total sulphur figure of 130 ppm for 37 responsive soils and 560 ppm for 8 non-responsive soils. These responses may not be confirmed in the field as some of the soils have high total S levels at depth in the profile. Jones (1970) demonstrated that analysis of the full soil profile is important in determining a plant field nutrient response, especially with a deep rooting plant like lucerne.

Interactions of sulphur with zinc and molybdenum emphasize the severity of the sulphur deficiency.

Exchangeable potassium values for most Db and Dy 3 soils are below 0.2 m. equivalents per 100 g which is widely accepted as a threshold value (Williams and Lipsett, 1960). Soil No. 14 and 36 in the pot experiments also had very low levels of exchangeable potassium. Despite this, no positive responses to potassium addition occurred.

Electrical conductivity and chloride values in the surface of all soils are low, but do rise to high values in the 50-60 cm zone for some Db and Ug soils. These could restrict the rooting depth of crops or pastures.

Extractable zinc values for the major soil groups (Table 3) indicate that the soils of Db, Dy-Dd and Ug groups are likely to be in the deficiency range. Data for these soils used in the pot experiments also emphasized this indication. Results of the pot experiments confirmed the deficiency in soils 14 (Db), 39 (Ug) and 25 (Ug).

Due to the high levels of extractable copper in these soils copper deficiency is not expected to be a problem. This is supported by the experimental results.

pH values of all soil groups are in the mildly acid to mildly alkaline range in the top 10 cm of the profiles and major nutrient availability problems would not be expcted.

The responses due to liming on soils 14 and 38 are not readily explained by the data. Liming was not expected to have affected nodulation and subsequent nitrogen production as the pH values (for limed and unlimed soil) were within the recommended range 6.2 to 6.7 (Andrew 1976). Plant

nitrogen concentrations were adequate; mean 3.8% (range 2.9 to 4.8%) and mean 3.9% (range 3.2 to 4.7%) for soil 14 and 38 respectively. Plant sulphur concentrations were unaffected by liming and soil exchangeable Ca levels were thought to be adequate, representing 42% (soil 14) and 32% (soil 38) of the cation exchange capacity.

Mean plant calcium concentration from nil lime treatments for soil 14 was 1.8% (range 1.3 to 2.2%) and for soil 38, 1.5% (range 1.2% to 1.6%). These are higher than the suggested critical value of 0.8% (Melsted *et al* 1969).

Reductions in plant zinc concentrations on lime addition has been reported by Pauli *et al* (1968). This is thought to be a pH effect.

Glasshouse pot nutrient studies are useful in determining areas where problems may occur in the field, especially when used in conjunction with full profile chemical analysis. Field experiments are required to clarify the results of these studies and test for sufficiency of sulphur, phosphorus, lime and zinc.

5. SUMMARY AND IMPLICATIONS FOR LAND USE

The Ug soils of units Ug, gil Ug, Ug-D and Ug complexes may have low available phosphorus at some sites and are likely to have very low levels of extractable zinc.

Soluble salts (mainly chloride) reach very high values within 50 to 60 cm of the surface and these could have major effects on plant growth and persistence. Observed patchiness in growth of sorghum and Dolichos has been attributed to high chloride values in the soil in parts of G block east of the yards.

In addition soil depth may be less than 40 cm in parts of M land and J block. Since these soils have been used for most agronomic work on the station these factors should be noted.

Gilgai formation can cause problems in planting, growth and harvesting of crops. Where gilgais are deep, crops may not persist. The overall effect is to severely reduce production per unit area on these soils.

The Db, Dy, and Dd soils of units Db, Dy-Db, Ts-Dy, TsDd and Dy also may have low or very low levels of available phosphorus and extractable zinc. A major limitation to plant growth on these soils is the available moisture storage.

Limited data on moisture extraction from lucerne and lucerne-grass pastures on Dy and Db soils in N block indicate that plant roots can extract moisture from the upper 50-70 cm (Gramshaw pers. comm.). Depth of wetting (and effective depth of rooting) coincide with a maximum in soluble salts and bulk density. In some areas of the Dy-Db, TsDy and Db-Dr units soil depth is less than 50 cm.

Crop growth on the duplex soils is likely to be limited or affected by physical properties of the surface. They have reasonably high levels of silt and fine sand.

The duplex soils of unit Sw-Db and the earths of unit Sw-Gn 2 have high levels of available nutrients particularly in the upper part of the profile. The chemical profiles indicate depth of wetting is at least 150 cm.

Data on moisture extraction in Sw-Db soils of Q block indicate moisture extraction occurs down to 120 cm (Gramsahw per comm.).

The alluvial clays and duplex soils of units Al-Ug and Al-Dd and Dd-Ug have high levels of plant nutrients.

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APPENDIX I: Rates and Chemical Forms of Nutrients Used in Pot Experiments

SERIES I				SERIES II			
Treatment	Compound Applied	Rate of Application kg ha^{-1}	g pot^{-1}	Treatment	Compound Applied	Rate of Application kg ha^{-1}	g pot^{-1}
Ca	$CaCO_3$	700	1.2	S	Na_2SO_4	140	.248
Mo	$(NH_4)_6MO_7O_{24}.4H_2O$	0.6	.001	K	KCl	120	.212
Zn	$ZnCl_2$	15	.026	Mo	$(NH_4)_6MO_7O_{24}.4H_2O$	0.6	.001
K	KCl	120	.212	Zn	$ZnCl_2$	15	.021
S	Na_2SO_4	140	.248	Cu	$CuCl_2.2H_2O$	15	.027
				Mn	$MnCl_2.4H_2O$	15	.027
				Fe	Iron Chelate		.2% Spray
Cu	$CuCl_2.2H_2O$	15	.026	Mg	$MgCl_2.6H_2O$	90	.159
B	$Na_2B_4O_7.10H_2O$	3	.0053	B	$Na_2B_4O_7.10H_2O$	3	.0053

APPENDIX II

Morphological and Analytical Data for Soil Profiles

Soil Association: Al-Ug
Great Soil Group: Black Earth
Parent Material: Alluvium
Topography: Alluvial Plain
Vegetation: cultivation

Site No. P 10
Location: S block Brigalow Research Station
Australian Map Grid Reference:
Air Photo Reference:
Principal Profile Form: Ug 5.16

Profile Morphology:

0 - 2 cm Very dark grey heavy clay (10YR 3/1 m), slightly hard to hard (dry), self mulching, granular (10 mm) abrupt change to

2 - 100 Very dark grey heavy clay (10YR 3/1 m), extremely hard (dry), coarse blocky breaking to sub-angular blocky (200 - >60 mm), 10% carbonate concretions (<5 mm) in 30-100 cm; gradual change to

100 - 150 Dark greyish brown heavy clay (10YR 4/2 m) with fine rust coloured mottle, very hard, coarse sub-angular blocky

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) µScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	6.9	175	.009		1	9	27	63	50	27.2	14.4	1.3	1.7	.067	1.30	.027	128
	10-20	7.0	310	.024		1	5	26	68	52	26.4	13.6	.9	2.7				106
	20-30	7.4	1200	.035		1	4	25	70	54	28.0	15.6	.6	3.0	.066	1.28	.039	84
	50-60	7.8	1720	.203		1	4	23	72	52	20.0	20.0	.2	9.5	.047	1.15	.021	82
	80-90	7.4	1500	.239		1	5	26	68	49	20.4	19.6	.3	4.1	.040	1.03	.039	135
	130-150	7.2	1550	.233		1	9	24	66	46	16.8	24.0	.4	3.7				81

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Bicarb Extr. P ppm	Repl. K m.equiv/100 g	Fe D.T.P.A.	Mn	Cu Extr. ppm	Zn	B ppm
	0-10	2.3	0.211					3.2	1.2	

Soil Association: Al-Ug
Great Soil Group: Black Earth
Parent Material: Alluvium
Topography: Alluvial Plain
Vegetation: Cultivation

Site No. P 11
Location: S block Brigalow Research Station
Australian Map Grid Reference:
Air Photo Reference:
Principal Profile Form: Ug 5.16

Profile Morphology:

0 - 3 cm Very dark greyish brown heavy clay (10YR 3/2 m), slightly hard, self-mulching, granular (10-20 mm); abrupt change to

3 - 100 Very dark greyish brown heavy clay (10YR 3/2 m), extremely hard, coarse sub-angular blocky (60 mm), 10-30% carbonate concretions in 30-100 cm; gradual change to

100 - 150 Dark greyish brown heavy clay, (10YR 4/2 m), brown mottle, very hard, structured

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) µScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	7.4	220	.003		2	10	24	64	48	32.0	14.4	1.2	.8				52
	10-20	7.8	245	.026		2	8	21	69	51	30.8	16.8	.4	2.1				33
	20-30	7.9	1050	.024		2	9	23	66	49	26.4	18.4	.2	2.4				27
	50-60	7.5	1440	.161		2	7	24	67	52	22.0	20.4	.5	6.2				78
	80-90	7.2	1450	.084		1	8	25	66	47	20.0	23.2	.2	3.3				89
	130-150	7.8	1100	.076		2	14	25	59	43	15.6	22.4	.2	3.2				52

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Bicarb Extr. P ppm	Repl. K m.equiv/100 g	Fe D.T.P.A.	Mn	Cu Extr. ppm	Zn	B ppm
	0-10	1.7	0.169							

Soil Association: Ug-D
Great Soil Group: Grey clay
Parent Material:
Topography: Plain
Vegetation: *Acacia harpophylla, Casuarina cristata, Geijera parviflora*

Site No. P 4
Location: W block Brigalow Research Station
Australian Map Grid Reference:
Air Photo Reference:
Principal Profile Form: Ug 5.24

Profile Morphology:

0 - 5 cm Dark greyish brown medium clay (10YR 4/2 m), very hard, sub-angular blocky 30 mm - >6 mm; clear change to

5 - 150 cm Greyish brown medium clay (10YR 5/2.5 m), very hard, blocky.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) µScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	5.9	200	.019		10	21	15	54	27	8.4	16.8	.15	.9				1
	10-20	5.8	375	.044		9	20	15	56	29	7.6	16.6	<.05	1.7				1
	20-30	5.6	505	.063		9	21	14	56	29	6.8	13.8	<.05	2.0				1
	50-60	4.9	630	.080		12	24	13	51	26	4.4	11.8	.05	3.7				1
	80-90	4.6	825	.010		10	20	15	55	26	3.2	9.6	<.05	3.2				1
	130-150	4.4	920	.124		10	17	15	58	26	2.4	9.6	<.05	3.4				1

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Bicarb Extr. P ppm	Repl. K m.equiv/100 g	Fe D.T.P.A.	Mn	Cu Extr. ppm	Zn	B ppm
	0-10	1.0	0.086							

Site No. P 5

Soil Association: Db
Great Soil Group: Solodic Soil
Parent Material:
Topography: Undulating Plain
Vegetation: Regrowth of *Eucalyptus cambageana, Acacia harpophylla, Eremophila mitchellii*

