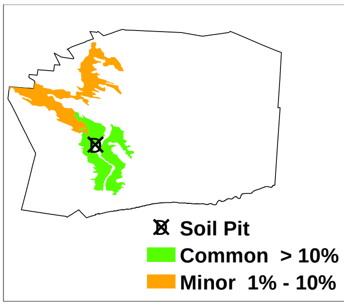
Soil 10 Sandy loam over brown clay



Landscape — Angas River flood plain formed on grey, red and brown massive porous micaceous sandy clay (old alluvium). Surface soil is hard setting and normally stone free.

Profile — Medium thickness hard sandy loam over a well structured brown clay grading to alluvial sediments.

Depth (cm)	*Description*
0-10	Dark brown friable massive sandy loam (with 2-10% calcrete fragments of unknown origin). Gradual to:
10-24	Brown friable massive sandy loam. Abrupt to:
24-55	Dark brown and brown firm medium clay with strong medium polyhedral structure. Gradual to:
55-90	Dark yellowish brown and dark brown mottled firm medium clay with strong medium prismatic structure. Diffuse to:
90-135	Yellow, brown and orange mottled hard slightly calcareous silty medium clay with weak very coarse prismatic structure.
135-180	Red, yellowish brown and greyish brown mottled very hard massive porous and micaceous sandy light medium clay.

Key properties

Drainage: Moderately well drained. Water perches on top of the clay for periods of no more than a week at a time during late winter. Deep drainage is satisfactory.

Potential root zone: 135 cm in sampling pit.

Barriers to root growth

Physical: The hard clayey subsoil presents a minor barrier to root growth. Root density and distribution uniformity decrease with depth.

Chemical: Marginally high salinity and sodicity below 55 cm and 90 cm respectively may have some impact on root growth and water uptake. Mild sodicity in top of subsoil (24-55 cm) is probably irrigation-induced.

Water holding capacity : Estimated for the depth of the potential root zone of grapevines

Total available: 180 mm
Readily available: 80 mm

Fertility: Nutrient retention capacity is moderately high. Maintaining adequate levels of nutrition in these soils is straightforward.

Erosion potential: Low potential for both water and wind erosion.

Laboratory data

Depth cm	pH H_2O	pH $CaCl_2$	CO_3 %	ECe dS/m	Cl mg/kg	S mg/kg	B mg/kg	Ext P mg/kg	Ext K mg/kg	Org C %	Exchangeable cations - cmol(+)/kg Ca	Mg	Na	K	#CEC	#ESP
Target →	< 9.2	>5.0	na	< 2.0	< 350	10	< 3	80	200	> 1.0	% of (Ca+Mg+Na+K) 65-75	10-15	< 6	3-8	> 5	< 6
0-10	8.7	7.8	0.9	1.41	50	10.2	1.3	64	319	1.36	8.24	2.86	0.55	0.74	12.4	4.4
10-24	8.8	7.9	0.9	1.34	62	13.5	0.9	52	312	0.73	8.27	1.96	0.64	0.65	11.5	5.6
24-55	8.7	7.7	0	1.64	136	48.8	1.8	26	955	0.40	13.6	4.58	2.33	2.39	22.9	10.2
55-90	8.4	7.8	0	3.17	282	99.8	1.4	5	1048	0.17	7.46	3.99	1.39	2.60	15.4	9.0
90-135	9.0	8.2	0.3	2.19	163	59.1	1.4	3	534	0.05	5.68	3.34	1.68	1.26	12.0	14.0
135-180	8.5	7.8	0	3.97	309	97.7	1.8	3	344	<0.05	4.88	3.72	1.76	0.81	11.2	15.8

CEC estimated from sum (Ca+Mg+Na+K). # ESP is estimated by = Na / (Ca+Mg+Na+K)

Explanation of highlighted data

Grape vines can suffer 10% yield loss when ECe exceeds 2.5 dS/m, or chloride exceeds 350 mg/kg.
Exchangeable sodium less than 6% of total of all four cations is desirable.
High surface pH and detectable carbonate due to calcrete (origin unknown).
Apply gypsum to increase the low ratio of Ca to Mg.

Notes:

Management of Soil 10
Sandy loam over brown clay

by John Rasic

Problems

This soil is similar to Soil 9, but its limitations are less severe. Its polyhedral (rather than prismatic) structure enables water and roots to penetrate into the clay layer between 24 and 55cm.

Any smearing that is caused by implements or by spinning tractor wheels will damage the polyhedral structure because smearing seals the network of connecting soil pores. This sealing prevents drainage and results in the saturation and collapse of the overlying sandy loam which then dries to form a pan at 24cm that can restrict the penetration of roots and of water.

Pre-planting action that can be used to tackle the problems

Deep rip and mix the layers down to 55cm (called sub-soiling) to increase soil uniformity and to increase the speed of water movement and to improve drainage.

To help to control slaking, during mixing incorporate gypsum and organic matter. If you consider using pig manure as the source of the organic matter, ensure that it will not cause water repellence.

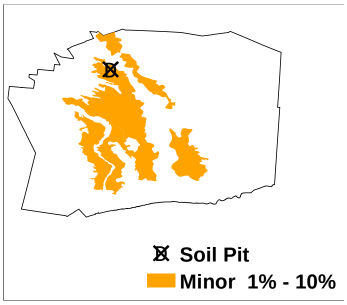
Soil management after planting

Establish and maintain a mid-row cover crop that is tolerant of alkaline soil. This important and inexpensive management tool can improve the penetration of water and of roots and it can help individual soil crumbs to retain their shape.