Location: Z1 block Brigalow Research Station
Australian Map Grid Reference:
Air Photo Reference:
Principal Profile Form: Dr 2.43

Profile Morphology:

0 - 20 cm Brown sandy loam (7.5YR 4/3 m) hard, massive, earthy; abrupt change to
20 - 22 Very pale brown sandy loam conspicuously bleached over
22 - 30 Reddish brown gritty clay (5YR 4/4 m), extremely hard, coarse blocky , some small manganiferous concretions (<5 mm); gradual change to
30 - 90 Brown sandy clay loam (7.5YR 4/4 m) slightly hard, massive with manganiferous staining; clear change to
90 - 150 Brown sandy clay (10YR 5/3 m) hard, structured

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca⁺⁺	Mg⁺⁺	K⁺	Na⁺	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	5.4	30	.003		37	37	14	12	11	2.2	2.0	.1	.5	.041	0.11	.018	6
	10-20	5.0	45	.009		-	-	-	-	-	-	-	-	-				-
	22-30	6.7	105	.009		32	25	8	35	14	1.0	11.6	<.05	1.9	.015	0.14	.010	2
	50-60	8.1	330	.043		-	-	-	-	20	0.8	11.2	.05	4.8	.014	0.11	.008	7
	80-90	7.7	480	.065		-	-	-	-	18	0.4	14.6	<.05	4.2	.014	0.16	.008	16
	130-150	5.3	410	.048		38	26	7	29	14	0.4	8.8	.15	2.4				2

Lab. No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb Repl. K m.equiv/100 g	Fe	Mn	Cu	Zn D.T.P.A. Extr. ppm	B ppm
	0-10	1.0	.098					1.6	0.3	

Site No. P 7

Soil Association: Db
Great Soil Group: Solodic Soil
Parent Material:
Topography: Undulating Plain
Vegetation: Low open forest of *Acacia harpophylla* and *Eucalyptus cambageana* shrub layer *Acacia harpophylla, Carissa ovata, Atalaya hemiglauca, Eremophila mitchellii*

Location: W 2/3 block Brigalow Research Station
Australian Map Grid Reference:
Air Photo Reference:
Principal Profile Form: Db 1.43

Profile Morphology: hard setting surface.

0 - 15 cm Dark brown sandy loam (7.5YR 3/2 m), hard, massive, earthy; abrupt change to
15 - 20 Pale brown sandy clay loam conspicuously bleached, hard, massive, abrupt change to
20 - 40 Brown heavy clay (10YR 4/3 m), extremely hard, coarse blocky (columnar?), some manganiferous staining on ped faces, small manganiferous concretions (5 mm); gradual change to
40 - 95 Dark brown heavy clay (7.5YR 3/4 m) extremely hard, blocky , some carbonate concretions (5-10 mm); gradual change to
95 - 135 Brown sandy clay (7.5YR 4/3 m) very hard, blocky profuse manganiferous staining; gradual change to
135 - 150 Brown sandy clay (7.5YR 4/4 m), very hard, blocky

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca⁺⁺	Mg⁺⁺	K⁺	Na⁺	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	6.1	37	<.001		29	40	14	17	17	8.8	2.4	.2	.2	.042	0.15	.022	20
	10-20	6.2	46	<.001		31	38	13	18	11	1.6	2.4	<.05	.5			...	8
	20-30	8.0	105	.003		22	23	10	45	22	6.2	14.4	<.05	2.0	.018	0.14	.008	3
	50-60	8.7	630	.043		23	27	10	40	22	3.6	13.2	.7	5.4	.014	0.16	.011	3
	80-90	8.8	710	.066		26	28	9	37	20	2.0	14.4	<.05	3.7	.017	0.20	.009	3
	130-150	5.2	620	.084		22	32	10	36	19	1.0	12.8	<.05	3.4				3

Lab. No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb Repl. K m.equiv/100 g	Fe	Mn	Cu	Zn D.T.P.A. Extr. ppm	B ppm
	0-10	1.2	0.113					1.8	0.3	

Site No. P 8

Soil Association: Db
Great Soil Group: Solodic Soil
Parent Material:
Topography: Undulating Plain
Vegetation: Low open forest *Acacia harpophylla* with emergent *Eucalyptus cambageana;* shrub layer *Acacia harpophylla, Eremophila mitchellii*

Location: W 1 block Brigalow Research Station
Australian Map Grid Reference:
Air Photo Reference:
Principal Profile Form: Db 1.43

Profile Morphology: hard setting surface

0 - 20 cm Dark brown sandy loam (7.5YR 3/2 m), slightly hard, massive, earthy, few manganiferous concretions (<5 mm); abrupt change to
20 - 25 Light grey sandy loam, conspicuously bleached, profuse manganiferous concretions (<5 mm) very hard, massive; abrupt change to
25 - 50 Dark brown heavy clay (10YR 4/3 m) extremely hard, blocky, some manganiferous concretions (<5 mm) gradual change to
50 - 90 Dark brown heavy clay (7.5YR 4/3 m), extremely hard, blocky, some carbonate concretions (5-10 mm); gradual change to
90 - 150 Brown heavy clay (7.5YR 4/3 m), extremely hard, blocky , some manganiferous staining

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca⁺⁺	Mg⁺⁺	K⁺	Na⁺	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	7.4	145	<.001		23	44	14	19	19	14.0	3.4	.7	.2	.061	0.47	.028	45
	10-20	7.0	160	<.001		24	42	14	20	16	10.6	4.2	-	.3				29
	25-30	7.4	170	.008		17	26	10	47	25	9.0	14.4	.2	3.1	.015	0.36	.023	7
	50-60	8.4	790	.057		15	31	9	45	26	6.0	14.0	.2	4.8	.016	0.34	.023	10
	80-90	8.6	960	.093		11	34	9	46	24	4.8	14.6	.1	4.9	.018	0.35	.026	6
	130-150	7.3	760	.084		12	33	11	44	23	2.6	18.4	<.05	6.0				11

Lab. No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb Repl. K m.equiv/100 g	Fe	Mn	Cu	Zn D.T.P.A. Extr. ppm	B ppm
	0-10	1.5	0.152					1.8	0.8	

Site No. P 9

Soil Association: Db
Great Soil Group: Solodic Soil
Parent Material:
Topography: Undulating Plain
Vegetation: *Acacia harpophylla, Eucalyptus cambageana*

Location: R 3 block Brigalow Research Station
Australian Map Grid Reference:
Air Photo Reference:
Principal Profile Form: Db 1.43

Profile Morphology: hard setting surface

0 - 10 cm Dark brown sandy loam (7.5YR 3/2 m), hard, massive, earthy, some manganiferous concretions (<5 mm) clear change to
10 - 18 Brown sandy loam (10YR 4/4 m), hard, massive, earthy, some manganiferous concretions (<5 mm); abrupt change
18 - 20 Light greyish brown sandy clay loam, conspicuously bleached, extremely hard, massive, earthy, profuse manganiferous concretions (5 mm); abrupt change to
20 - 50 Dark brown clay (7.5YR 3/4 m), extremely hard, blocky (columnar?), some manganiferous concretions (<5 mm); gradual change to
50 - 70 Reddish brown clay (5YR 4/4 m) extremely hard, blocky, carbonate concretions; gradual change to
70 - 150 Reddish brown clay (5YR 4/4 m) extremely hard, blocky, profuse manganiferous staining and few concretions (5 mm)

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) µSom^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	5.5	35	.004		25	39	18	18	16	4.8	1.8	<.05	.5	.044	0.13	.019	15
	10-18	5.6	58	.005		29	38	14	19	14	2.6	2.2	<.05	.7				8
	20-30	6.3	140	.015		30	28	13	29	16	2.2	7.8	<.05	1.4	.018	0.10	.009	12
	50-60	8.9		.058		23	28	13	36	18	2.8	10.8	.05	4.5	.015	0.16	.007	8
	80-90	8.0	530	.075		24	26	13	37	19	1.8	10.8	<.05	3.1	.014	0.12	.004	8
	130-150	5.4	570	.078		24	27	12	37	17	1.0	6.8	<.05	2.3				22

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Bicarb Extr. P ppm	Repl. K m.equiv/100 g	Fe	Mn	Cu	Zn	B ppm
						D.T.P.A. Extr. ppm				
	0-10	1.2	0.116					2.6	0.4	

Site No. P 12

Soil Association: Al-Dd
Great Soil Group: Solodic Soil
Parent Material: Alluvium
Topography: Alluvial Plain
Vegetation: Woodland *Eucalyptus populnea, Bauhinia carronii* shrub layer *Eremophila mitchellii, Eucalyptus cambageana.*
Profile Morphology: hard setting surface.

Location: V Block Brigalow Research Station
Australian Map Grid Reference:
Air Photo Reference:
Principal Profile Form: Dd 1.43

0 - 20 cm Very dark grey silty loam (10YR 3/1 m) hard, massive, few manganiferous concretions (<5 mm) abrupt change to very thin conspicuous bleach over
20 - 100 Very dark grey medium clay (10YR 3/1 m) very hard, blocky, gradual change to
100 - 150 Grey clay (10YR 5/2 m) very hard, blocky , few carbonate concretions.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) µSom^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	5.5	56	.006		37	36	15	12	16	6.0	2.8	0.9	0.2	.078	1.41	.023	64
	10-20	5.6	43	.017		36	36	16	12	14	4.2	3.0	0.3	0.9				34
	20-30	8.5	220	.037		26	30	13	31	25	9.2	9.2	0.2	2.2	.045	1.24	.012	16
	50-60	8.3	690	.057		19	35	15	31	25	8.4	9.6	0.2	5.4	.030	1.33	.022	14
	80-90	8.3	720	.080		12	36	15	37	26	8.8	12.4	0.3	2.8	.024	1.22	.020	14
	130-150	8.7	830	.090		7	35	16	42	28	8.8	14.8	0.4	2.8				36

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Bicarb Extr. P ppm	Repl. K m.equiv/100 g	Fe	Mn	Cu	Zn	B ppm
						D.T.P.A. Extr. ppm				
	0-10	1.6	0.119					1.9	1.8	

Site No. P 13

Soil Association: Al-Dd
Great Soil Group: Solodic
Parent Material: Alluvium
Topography: Alluvial plain
Vegetation: Open scrubs *Acacia harpophylla* and *Casuarina cristata* with emergent *Eucalyptus cambageana.*
Profile Morphology: hard setting surface.

Location: V block Brigalow Research Station
Australian Map Grid Reference:
Air Photo Reference:
Principal Profile Form: Dd 1.43

0 - 20 cm Very dark brown silty loam (10YR 2/2 m), slightly hard, massive, abrupt change to
20 - 95 Very dark grey silty clay (10YR 3/1 m), very hard, blocky (40 mm); gradual change to
95 - 150 Brown sandy clay loam (10YR 4/3 m) with dark yellowish brown and dark grey mottles, slightly hard, weak blocky

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) µSom^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	8.0	100	.008		37	36	15	12	21	12.6	4.2	.5	.3	.095	1.56	.027	107
	10-20	7.6	160	.021		36	36	16	12	23	12.6	8.8	.2	1.2				64
	20-30	7.4	390	.042		26	30	13	31	29	13.6	12.0	.2	2.0	.032	1.30	.018	36
	50-60	8.4	1200	.125		19	35	15	31	35	11.6	14.4	.3	-	.040	1.22	.043	44
	80-90	8.0	960	.116		12	36	15	37	32	11.2	15.0	.2	2.8	.034	1.37	.034	77
	130-150	7.6	830	.108		7	35	16	42	25	7.4	15.0	.1	3.0				106

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Bicarb Extr. P ppm	Repl. K m.equiv/100 g	Fe	Mn	Cu	Zn	B ppm
						D.T.P.A. Extr. ppm				
	0-10	1.7	.152					1.6	1.8	

Soil Association: Dy 3

Great Soil Group: Solodic Soil

Parent Material:

Topography: Undulating Plain

Vegetation: Woodland *Eucalyptus populnea, E. tessellaris, Atalaya hemiglauca* shrub layer *Eucalyptus cambageana, Acacia excelsa, Eremocitrus glauca, Eremophila mitchellii*

Profile Morphology: Hard setting surface.

Site No. P 6

Location: W2 block Brigalow Research Station

Australian Map Grid Reference:

Air Photo Reference:

Principal Profile Form: Dy 3.42

0 - 8 cm Very dark greyish brown loamy sand (10YR 3/2 m), slightly hard massive, earthy; gradual change to
8 - 40 Dark greyish brown loamy sand, (7.5YR 4/2 m) soft, massive, earthy; abrupt change to
40 - 50 Very pale brown loamy sand, bleached, slightly hard, massive, earthy, few ironstone to concretions (5 mm); abrupt change to
50 - 70 Greyish brown sandy clay (10YR 5/2 m) with yellowish brown mottle, very hard, columnar (?) gradual change to
70 - 150 Yellowish brown sandy loam (10YR 5/4 m), very hard, structured (?), some quartzitic gravel (7 mm)

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C Particle Size % O.D.	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+} Exch.Cations m.equiv/100g O.D.	P	K	S % O.D.	Acid Extr. P ppm
	0-10	5.7	30	<.001		47	38	8	7	7	2.4	.8	.3	.3	.123	0.93	.047	11
	10-20	5.0	40	<.001		49	38	4	9	7	1.2	.8	.2	.3				15
	20-30	5.0	28	<.001		38	49	4	9	6	.8	.6	.25	.2	.099	0.82	.037	6
	50-60	6.1	97	.005		33	33	4	30	14	3.6	7.2	.1	1.5	.027	0.65	.021	4
	80-90	6.5	225	.020		36	35	3	26	14	3.4	6.6	-	1.7	.024	0.76	.021	18
	130-150	6.5	300	.037		68	10	1	21	14	3.0	7.2	.1	2.1				21

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Bicarb Extr. P ppm	Repl. K m.equiv/100 g	Fe D.T.P.A.	Mn	Cu Extr. ppm	Zn	B ppm
	0-10	.6	.065					3.9	3.3	

Soil Association: Ug

Great Soil Group: Grey Clay

Parent Material:

Topography: Undulating Plain

Vegetation: Low woodland *Acacia harpophylla, Bauhinia carronii;* shrub layer *Geijera parviflora, Eremophila mitchellii*

Profile Morphology: cracking surface with thin crust (3-5 mm)

Site No. P18

Location: R2 block Brigalow Research Station

Australian Map Grid Reference:

Air Photo Reference:

Principal Profile Form: Ug 5.24

0 - 5 cm Dark greyish brown clay (10YR 4/2 m) hard, granular to fine subangular blocky (10 mm), some carbonate concretions (5 mm), occasional quartzitic gravel (up to 25 mm); clear change to
5 - 40 Dark greyish brown heavy clay (10YR 4/2 m), very hard, subangular blocky, few carbonate concretions (5 mm); gradual change to
40 - 80 Greyish brown heavy clay (10YR 5/2 m) with pale brown mottle, very firm (moist), few carbonate concretions; gradual change to
80 - 150 Pale brown heavy clay (10YR 5.5/3 m) very firm, subangular blocky

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C Particle Size % O.D.	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+} Exch.Cations m.equiv/100g O.D.	P	K	S % O.D.	Acid Extr. P ppm
	0-10	8.2	140	.004		14	17	16	53	37	22.0	8.8	.5	1.9	.018	0.71	.016	22
	10-20	8.6	330	.023		14	17	16	53	38	18.8	10.6	.4	5.0				26
	20-30	8.5	750	.084		13	16	16	55	38	17.2	12.4	.4	6.0	.017	0.68	.016	28
	50-60	8.4	1000	.113		10	16	16	58	34	13.6	17.6	.4	8.3	.012	0.68	.015	25
	80-90	6.4	1000	.137		9	15	17	59	38	12.0	14.0	.4	8.0	.012	0.69	.009	22
	130-150	5.1	950	.146		10	15	16	59	38	7.6	13.2	.3	8.0				8

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Bicarb Extr. P ppm	Repl. K m.equiv/100 g	Fe D.T.P.A.	Mn	Cu Extr. ppm	Zn	B ppm
	0-10	1.1	.054					2.6	0.2	

Soil Association: Ug

Great Soil Group: Grey Clay

Parent Material:

Topography: Undulating Plain

Vegetation: Low open forest *Casuarina cristata, Acacia harpophylla;* tall shrub layer *Geijera parviflora, Atalaya hemiglauca, Eremocitrus glauca, Eremophila mitchellii*

Profile Morphology: Cracking surface with thin crust (3-5 mm)

Site No. P 19

Location: C block Brigalow Research Station

Australian Map Grid Reference:

Air Photo Reference:

Principal Profile Form: Ug 5.15

0 - 10 cm Very dark grey heavy clay (10YR 3/1 m), very hard, granular (5-10 mm), carbonate concretions; clear change to
3 - 30 Very dark grey heavy clay (10YR 3/1 m), extremely hard, subangular blocky (37 - >5 mm), some carbonate concretions; gradual change to
30 - 60 Dark grey heavy clay (10YR 4/1 m), extremely hard, blocky, few carbonate concretions (5 mm); gradual change to
60 - 100 Brown heavy clay (10YR 5/3 m), extremely hard, blocky; gradual change to
100 - 150 Brown clay (10YR 5/3 m), extremely hard, blocky.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C Particle Size % O.D.	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+} Exch.Cations m.equiv/100g O.D.	P	K	S % O.D.	Acid Extr. P ppm
	0-10	7.0	115	.004		22	19	16	43	37	20.4	12.2	.6	2.0	.027	0.45	.025	9
	10-20	8.5	295	.017		-	-	-	-	38	19.6	13.2	.3	3.6				10
	20-30	8.6	480	.041		20	15	15	50	38	16.6	12.4	.2	4.5	.021	0.35	.020	8
	50-60	8.2	1050	.134		15	19	15	51	36	11.6	19.0	.2	6.7	.015	0.33	.013	35
	80-90	5.1	880	.120		16	21	15	48	32	6.8	11.6	.2	5.6	.009	0.28	.005	11
	130-150	4.6	1050	.157		12	19	19	50	32	5.6	13.4	.1	6.0				2

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Bicarb Extr. P ppm	Repl. K m.equiv/100 g	Fe D.T.P.A.	Mn	Cu Extr. ppm	Zn	B ppm
	0-10	1.3	0.137					2.8	0.3	

Soil Association: Ug
Great Soil Group: Grey Clay
Parent Material:
Topography: Undulating Plain
Vegetation: cultivated

Site No. P 20

Location: J block Brigalow Research Station
Australian Map Grid Reference:
Air Photo Reference:
Principal Profile Form: Ug 5.14

Profile Morphology:

0 - 5 cm — Very dark grey heavy clay (10YR 3/1 m) extremely hard, granular to fine blocky (up to 12 mm) some carbonate concretions (<5 mm); clear change to
5 - 70 — Very dark grey heavy clay (10YR 3/1 m), very firm (moist), few carbonate concretions (<5 mm), few roots; gradual change to
70 - 100 — Yellowish brown (10YR 5/4) and very dark grey heavy clay (10YR 3/1 m), very firm, sub-angular blocky, few carbonate concretions, few manganiferous concretions (<5 mm); clear change to
100 - 110 — Weathered sandstone and clay, with few carbonate concretions.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	7.7	115	.008		21	23	15	41	33	23.0	8.0	.45	1.2	.028	0.26	.017	17
	10-20	7.5	185	.010		21	25	12	42	31	10.4	8.0	.3	1.6				9
	20-30	7.5	140	.011		23	24	12	41	30	18.4	10.0	.3	2.5	.029	0.27	.021	4
	50-60	8.5	430	.025		19	22	13	46	35	14.8	16.0	.15	4.9	.015	0.22	.020	6
	80-90	8.7	660	.059		21	21	12	48	32	12.4	15.2	.20	6.8	.017	0.22	.012	21

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Extr. P ppm	Bicarb	Repl. K m.equiv/100 g	Fe D.T.P.A.	Mn	Cu Extr. ppm	Zn	B ppm
	0-10	.6	.080						2.8	0.2	

Soil Association: Ug
Great Soil Group: Grey Clay
Parent Material:
Topography: Undulating Plain
Vegetation: Pasture. *Chloris gayana, Acacia harpophylla* suckers

Site No. P 21

Location: D block Brigalow Research Station
Australian Map Grid Reference:
Air Photo Reference:
Principal Profile Form: Ug 5.16

Profile Morphology: surface cracking, thin crust (3-5 mm)

0 - 3 — Very dark greyish brown clay (10YR 3/2 m) hard granular, few large quartzitic gravels (up to 75 mm); clear change to
3 - 100+ — Very dark greyish brown heavy clay (10YR 3.5/2 m), extremely firm, sub-angular blocky , few carbonate concretions, some quartzitic gravel (up to 50 mm).

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	8.4	110	.001		24	23	12	41	30	18.6	9.0	.25	2.0	.020	0.20	.017	12
	10-20	9.2	140	.004		24	23	11	42	30	16.0	10.2	.15	3.5				7
	20-30	9.3	230	.017		23	24	12	41	26	8.4	4.8	.15	5.6	.025	0.20	.019	7
	50-60	9.2	580	.072		22	24	12	42	31	11.4	13.0	.1	6.0	.018	0.19	.025	6
	80-90	8.2	420	.062		21	26	11	42	29	12.8	11.2	.15	5.1	.013	0.16	.013	6

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Extr. P ppm	Bicarb	Repl. K m.equiv/100 g	Fe D.T.P.A.	Mn	Cu Extr. ppm	Zn	B ppm
	0-10	.5	.065						2.7	0.1	

Soil Association: Gil Ug
Great Soil Group: Grey Clay
Parent Material:
Topography: Undulating Plain
Vegetation: Pasture. *Chloris gayana*

Site No. P 25

Location: N block Brigalow Research Station
Australian Map Grid Reference:
Air Photo Reference:
Principal Profile Form: Ug 5.24

Profile Morphology: cracking surface.

0 - 5 cm — Dark greyish brown heavy clay (10YR 4/1.5 m), plastic (moist), gradual change to
5 - 30 — Dark greyish brown heavy clay (10YR 4/1.5 m), very firm, sub-angular blocky; gradual change to
30 - 60 — Dark greyish brown heavy clay (10YR 4/2 m), very firm, sub-angular blocky , some manganiferous stains; gradual change to
60 - 150 — Greyish brown heavy clay (10YR 5/2.5 m), very hard, sub-angular blocky.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	7.6	125	.006		18	25	10	47	29	14.2	12.4	.25	2.3				16
	10-20	7.9	350	.040		19	24	10	47	30	13.6	12.8	.15	4.2				19
	20-30	8.0	850	.120		19	23	10	48	29	11.2	12.8	.20	4.0				8
	50-60	5.2	1050	.151		17	24	10	49	32	7.8	13.0	.1	5.1				3
	80-90	4.7	1050	.151		14	22	11	53	30	6.6	12.8	.1	6.8				9
	130-150	4.5	1100	.167		12	22	10	56	31	5.2	12.4	.1	6.0				1

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Extr. P ppm	Bicarb	Repl. K m.equiv/100 g	Fe D.T.P.A.	Mn	Cu Extr. ppm	Zn	B ppm
	0-10	.9	.098								

Soil Association: Gil-Ug

Great Soil Group: Grey Clay

Parent Material:

Topography: Undulating Plain

Vegetation: Cleared. *Acacia harpophylla* suckers

Site No. P 3

Location: R2 Block Brigalow Research Station

Australian Map Grid Reference:

Air Photo Reference:

Principal Profile Form: Ug 5.24

Profile Morphology: cracking surface.

0 - 3 cm	Dark grey clay (10YR 4/1 m), hard, fine blocky; clear change to
3 - 40	Dark grey clay (10YR 4/1 m), very hard, sub-angular blocky (40 mm), occasional gravel (15 mm); gradual change to
40 - 70	Dark greyish brown clay (10YR 4/2 m), hard, sub-angular blocky; gradual change to
70 - 120	Dark greyish brown clay (10YR 4.5/2 m) very firm, blocky ; gradual change to
120 - 150	Greyish brown clay (10YR 5/2) very firm, blocky

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C Particle Size % O.D.	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+} Exch.Cations m.equiv/100g O.D.	P	K	S % O.D.	Acid Extr. P ppm
	0-10	6.6	340	.03		23	19	13	46	31	19.0	10.0	.5	2.3				14
	10-20	6.8	520	.034		20	19	15	47	33	13.0	12.0	.4	3.1				14
	20-30	7.2	620	.054		12	15	16	58	33	12.0	13.4	.4	4.2				11
	50-60	5.9	1400	.187		8	14	17	62	34	11.2	12.4	.3	6.4				-
	80-90	4.7	1625	.209		-	-	-	-	35	9.4	12.8	.3	6.7				15
	130-150	4.5	1540	.224		8	13	17	62	33	6.4	12.8	.8	7.3				14

Lab. No.	Depth cm	Org. C %	Tot. N %	Acid Bicarb Extr. P ppm	Repl. K m.equiv/100 g	Fe	Mn	Cu	Zn D.T.P.A. Extr. ppm	B ppm
	0-10		.094							

Soil Association: Gil-Ug

Great Soil Group: Grey Clay

Parent Material:

Topography: Undulating Plain

Vegetation: Open forest *Acacia harpophylla, Casuarina cristata* shrub layer *Geijera parviflora, Myoporum deserti, Capparis mitchellii, Acacia harpophylla.*

Site No. P 2

Location: R2 block Brigalow Research Station

Australian Map Grid Reference:

Air Photo Reference:

Principal Profile Form: Ug 5.24

Profile Morphology: Cracking surface.

0 - 8 cm	Dark grey clay (10YR 4/1 m), hard, granular (10 mm); clear change to
8 - 40	Dark grey clay (10YR 4/1 m) very hard, subangular blocky, profuse carbonate concretions; gradual change to
40 - 120	Greyish brown clay (2.5Y 4.5/2 m) very hard, subangular blocky , few manganiferous concretions (<5 mm) few carbonate concretions (5 mm); gradual change to
120 - 150	Dark greyish brown clay (10YR 4/2 m), very hard, subangular blocky , few carbonate concretions

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C Particle Size % O.D.	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+} Exch.Cations m.equiv/100g O.D.	P	K	S % O.D.	Acid Extr. P ppm
	0-10	7.4	335	.003		22	25	11	42	31	25.0	5.6	0.9	.4				25
	10-20	8.0	435	.005		19	29	10	42	26	20.3	8.7	.7	1.4				11
	20-30	8.4	485	.006		16	29	10	44	24	16.8	9.9	.6	1.8				8
	50-60	8.5	975	.066		14	28	12	46	28	11.8	11.8	.8	5.5				5
	80-90	8.7	1150	.102		-	-	-	-	27	10.0	12.0	.8	6.7				5
	130-150	8.6	1240	.134		14	25	13	49	30	9.2	14.0	.4	7.5				5

Lab. No.	Depth cm	Org. C %	Tot. N %	Acid Bicarb Extr. P ppm	Repl. K m.equiv/100 g	Fe	Mn	Cu	Zn D.T.P.A. Extr. ppm	B ppm
	0-10	3.2	0.26							

Soil Association: Gil - Ug

Great Soil Group: Solodic Soil

Parent Material:

Topography: Undulating Plain

Vegetation: Pasture. *Cenchrus ciliaris*

Site No. P 24

Location: O6 block Brigalow Research Station

Australian Map Grid Reference:

Air Photo Reference:

Principal Profile Form: Dd 1.43

Profile Morphology: hard setting surface.

0 - 3 cm	Dark brown sandy loam (10YR 3/2 m), very hard, massive, few small manganiferous concretions; abrupt change to very thin conspicuous bleach over
3 - 60	Very dark grey heavy clay (10YR 3/1 m), extremely firm, blocky, numerous carbonate concretions; gradual change to
60 - 150	Brown heavy clay (10YR 4.5/3 m), extremely firm, blocky, few pieces of sandstone in 70-90 cm zone.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C Particle Size % O.D.	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+} Exch.Cations m.equiv/100g O.D.	P	K	S % O.D.	Acid Extr. P ppm
	0-3	7.2	95	.014		25	40	2	33	18	8.4	4.6	2.0	.9				10
	3-10	7.1	90	.030		10	41	15	34	30	13.0	9.0	.3	2.8	.034	0.53	.019	9
	10-20	8.6	245	.032		19	31	7	43	32	15.8	11.4	.15	3.4				9
	20-30	8.9	280	.034		17	29	11	43	31	14.8	12.2	.05	3.3	.020	0.24	.017	6
	50-60	8.8	670	.087		18	31	10	41	27	10.4	12.8	.1	4.7	.016	0.29	.015	6
	80-90	8.5	840	.110		16	28	1	55	30	8.8	14.6	.2	5.8	.014	0.30	.080	4
	130-150	7.0	660	.094		15	28	1	56	29	6.8	16.8	.15	5.6				4

Lab. No.	Depth cm	Org. C %	Tot. N %	Acid Bicarb Extr. P ppm	Repl. K m.equiv/100 g	Fe	Mn	Cu	Zn D.T.P.A. Extr. ppm	B ppm
	0-10	1.0	.098					1.6	0.5	

Soil Association: Sw-Db

Great Soil Group:

Parent Material: Alluvium

Topography: Alluvial levee

Vegetation: Low open forest *Macropteranthes leichhardtii* with emergent *Bauhinia carronti*, *Acacia harpophylla*, and *Atalaya hemiglauca*

Site No. P 14

Location: R1 block Brigalow Research Station

Australian Map Grid Reference:

Air Photo Reference:

Principal Profile Form: Db 3.13

Profile Morphology: soft setting surface.

0 - 5 cm	organic litter.
5 - 15	Dark brown sandy loam (7.5 YR 3/2 m), soft, weak crumb, profuse roots; abrupt change to
15 - 30	Dark brown sandy clay (7.5YR 3/2 m), hard, weak blocky (porous), some small manganiferous flecks, graudal change to
30 - 50	Brown sandy clay (7.5 YR 4/4 m), hard, blocky; gradual change to
50 - 90	Yellowish red clay (5YR 4/6 m), very hard, blocky; profuse carbonate gravel (up to 10 mm), numerous manganiferous concretions (<5 mm); gradual change to
90 - 150	Reddish brown clay loam (5YR 4/4 m) with yellowish brown mottle, very hard, blocky, moderate carbonate gravel and manganiferous concretions (<5 mm).

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) µScm⁻¹	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca⁺⁺	Mg⁺⁺	K⁺	Na⁺	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	7.0	215	.003		28	35	14	23	22	11.6	2.6	1.0	.1				105
	10-15	5.9	135	.002		21	39	11	29	19	8.0	2.2	1.2	.1				56
	20-30	5.5	225	.004		17	36	6	41	20	9.6	4.0	.7	.2				15
	50-60	7.0	600	.003		19	27	9	45	26	13.6	8.4	1.2	.7				19
	80-90	8.1	1250	.089		23	28	8	41	18	10.2	6.2	1.0	1.0				18
	130-150	8.5	800	.117		20	30	10	40	17	8.2	8.0	.75	2.4				14

Lab. No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb P ppm	Repl. K m.equiv/100 g	Fe D.T.P.A.	Mn D.T.P.A.	Cu Extr. ppm	Zn Extr. ppm	B ppm
	0-10	2.2	.220								

Soil Association: SW-Db

Great Soil Group: Solodic Soil

Parent Material:

Topography: Undulating Plain

Vegetation: Pasture of *Chloris gayana*, and *Panicum maximum*

Site No. P 16

Location: L2 block Brigalow Research Station

Australian Map Grid Reference:

Air Photo Reference:

Principal Profile Form: Db 1.43

Profile Morphology:

0 - 7 cm	Black sandy loam (10YR 2/1 m), soft (moist), massive; clear change to
7 - 20	Dark brown sandy loam (10YR 3/3 m), soft (moist), massive, earthy; abrupt change to
20 - 30	Dark brown clay (10YR 3/3 m) very hard, blocky; clear change to
30 - 90	Yellowish brown clay (10YR 5.4 m), very hard, blocky, some manganiferous flecks and profuse carbonate concretions, some soft carbonate. gradual change to
90 - 150	Yellowish brown clay (10YR 5/4 m), few brown mottles, very hard, blocky, some carbonate concretions

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) µScm⁻¹	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca⁺⁺	Mg⁺⁺	K⁺	Na⁺	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	6.4	87	.008		17	46	11	26	26	19.6	4.0	2.0	.1	.143	0.90	.048	240
	10-20	7.5	140	.008		15	45	9	31	25	16.0	3.6	.55	.3				108
	20-30	7.2	110	.003		19	30	10	41	26	17.6	5.0	.6	.4	.051	0.61	.030	27
	50-60	8.5	170	.048		10	31	13	46	23	10.8	15.2	.7	2.4	.023	0.55	.079	18
	80-90	8.6	230	.125		7	33	11	49	24	8.0	14.8	.6	2.9	.020	0.56	.064	16
	130-150	8.3	1000	.131		6	34	11	49	28	6.0	12.8	.5	3.5				16

Lab. No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb P ppm	Repl. K m.equiv/100 g	Fe D.T.P.A.	Mn D.T.P.A.	Cu Extr. ppm	Zn Extr. ppm	B ppm
	0-10	2.4	.261						1.6	2.6	

Soil Association: SW-Db

Great Soil Group: Solodic Soil

Parent Material:

Topography: Undulating Plain

Vegetation: Woodland *Casuarina cristata*, *Eucalyptus populnea* shrub layer *Eremophila mitchellii*, *Geijera parviflora*.

Site No. P 17

Location: P1 block Brigalow Research Station

Australian Map Grid Reference:

Air Photo Reference:

Principal Profile Form: Db 1.43

Profile Morphology: hard setting surface

0 - 2 cm	Organic litter + soil
2 - 15	Dark brown sandy loam (7.5YR 3/2 m), slightly hard, massive, earthy, profuse roots; gradual change to
15 - 40	Brown sandy loam (7.5YR 3.4 m), hard massive, earthy, occasional quartzitic gravel (up to 7 mm) abrupt change to very thin conspicuous bleach overlying
40 - 80	Brown clay (7.5YR 4/3 m), very hard, blocky, manganiferous concretions (5 mm), some carbonate concretions in lower part; gradual change
80 - 120	Yellowish brown clay (10YR 5/4 m), very hard, blocky, profuse carbonate concretions and some manganiferous stains and concretions (5 mm)
120 - 150	As above with little carbonate concretions

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) µScm⁻¹	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca⁺⁺	Mg⁺⁺	K⁺	Na⁺	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	6.4	50	.002		20	54	11	15	16	9.2	2.0	.6	.1				45
	10-20	6.2	81	.007		16	56	10	18	10	4.2	2.0	.6	.3				22
	20-30	6.9	27	.002		16	55	9	20	10	4.0	1.8	.5	.3				17
	50-60	7.0	300	.037		11	37	8	44	21	7.0	8.4	.4	2.7				12
	80-90	8.8	520	.050		15	39	9	37	18	6.0	5.6	.3	3.3				17
	130-150	9.0	600	.052		8	42	10	40	22	6.0	7.6	.15	4.9				10

Lab. No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb P ppm	Repl. K m.equiv/100 g	Fe D.T.P.A.	Mn D.T.P.A.	Cu Extr. ppm	Zn Extr. ppm	B ppm
	0-10	1.5	.146								

Soil Association: SW-Db

Great Soil Group: Solodic Soil

Parent Material:

Topography: Undulating Plain

Vegetation: Disturbed woodland *Eucalyptus cambageana, Brachychiton rupestre, Geijera parviflora,* remaining

Profile Morphology: hard setting surface

Site No. P 26

Location: H1 block Brigalow Research Station

Australian Map Grid Reference:

Air Photo Reference:

Principal Profile Form: Db 1.43

0 - 10 cm Dark brown sandy loam (7.5YR 3/2 m), soft, massive, clear change to
10 - 30 *Brown sandy loam (7.5YR 4/3 m), soft, massive earthy;* abrupt change to *very thin conspicuous bleach over*
30 - 60 Brown light sandy clay (10YR 4/3 m), very firm, blocky , gradual change to
60 - 90+ Brown sandy clay (10YR 4/3 m), very firm, blocky , some manganiferous concretions (<5 mm), few carbonate concretions.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	6.4	60	.005		27	49	10	14	14	7.6	1.1	.8	.2	.084	.24	.020	94
	10-20	5.3	80	.006		26	48	9	17	11	2.6	1.0	.65	.5				14
	20-30	5.1	43	.002		29	48	9	14	9	2.0	1.0	.65	.3	.031	.14	.012	8
	50-60	8.6	270	.027		29	34	7	30	15	2.4	6.0	.05	3.8	.012	.12	.019	3
	80-90	8.7	640	.048		34	33	8	25	18	3.2	9.0	.1	5.3	.014	.14	.011	1

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Bicarb Extr. P ppm	Repl. K m.equiv/100 g	Fe D.T.P.A.	Mn	Cu Extr. ppm	Zn	B ppm
	0-10	1.4	.122					1.1	1.0	

Soil Association: SW-Db

Great Soil Group: Solodic Soil

Parent Material:

Topography: Undulating Plain

Vegetation: Pasture. *Cenchrus ciliaris*

Site No. P 22

Location: N Block Brigalow Research Station

Australian Map Grid Reference:

Air Photo Reference:

Principal Profile Form: Db 1.43

Profile Morphology: hard setting surface.

0 - 20 cm Dark brown loamy sand (10YR 3/3 m), very hard, massive, earthy; abrupt change to
20 - 23 Light brownish grey loamy sand (10YR 5/2 m), very hard, massive, conspicuously bleached; abrupt change to
23 - 33 Dark brown sandy clay (10YR 3/3 m), extremely hard, blocky , few manganiferous concretions (<5 mm); clear change to
33 - 80 Brown sandy clay (7.5YR 4/4 m), very hard, blocky few carbonate concretions; gradual change to
80 - 140 Yellowish brown sandy clay loam (10YR 5/4 m), very hard, blocky , few manganiferous stains; clear change to
140 - 150 Light yellowish brown sandy clay loam (10YR 6.4 m), very hard, massive, weathered sandstone included.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	5.6	50	.004		37	46	8	9	10	4.6	.8	.3	.4	.056	0.17	.025	26
	10-20	5.5	35	.002		37	45	7	11	8	2.8	1.2	.15	2.9				6
	23-30	7.7	200	.016		34	40	9	17	16	2.4	7.4	.05	3.6	.015	0.14	.015	7
	50-60	8.3	285	.025		32	39	4	25	14	2.2	6.8	.05	4.0	.015	0.16	.018	7
	80-90	9.1	680	.058		30	35	9	26	15	2.2	8.0	.05	5.1	.012	0.15	.021	20
	130-150	7.7	640	.074		33	28	8	31	20	5.6	4.4	.3	7.0				23

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Bicarb Extr. P ppm	Repl. K m.equiv/100 g	Fe D.T.P.A.	Mn	Cu Extr. ppm	Zn	B ppm
	0-10	1.2	.119					1.3	0.8	

Soil Association: SW - Gn2

Great Soil Group: Red Earth

Parent Material: Alluvium

Topography: Alluvial levee

Vegetation: *Macropteranthes leichhardtii, Bauhinia carronii, Brachychiton rupestre*

Site No. P 15

Location: R1 block Brigalow Research Station

Australian Map Grid Reference:

Air Photo Reference:

Principal Profile Form: Gn 2.13

Profile Morphology: Soft surface:

0 - 2 cm Organic litter
2 - 9 Dark reddish brown light sandy loam (5YR 3/3 m), soft, massive - weak crumb, profuse roots; gradual change to
9 - 20 Dark reddish brown sandy loam (5YR 3/4 m), slightly hard, massive, earthy, profuse worm casts; clear change to
20 - 40 Reddish brown sandy clay loam (5YR 4/4 m), very hard, massive, earthy, some manganiferous concretions (<5 mm), worm casts; gradual change to
40 - 50 Reddish brown clay (5YR 4/4 m), very hard, massive, earthy, occasional worm cast; clear change to
50 - 150 Dark brown clay loam (7.5YR 3/3 m), hard, weak structure, profuse carbonate concretions, manganiferous staining

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm^{-1}	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	6.5	50	.001		14	52	13	21	17	9.8	2.2	1.0	.25	.123	0.93	.047	118
	10-20	6.5	105	.003		21	45	9	25	18	9.4	2.2	.75	.1				52
	20-30	6.1	83	.003		16	49	8	27	16	7.0	2.0	.4	.1	.099	0.82	.037	36
	50-60	7.2	140	.005		15	35	15	35	20	15.6	3.4	.15	.4	.027	0.65	.021	18
	80-90	8.1	140	.004		15	41	17	27	21	15.0	4.0	.2	.3	.024	0.76	.021	28
	130-150	8.5	410	.034		7	41	16	36	21	10.4	7.4	.45	1.2				20

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Bicarb Extr. P ppm	Repl. K m.equiv/100 g	Fe D.T.P.A.	Mn	Cu Extr. ppm	Zn	B ppm
	0-10	1.3	0.175					3.9	3.3	

Soil Association: Db - Dr
Great Soil Group:
Parent Material: Sandstone
Topography: Undulating Plain
Vegetation: Pasture. *Chloris gayana, Cenchrus ciliaris*

Site No. P 27
Location: G1 block Brigalow Research Station
Australian Map Grid Reference:
Air Photo Reference:
Principal Profile Form: Dr 2.12

Profile Morphology: hard setting surface.

0 - 5 cm Dark brown sandy loam (7.5YR 3/2 m), slightly hard, massive, earthy; abrupt change to
5 - 20 Yellowish red heavy clay (5YR 4/6 m) very firm, blocky; gradual change to
20 - 43 Dark reddish brown heavy clay (5YR 3/6 m) very firm, blocky; gradual change to
43 - 53 Yellowish brown heavy sandy clay (10YR 5/4 m), very firm, blocky; abrupt change to
53 - 60 Weathered sandstone and sandy clay

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm⁻¹	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca⁺⁺	Mg⁺⁺	K⁺	Na⁺	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0 - 5	5.8	39	.004		28	31	15	26	14	7.4	5.8	.3	.4				16
	5-10	5.8	36	.004		27	23	14	36	16	7.8	7.4	.15	.4				8
	10-20	5.9	96	.006		18	20	12	50	19	8.4	10.2	.2	.5				
	20-30	6.1	120	.006		17	15	10	58	22	9.2	11.6	.15	.6				
	40-50	7.0	69	.004		15	14	10	61	24	10.2	13.4	.15	.5				
	*50-60	7.4	33	.003		-	-	-	-	-	-	-	-	-				365

*weathered sandstone

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Extr. P ppm	Bicarb	Repl. K m.equiv/100 g	Fe	Mn	Cu	Zn	B ppm
							D.T.P.A. Extr. ppm				
	0-10	.3	.092								

Soil Association: Db-Dr
Great Soil Group:
Parent Material: Sandstone
Topography: Undulating Plain
Vegetation: Pasture, *Chloris gayana, Cenchrus ciliaris*

Site No. P 28
Location: G1 lane Brigalow Research Station
Australian Map Grid Reference:
Air Photo Reference:
Principal Profile Form: Db 1.13

Profile Morphology: hard setting surface

0 - 5 cm Very dark greyish brown sandy loam (10YR 3/2 m) firm, massive, some manganiferous concretions (<5 mm); abrupt change to
5 - 20 Dark brown heavy clay (10YR 3/3 m); very firm, blocky ; gradual change to
20 - 50 Brown heavy clay (10YR 4/3 m), very firm, blocky; clear change to
50 - 60 Yellowish brown sandy clay loam with weathered sandstone

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm⁻¹	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca⁺⁺	Mg⁺⁺	K⁺	Na⁺	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-5	6.6	69	.009		-	-	-	-	21	9.0	7.2	.5	1.0				16
	5-10	6.5	95	.012		28	16	14	42	30	10.4	13.4	.3	2.4				7
	10-20	7.5	165	.015		27	14	16	43	30	7.6	-	.2	2.1	.027	1.56	.018	9
	20-30	8.0	200	.021		28	15	10	47	28	10.0	14.8	.2	3.1	.017	1.08	.013	13
	50-60	8.6	450	.046		41	15	12	32	25	8.4	20	.1	4.1	.026	0.86	.010	80

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Extr. P ppm	Bicarb	Repl. K m.equiv/100 g	Fe	Mn	Cu	Zn	B ppm
							D.T.P.A. Extr. ppm				
	0-10	1.2	0.110						1.4	0.3	

Soil Association: Ts-Dd-Ug
Great Soil Group: Solodic Soil
Parent Material:
Topography: Undulating Plain
Vegetation: Woodland *Acacia harpophylla, Casuarina cristata, Eucalyptus cambageana* shrub layer *Eremophila mitchellii, Geijera parviflora*

Site No. P 23
Location: C block Brigalow Research Station
Australian Map Grid Reference:
Air Photo Reference:
Principal Profile Form: Dd 1.43

Profile Morphology: hard setting surface

0 - 12 cm Very dark greyish brown sandy loam (10YR 3/2 m), hard, massive, few manganiferous concretions, few quartzitic gravels (up to 50 mm); abrupt change to very thin conspicuous bleach overlying -
12 - 23 Very dark greyish brown sandy clay (10YR 3/2 m), extremely hard, coarse blocky (columnar?); gradual change to
23 - 60 Brown sandy clay loam (10YR 4/2.5 m), very hard, coarse blocky, numerous carbonate concretions; gradual change to
60 - 76 Yellowish brown sandy clay loam (10YR 5/4 m), hard, structured, few carbonate concretions few manganiferous stains; gradual change to
76 - 150 Yellowish brown sandy clay loam (10YR 5/4 m), light grey mottle in lower part, hard, structured, few manganiferous stains.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) μScm⁻¹	Cl %	A.D. Mois. %	C.S.	F.S.	Si	C	C.E.C.	Ca⁺⁺	Mg⁺⁺	K⁺	Na⁺	P	K	S	Acid Extr. P ppm
						Particle Size % O.D.				Exch.Cations m.equiv/100g O.D.					% O.D.			
	0-10	6.3	60	.009		31	45	7	17	16	5.4	4.4	.15	1.2	.050	0.33	.020	16
	12-20	7.0	160	.022		28	38	5	29	22	4.8	10.6	.15	4.2				4
	20-30	8.9	570	.052		27	36	4	33	22	4.8	12.2	.15	6.3	.017	0.24	.016	6
	50-60	9.3	780	.082		29	37	4	30	19	3.6	10.4	.05	6.4	.014	0.26	.019	6
	80-90	9.2	840	.095		23	44	5	28	19	2.0	10.2	.15	7.5	.014	0.27	.008	2
	130-150	8.4	550	.076		31	41	5	23	16	1.2	7.8	.05	4.6				1

Lab. No.	Depth cm	Org. C %	Tot. N	Acid Extr. P ppm	Bicarb	Repl. K m.equiv/100 g	Fe	Mn	Cu	Zn	B ppm
							D.T.P.A. Extr. ppm				
	0-10	1.0	.098						2.5	0.3	

APPENDIX III

Soil Survey of Brigalow Research Station

by A.A. Webb

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SOIL SURVEY OF BRIGALOW RESEARCH STATION

by A.A. Webb,
Soils Technologist

During the 1968-1969 year, a detailed reconnaissance soil survey was conducted on the Brigalow Research Station via Theodore.

METHOD

Detailed reconnaissance methods were employed using low altitude colour aerial photos, much ground checking and selected traverses. A 5 ch. grid survey was employed on some limited areas. Boundaries have been selected to distinguish between different soil associations and these have been termed 'units'. Soil descriptions have been designed to give physical characteristics of the major soils of the unit.

Soils have been described and classified using the factual key (Northcote 1965). The colour aerial photos were approximately 20 ch. to the inch and were of considerable assistance for delineating boundaries of units. Large areas which are still uncleared, notably those on the western and eastern side of Roundstone Creek and on the northern boundary have a slightly lower reliability of mapping than cleared areas. This is due to the difficulty of access and the complexity of soils in what appears to be a simple photo pattern. The accompanying map is not drawn accurately to scale as it was compiled from all the separate photos covering the Station.

GENERAL

The area mapped is part of the Highworth and Thomby Land Systems (Speck et.al. 1968). It is also mapped as units CB4 and Si6 of the Atlas of Australian Soils sheet 4 (Isbell et al 1967).

The geology is described in the 1:250,000 Geological Series for Baralaba, Qld. (1966). On the geological map the Research Station is shown as mainly soil and alluvium overlying the Triassic, Moolayember formation. A small part of the Station is mapped as Moolayember formation which is lithic sandstone, grey shale, conglomerate, and plant fossils.

In general, there are four main types of land on Brigalow Research Station:

1. Very gently undulating plains with gilgaied and non-gilgaied clays.

2. Alluvial plains with clays and silty duplex soils.

3. Hard setting loamy surfaced duplex soils often with quartzitic gravels.

4. 'Softwood areas' with loamy and sandy brown and red earths and loamy duplex soils with deep A horizons.

SOILS

A map showing units is attached. The scale is approximately 20 ch. to 1 in. The soil units as mapped are described in Appendix 1. A list of the units occurring is shown in Table 1.

Table 1

Mapping Units of Brigalow Research Station

Ug	Dy-Db	Dy
Ug-Uf	Dy-Dd	Ug-D
Dd-Ug	Al-Dd	Db
Ts-Dd	Ts-Dd-Ug	Gn2
Ts-Dy	SW-Db	Dy3
Um	Gil Ug	Al-Ug
Db-Dr	Dy-Ug	Dd-Db
Dy2.8	SW-Gn2	
Ug-Dd-Db	Uc	

There are very close similarities between several of the soils described ir the various units. This applies especially to the Dd, Db and Dy soils; in most cases the principal profile form of these soils in the different mapping units is the same. However, distinctions have been made using the following criteria as general guides. These were not included in the classification as a further numeral.

(a) depth of A horizon

(b) texture of A horizon

(c) relative presence of gravels

(d) presence of carbonate concretions in the profile

(e) degree of gilgai development

(f) depth of soil profile

(g) associated soils

Units Dy-Db, Dd-Db, Ts-Dy are similar in many respects, and the principal profile forms are often the same. Unit Dy-Db generally has slightly coarser textured A horizons; there may be small areas of cracking clays in the Dd-Db unit which are not present in the Dy-Db unit. There appear to be more dark B horizons in Dd-Db than in Dy-Db. Ts-Dy has associated shallow loams and sandstone outcrops not found in the other two units. Units Dy-Db and Db have been separated because gravel is not as common in Db as it may be in the Dy-Db; however, the profile forms may be the same. Db and SW-Db have been differentiated on the overall thickness of the A horizon; textures may be slightly coarser in the SW-Db. Unit Ug has some gilgai development scattered through it but not to the same degree as in unit Gil Ug.

It is interesting to note that almost every profile examined on the Station had carbonate concretions somewhere in the profile. In the duplex soils, the zone of carbonate accumulation is fairly constant at the 18 to 30 in. interval.

All or most of the clays and duplex soils had small manganiferous concretions in the profile.

All duplex soil units with the exception of unit Dy have soils with a conspicuously bleached A2 horizon and a very hard B horizon as the dominant soil; gypsum was encountered at only a few of the classification sites in the non-cracking and cracking clay units.

The units of the Highworth and Thomby Land Systems which are equivalent to or approximate to the units as mapped are given in Table 2.

TABLE 2

Land System Units Comparable to Mapping Units on Brigalow Research Station

Highworth L.S.	Mapping Unit(s)	Thomby L.S.	Mapping Unit
Unit 2	Dy-Db,Dd-Db,Ts-Dd	Unit 1	Gn2
3	Ug, Dy-Dd,Ts-Dd-Ug	3	Db
4	Ug,Ug-Dd-Db	5	Ug-D
5	Db-Dr,Ts-Dy	6	Dy3
6	Gil-Ug,Dy-Ug,Ug-Uf	7	Ug-D
7	SW-Db,SW-Gn2	9	Dd-Ug
8	Dd-Ug,Dy	10	Al-Dd
9	Dy2.8,Al-Dd		
10	Uc		

LAND UTILIZATION OF UNITS

The major agricultural units on the Research Station are unit Ug and unit Gil-Ug. Parts of Ug have limitations imposed on them by occasional gilgais; however, the number and development of these gilgais do not present the problems which occur with Gil-Ug. The pricipal soils of these units are deep, dark, cracking clays. These have very good moisture storing capabilities, but due to their high clay content are not able to take advantage of light falls of rain. Unit Al-Ug has very dark cracking clays forming an alluvial plain. It has only a few gilgais in isolated areas and appears to be excellent agricultural land.

The gilgai complex of unit Ug-D is not generally suited to cultivation; some parts where the gilgai development is comparatively weak may be suitable, provided the associated duplex soils do not cause a complex soil pattern. Units Ug-Dd-Db, Ts-Dd-Ug appear suitable for cultivation if care if taken in management and the associated duplex soils are not cultivated too frequently. Some of the dark duplex soils have very shallow A horizons and these appear to be suitable for cropping. Erosion could be a problem.

The inherent difficulties of dealing with a soil complex may make cultivation of the units unattractive. Differential moisture storage and working moistures of the soils can cause problems in establishment and time of maturity of a crop.

The alluvial units Al-Dd and Dd-Ug are not ideal for cropping; the many difficulties associated with the silty nature of the surface horizons of the soils make them inhospitable. However, with very limited working the units could be very useful for pasture production.

The 'softwood units' SW-Gn2, Gn2 SW-Db could be suitable for cropping provided cultivation is kept to a minimum - the light texture, lack of structure and the occasional slope may provide problems. Moisture storage could well be limiting except under very good conditions. These soils do have the advantage of responding quickly to comparatively light falls of rain and for this reason may be useful for a fodder crop. The soils are suitable for pastures with the reservation that the sandier sites have moisture limitations.

The loamy duplex soil units Ts-Dy, Ts-Dd, Dy-Db, Dy, Db, Dd-Db, and Db-Dr may be classed as very similar with respect to usage. Gravel may be present in varying amounts in most units - A horizons are hard setting and massive, and B horizons are usually very hard and sometimes columnar. They have poor workability, are prone to erosion and have poor moisture penetration due to surface sealing. The soils are not suited to regular cropping, but are well suited to pasture production. Soils of unit

Dy3 are sandier and have deeper A horizons, but are of limited value for cropping.

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SOIL SURVEY OF BRIGALOW RESEARCH STATION

- APPENDIX 1

Unit Symbol	Dominant Soils	Horizon	Characteristics of Dominant Soils	Land Form	General
Ug	Dark uniform textured cracking clays		Self mulching, cracking, thin surface crust breaks into small polygonal plates as surface dries. The surface 2 to 4 in. very dark grey, very dark greyish brown or dark greyish brown medium clay, crumb to fine blocky, hard (dry) friable (moist), some quartzitic gravel 1 to 2 in. on surface and in profile; carbonate often occurs on the surface. At depth, grades to brown, yellowish brown or greyish brown often with yellowish brown or dark brown mottles, heavy clay, blocky, very hard (dry), plastic (moist) carbonate may occur throughout but generally in the upper 36 in. of the profile. Soil often more than 5 ft. deep. Soil reaction is alkaline at the surface and acid in the lower part of the solum. Principal profile forms: Ug5.25, Ug5.24, Ug5.16, Ug5.15, Ug5.22, Ug5.23, Ug5.13	Very gently undulating plain with occasional gilgais	In some area, notably J Block, G block, nursery, and eastern end of the reference area the soil is less than 5 ft.deep. It is underlain by weathered or unweathered sandstone. Associated are thin surfaced loamy duplex soils of unit Ts-Dd-Ug

Unit Symbol	Dominant Soils	Horizon	Characteristics of Dominant Soils	Land Form	General
gil Ug	Uniform textured		Mound - self mulching, cracking surface 2 to 4 in., very dark greyish brown, very dark grey, dark greyish brown or dark grey medium or heavy clay, crumb to fine blocky, very hard (dry), friable (moist), gradual change at depth to brown, grey brown or grey heavy clay, blocky or coarse blocky, very hard (dry), carbonate usually in upper 3 ft., reaction trend is acid, pH 5 to pH6 at depth. Principal profile forms: Ug5.25, Ug5.24. Shelf - cracking, organic litter, surface 2 to 5 in. very dark grey, dark grey or very dark greyish brown medium or heavy clay, crumb or fine blocky, very hard (dry). At depth grade to grey, grey brown or brown heavy clay similar to lower parts of soils on the mound, reaction trend acid. Principal profile forms: Ug5.24, Ug5.25, Ug5.15	Nearly level plain with normal and tank form of gilgai micro-relief, shelves vary in shape from roughly circular to elongate 12 to 60 ft. long. Vertical interval 1 to 4 ft.	Associated on the mounds are loamy duplex soils of unit D^b, and uniform textured non-cracking clays of unit Ug-Uf

Unit Symbol	Dominant Soils	Horizon	Characteristics of Dominant Soils	Land Form	General
Ug-Uf	Uniform textured, non-cracking clays and uniform textured cracking clays.	A B	Mounds - non-cracking clays with weak horizonation, surface 8 to 10 in. dark greyish brown medium clay, fine blocky, slightly hard or hard (dry), carbonate usually at the surface and in the profile, diffuse boundary with B. Dark greyish brown, greyish brown or dark brown medium or heavy clay, blocky, hard or very hard (dry), may grade to brown or greyish brown clay, carbonate abundant in 30 to 36 in. zone, gypsum may be present. Principal profile forms: Uf6.33, Uf6.31 Shelf - dark uniform cracking clays of unit gil-Ug	Nearly level plain with normal gilgai microrelief, vertical interval 1 to 6 ft.	Associated are some loamy duplex soils of SW-Db
Ug-D	Dark uniform textured cracking clays		Mound - There are no clearly defined soil horizons. Surface 1 to 3 in. are dark grey, dark greyish brown or very dark brown medium or heavy clay, fine granular, very hard (dry), few small manganiferous concretions. At depth grades to greyish brown heavy clay with fine diffuse rust coloured mottle, blocky or coarse blocky very hard, moderate carbonate in upper 2 ft., soil more than 5 ft. deep. Principal profile forms: Ug5.24, Ug5.35 Shelf - Usually an organic litter and thin Ao. Surface 1 to 3 in. very dark grey or dark grey medium or heavy clay, crumb or fine granular hard (dry), at depth grading to greyish brown heavy clay, blocky, very hard (dry), carbonate often absent. Principal profile form: Ug5.24	Nearly level plain with gilgai microrelief-normal and tank form; 12 to 60 ft. long and vertical interval 1 to 4 ft.	In isolated areas are loamy surfaced duplex soils of unit Db.
Um	Shallow loams		Dark brown or very dark greyish brown sandy loam, 8 to 10 in., massive, earthy, hard (dry). Principal profile forms: Um5.41, Um5.51	Broad crests with outcropping sandstone.	Associated are shallow soils of unit Ts-Dy

Unit Symbol	Dominant Soils	Horizon	Characteristics of Dominant Soils	Land form.	General
Ts-Dd-Ug	Loamy surfaced duplex soils with dark clay B horizon	A1 *A2 B	Hard setting, some quartzitic gravel, very dark grey, very dark greyish brown or dark greyish brown sandy clay loam, 2 to 6 in., massive, hard (dry), abrupt boundary with A2. Conspicuously bleached, very light grey sandy loam or sandy clay loam, ½ in., massive, hard, abrupt boundary with B. Very dark grey of very dark greyish brown medium or heavy clay, blocky, very hard (dry), in upper part. At depth, grades to dark greyish brown and yellowish brown clay, coarse blocky, very hard (dry), carbonate profuse in 10 to 30 in. zone. Principal profile forms: Dd1.43; Dd1.13, Dy2.43 * A2 may be absent	Plain	Some weak gilgai, micro relief. Associated are dark uniform textured non-cracking clays of unit Ug-Uf and cracking clays of unit Ug. Some soft surfaced duplex soils similar to dominant soils occur. Principal profile form: Dd3.13
Dd-Ug	Loamy surfaced duplex soils with dark clay B horizon	A1 *A2 B	Hard setting, very dark greyish brown or very dark brown silty clay loam, 2 to 8 in., usually massive but weak fine blocky may occur where organic matter is high, hard (dry), abrupt boundary with A2. Conspicuously bleached, very light grey fine sandy clay loam approximately 1 in., hard, massive, abrupt boundary with B. Very dark grey or black medium to heavy clay, blocky, very hard, carbonate in top 18 in. Principal profile forms: Dd1.43, with lesser Dd1.13 * A2 may be absent	Alluvial plain with some normal gilgais	Associated are very dark cracking clays of unit A1-Ug

Unit Symbol	Dominant Soils	Horizon	Characteristics of Dominant Soils	Land Form	General
Al-Dd	Loamy surfaced duplex soils with dark clay B horizon	A1 A2	Hard setting, dark brown, very dark brown or very dark greyish brown silty clay loam or fine sandy clay loam; 5 to 11 in., massive, hard (dry), abrupt boundary with A2. Conspicuously bleached, greyish brown silty clay loam or fine sandy clay loam, up to 2 in., massive, hard (dry), abrupt boundary with A2. Very dark greyish brown or dark brown medium or heavy clay, blocky, hard (dry). At depth, change to brown or grey brown light clay, blocky, very hard (dry), carbonate present. Principal profile forms: Dd1.43, Dy2.43, Db1.43	Alluvial plain	On slightly higher sites B horizon may be sandy medium clay.
Dy2.8	Sandy surfaced duplex soils with a massive B horizon	A1 A2 B	Hard setting dark greyish brown, greyish brown or brown sandy loam 18 to 24 in., massive, earthy, slightly hard (dry), abrupt boundary with A2. Conspicuously bleached, white or very light grey, sandy loam, 1 to 4 in., massive, slightly hard or hard, abrupt boundary with B. Dark brown or yellowish brown sandy clay loam or heavy sandy clay loam with grey or dark yellowish brown fine mottling, massive, earthy, very hard, some carbonate concretions may be present at depth. Reaction trend usually neutral. Principal profile forms: Dy3.82, Dy3.83, Dy2.82	Alluvial levee	Associated are similar soils with blocky B horizon, these soils tend to be nearer the back slope of the levee. Principal profile forms: Db2.42, and Db1.42

Unit Symbol	Dominant Soil	Horizon	Characteristics of Dominant Soils	Land Form	General
A1-Ug	Very dark, uniform textured, cracking clays		No clearly defined soil horizons, self mulching, cracking. Surface 2 to 3 in. very dark grey medium clay, concretions. At depth, gradual change to dark greyish brown heavy clay with diffuse brown mottle, blocky to coarse blocky, very hard (dry). Soil more than 4 ft. deep. Principal profile form: Ug5.16	Alluvial plain with some normal gilgais	
Dy3	Sandy surfaced texture contrast soils	A1 A2 B	Hard setting, dark brown to brown, loamy sand to sandy loam, 11 to 24 in. thick, commonly 12 to 15 in. massive, slightly hard (dry), ironstone concretions (½ in.) in lower part, abrupt boundary with A2. Conspicuously bleached, pale brown or very light grey loamy sand to sandy loam, 1 to 2 in. thick, massive, slightly hard, ironstone concretions (½ in.) abrupt boundary with B. Yellowish brown, brownor greyish brown sandy clay or clay, often dark yellowish brown, yellowish brown, brown yellowish red or greyish brown mottle, blocky, very hard (dry). At depth, sandy clay; reaction usually alkaline Principal profile forms: Dy3.34, Dy2.43, Db2.43 Db1.43	Undulating land with broad crests and long slopes	Soils in higher parts of unit show little or no mottling soils in lower sites usually mottled and greyer

Unit Symbol	Dominant Soils	Horizon	Characteristics of Dominant Soils	Land Form	General
Dy	Loamy surfaced duplex soils with dark B	A	Hard setting, very dark greyish brown sandy loam or occasionally clay loam, 4 to 6 in., massive, slightly hard (dry), abrupt boundary with B	Alluvial terrace (?)	On eastern bank of Roundstone creek
		B	Dark greyish brown or very dark greyish brown heavy clay or heavy sandy clay in upper part, blocky, very hard (dry). Lower part brown or yellowish brown heavy sandy clay loam, blocky, very hard (dry), profuse carbonate in 10 to 30 in., zone.	—	
			Principal profile forms: Dy2.13, Dd1.13,		
Dy-Dd	Loamy duplex soils with very thin A and dark B	A1	Very dark grey sandy clay loam or clay loam, 1 to 2 in., massive, very hard (dry), abrupt boundary with A2	Plains of limited size.	Often treeless, polygonal cracking often evident at surface. Associated are dark cracking clays of unit Ug.
		A2	conspicuously bleached very light grey sandy clay loam, very thin ½ in., massive, very hard, abrupt boundary with B.		
		B	Very dark grey or very dark greyish brown heavy clay blocky, very hard (dry), very small manganiferous concretions in upper part. At depth, grades to dark greyish brown heavy sandy clay loam, massive, hard to very hard (dry), carbonate common.		
			Principal profile forms: Dd1.43, Dy2.43		

Unit Symbol	Dominant Soils	Horizon	Characteristics of Dominant Soils	Land Form	General
Dy-Ug	Loamy surfaced duplex soils	A1 *A2 B	Mound - hard setting, dark brown to very dark greyish brown sandy clay loam, 3 to 6 in., massive, hard, small manganiferous concretions up to ¼ in., abrupt boundary with A_2 Conspicuously bleached, very thin ½in.,abrupt boundary with B. Yellowish brown, greyish brown or very dark greyish brown clay, blocky to coarse blocky, very hard (dry), carbonate at depth. Principal profile forms: Dy2.43, Db1.43, Dy2.13, Dd1.43 * A_2 occasionally absent	Gently undulating plain with gilgai microrelief vertical interval 1 to 5 ft.; horizontal interval 3) ft.	Associated are uniform textured, non-cracking clays of unit Ug-Uf
	Dark uniform cracking clays		In shelves and depressions are cracking clays; these are described in unit gil Ug Principal profile forms: Ug5.24, Ug5.25, Ug5.28, Ug5.16, Ug5.15,		Spread across this unit in a SE-NW direction is a belt of exposed quartzitic rocks; these rocks prevent any possibility of cultivation in the south eastern corner of the unit.

Unit Symbol	Dominant Soils	Horizon	Characteristics of Dominant Soils	Land Form	General
Db	Loamy surfaced texture contrast soils	A1 A2* B	Hard setting, brown to very dark brown sandy loam, occasionally sandy clay loam, 6 to 9 in. thick, massive, slightly hard to hard (dry), clear boundary with A2. Conspicuously bleached, pale brown to very pale brown sandy loam, 1 in. thick, massive, slightly hard (dry), abrupt boundary with B. Yellowish brown, brown or dark brown medium to heavy clay in upper part, grading to brown light clay, sandy clay or clay loam at depth, blocky, very hard (dry) small manganiferous concretions (1/8 in.), carbonate below 18 in. Principal profile forms: Db1.43, Dy2.43, Db1.13 (solodized solonetz), * A2 may be absent	Gently undulating land	Associated are darker surfaced texture contrast soils with very dark B horizon - usually in lower sites of unit. Small areas of unit Ug-D may occur
Ts-Dy	Loamy surfaced texture contrast soils	A1 A2 B	Hard setting very dark greyish brown to dark brown sandy loam, 3 to 10 in. thick, massive, hard to very hard (dry), clear boundary with A2. conspicuously bleached, very pale brown or light grey sandy loam, < 1 in. thick, massive, hard, abrupt boundary with B. Very dark greyish brown to dark brown medium to heavy clay 13 to 30 in. thick, may have yellowish brown, brown or reddish brown mottle, blocky to prismatic with columnar, very hard, (dry). Reaction trend at depth is alkaline, carbonate at depth. Principal profile forms: Dy2.43, Db2.43, Dd1.43, Dy3.43, Db1.43	Undulating land with broad crests and long slopes; occasional exposed sandstone rocks	Associated on crests are shallow brown to very dark brown sandy loams of unit Um

Unit Symbol	Dominant Soils	Horizon	Characteristics of Dominant Soils	Land Form	General
Db-Dr	Loamy surfaced duplex soils with dark brown B horizon	A1 A2* B	Overall depth to weathering rock 10 to 42 in.,usually 18 to 24. Hard setting, very dark greyish brown to dark brown sandy loam or light sandy clay loam, 4 to 5 in., thick massive, hard to very hard (dry), clear boundary with A2. Conspicuously bleached, light grey to pale brown sandy loam, 1 in. thick, massive, slightly hard to hard, abrupt boundary with B. Dark brown to reddish brown medium to heavy clay, blocky, hard to very hard (dry), carbonate often in lower part. Principal profile forms: Dd1.12, Db1.42, Db1.43, Dr2.43, Dr2.12, Db1.13, Dy2.12, Db1.22, Dd1.13, Dy2.42 * A2 often absent	Broadly undulating land with gentle slopes. Sandstone outcrops occur.	Associated on crests may be shallow loams of unit Um
Ts-Dd	Loamy surfaced duplex soils with very dark B horizon	A1 A2 B	Hard setting very dark greyish brown sandy loam to clay loam, 2 to 10 in., massive, hard (dry), abrupt boundary with A2. Conspicuously bleached, pale brown to very light grey sandy loam < 1 in., massive,hard, abrupt boundary with B. Very dark greyish brown, very dark brown or dark greyish brown medium to heavy clay in upper part, may have reddish brown or greyish brown mottle, columnar breaking down to blocky, very hard (dry), in the lower part greyish brown or brown sandy clay or sandy clay loam, blocky, very hard (dry), abundant carbonate. Principal profile forms: Dd1.43, Dy2.43, Dd1.33, Dd1.13, Dy 3.43, Db1.43, Dy2.13.	Lowest sites in gently undulating land, particularly in drainage lines	

Unit Symbol	Dominant Soils	Horizon	Characteristics of Dominant Soils	Land Form	General
Dd-Db	Loamy surfaced duplex soils with very dark B	A1 *A2 B	Depth of soil is 20 to 40 in. overlying sandstone; hard setting with reddish brown quartzitic gravel up to 2 in. size, very dark greyish brown to dark brown sandy clay loam or clay loam 3 to 6 in., massive, hard (dry), abrupt boundary with A2. Conspicuously bleached, very pale brown to very light grey sandy loam <1 in., massive, hard, abrupt boundary with B. Very dark greyish brown, very dark grey or very dark brown heavy clay in upper part, blocky, very hard (dry), small manganiferous concretions. In lower part grades to yellowish red, brown or dark yellowish brown sandy clay loam, blocky, hard (dry), carbonate below 12 in. Principal profile forms: Dd1.43, Dd1.13, Db1.43 * A2 may be absent	Gently undulating	Gravel strewn. Associated are areas of dark uniform textured non-cracking clays of unit Uf-Ug and soft surfaced duplex soils similar to dominan soils. Principal profile forms: Uf6.32, Uf6 31, in the clays, and Dd3.33, Dd3.43 in the duplex soil
Uc	Deep sands	A1 *A2 B	Dark brown sand, 4 to 6 in., massive, soft (dry), loose, clear boundary with A2. Dark brown or brown sand, 21 to 26 in. thick, massive, soft (dry), diffuse boundary with B. Brown or yellowish brown sand, massive, earthy, soft (dry). Principal profile forms: Uc4.22, Uc5.21 * A2 may be absent	Alluvial levee	

Unit Symbol	Dominant Soils	Horizon	Characteristics of Dominant Soils	Land Form	General
Dy-Db	Loamy surfaced duplex soils with dark B horizon		Depths of soil varies from 18 to 36 in. or more overlying sandstone.	Gently undulating to undulating	Gravel strewn.
		A1	Hard setting often with reddish brown quartzitic gravels up to 3 in. size, dark brown to very dark greyish brown sandy loam, occasionally sandy clay loam, 4 to 10 in. thick, massive, slightly hard to hard, some manganiferous concretions, abrupt boundary with A2.		
		A2 *	Conspicuously bleached, light grey to very pale brown sandy loam <1 in. thick, massive, slightly hard, some manganiferous concretions, abrupt boundary with B.		
		B	Very dark greyish brown, dark greyish brown, very dark brown or brown sandy medium clay or heavy clay, may have yellowish brown, reddish brown or dark yellowish brown mottles, columnar breaking down to coarse blocky or blocky; very hard (dry), small manganiferous concretions, carbonate below 18 in. Lower part brown, dark greyish brown or light olive brown light clay or sandy clay loam, blocky, hard or very hard (dry), carbonate usually abundant.		
			Principal profile forms: Dy2.43, Dd1.43, Db1.43, Dy3.43, Dd2.43, Dy2.13, Dd1.13, Dy3.42		
			* A2 may be absent		

Unit Symbol	Dominant Soils	Horizon	Characteristics of Dominant Soils	Land Form	General
Gn2	Sandy red earths	A B1 B2	Dark brown or dark reddish brown loamy sand, 6 to 8 in., massive, soft (dry), clear boundary with B. Dark reddish brown or dark red sandy laom, 18 to 22 in., massive, earthy, soft (dry), diffuse boundary with B2. Dark red or yellowish red sandy clay loam, more than 12 in., massive, earthy, slightly hard to hard (dry), reaction trend is neutral. Principal profile form: Gn2.12	Undulating land	On upper slopes and crests are sandy red earths, associated on lower slopes and margins of the unit are sandy surfaced duplex soils. These are similar to the dominant soils of unit Dy3 but have a thinner A1 and may have water worn gravel in the upper part.
Sw-Gn2	loamy red and brown earths	Ao A B1 B2	May have thin litter layer dark brown, reddish brown or dark reddish brown loamy sand to sandy loam, 4 to 8 in. usually massive, although surface 2 to 3 in. may have very weak crumb, soft (dry), diffuse boundary with B. Dark greyish brown to reddish brown sandy clay loam, massive, earthy, hard (dry), diffuse boundary to next horizon. Reddish brown, brown or yellowish brown heavy sandy clay loam or sandy clay, massive, earthy, very hard (dry), small manganiferous concretions, p nfuse cambonate below 22 in. Occasionally structured clays underly this zone. Principal profile forms: Gn2.43, Gn2.13	Alluvial levee(?)	

Unit Symbol	Dominant Soils	Horizon	Characteristics of Dominant Soils	Land Form	General
SW-Db	Loamy surfaced duplex soils	Ac A1 A2 B	If present <1 in. Hard setting, very dark greyish brown, very dark brown, dark brown or brown sandy loam, 5 to 22 in., commonly 9 to 12, massive, slightly hard (dry), clear boundary with A2. Conspicuously bleached very pale brown sandy loam, <1 in., may be only very thin line on top of B, abrupt boundary with B. Very dark greyish brown, very dark brown, dark brown, brown or yellowish brown heavy sandy clay to medium heavy clay, blocky, very hard (dry), small manganiferous flecks. At depth, grades to brown or yellowish brown clay loam or sandy clay loam, manganiferous concretions may occur, carbonate usually abundant below 20 in. Principal profile forms: Db1.43, Dy2.43, Dd1.43, Dy2.13, Db1.13, Dd1.13	Gently undulating land	Associated are some similar soils which have a soft surface. Principal profile forms: Db3.43, Db3.13. Dd3.33
Ug-Dd-Db	Dark uniform cracking clays		Soils of unit Ug Principal profile form: Ug5.24	Gently undulating land	Intimately associated are loamy duplex soils of unit Dd-Db, quartzitic gravels strewn on surface. Principal profile forms: Dd1.43, Db1.43