Apply fertiliser for quicker and better growth of the cover crop.

Reduce compaction and allow the cover crop to establish by minimising vehicle traffic and excluding grazing animals.

Soil 11 Gradational sandy clay loam



Landscape — Very gently undulating dune field superimposed on a former flood plain of the Bremer River. Site is in swale between sandy rises. Surface is soft and stone free.

Profile — Reddish sandy loam to sandy clay loam grading to a red clay, calcareous with depth over medium to fine grained alluvium.

Depth (cm)	*Description*
0-10	Dark reddish brown friable massive slightly calcareous light sandy clay loam. Clear to:
10-20	Dark reddish brown and brown friable weakly structured fine sandy light clay. Abrupt to:
20-45	Dark reddish brown and strong brown friable medium clay with moderate polyhedral structure. Clear to:
45-75	Dark reddish brown and brown friable massive highly calcareous fine sandy clay loam with more than 50% nodular and fine carbonate. Clear to:
75-100	Dark reddish brown and dark brown firm highly calcareous light clay with moderate polyhedral structure and 10-20% fine carbonate. Gradual to:
100-160	Dark brown firm light medium clay with smooth ped angular blocky structure and minor soft carbonate.

Key properties

Drainage — Moderately well drained. Subsoil may remain wet for up to a week after heavy or prolonged rainfall. Deep drainage is impeded by the clay from 75 cm.

Potential root zone — Strong root growth to 45 cm, diminishing to 100 cm, with very few roots below 100 cm in the sampling pit.

Barriers to root growth

Physical: There are no significant physical barriers.

Chemical: Elevated boron concentrations from 45 cm and sodicity from 75 cm restrict deep subsoil root growth.

Water holding capacity : Estimated for the depth of the potential root zone of grapevines

Total available: 115 mm
Readily available: 60 mm

Fertility — Inherent fertility is moderate, as indicated by the exchangeable cation data. Test data indicate that concentrations of all measured elements are adequate. High surface pH (possibly due to pre-plant ripping and movement of subsoil to surface) may cause some reduction in trace element availability.

Erosion potential — Low potential for both wind and water erosion.

Laboratory data

Depth Cm	pH H_2O	pH $CaCl_2$	CO_3 %	ECe dS/m	Cl mg/kg	S mg/kg	B mg/kg	Ext P mg/kg	Ext K mg/kg	Org C %	Exchangeable cations - cmol(+)/kg Ca	Mg	Na	K	#CEC	#ESP
Target →	< 9.2	>5.0	na	< 2.0	< 350	10	< 3	80	200	> 1.0	% of (Ca+Mg+Na+K) 65-75	10-15	< 6	3-8	> 5	< 6
0-10	8.3	7.6	0.6	1.30	36	28.6	2.0	89	880	1.21	11.5	6.94	0.67	2.47	21.6	3.1
10-20	8.5	7.7	0.6	1.02	37	27.2	1.4	7	550	0.39	11.5	8.00	1.02	1.40	21.9	4.7
20-45	8.6	7.6	0.3	0.65	22	10.3	2.8	2	360	0.30	9.17	9.61	1.37	1.01	21.2	6.5
45-75	9.1	7.9	13.7	1.26	16	38.3	4.0	2	309	0.18	9.29	8.03	1.63	0.83	19.8	8.2
75-100	8.9	7.7	3.3	2.88	141	128	4.7	2	467	0.23	10.3	2.44	3.18	1.20	17.1	18.6
100-160	8.9	7.9	0.7	2.35	230	75.8	6.6	2	628	0.16	7.09	11.2	5.45	1.66	25.4	21.5

CEC estimated from sum (Ca+Mg+Na+K).   # ESP is estimated by = Na / (Ca+Mg+Na+K)

Explanation of highlighted data

Exchangeable sodium less than 6% of total of all four cations is desirable.
Boron concentrations exceeding 3 mg/kg may be a problem for grape vines (American literature).
Moderately high surface pH may reduce trace element availability.
Gypsum will help increase Ca:Mg ratio, improving surface condition.

Notes:

Management of Soil 11

Gradational sandy clay loam

by John Rasic

Problems

This soil does not have any serious physical limitations. Increases in the levels of sodium, salts and boron are associated with the deeper clay layers.

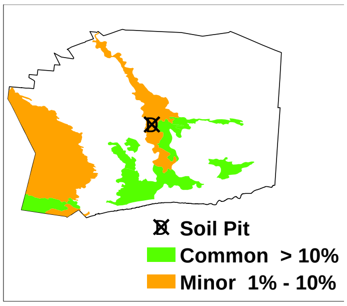
Pre-planting action that can be used to tackle the problems

Soil improvement is not required because there are no serious physical limitations. Consider mounding and planting into the mound. To install trellis posts, rip to 70cm using a straight, single-tine ripper. To avoid contamination of the complete profile with boron, salts, and sodium do not use wings or parabolic-curve sub-soilers.

Soil management after planting

Under intense irrigation the accumulation of salts and toxins may become a serious problem. Do not allow salts, sodium and boron to accumulate within the top metre. Use mid-row trenching or slotting to enable salts and toxins to leach below the depth of the effective rootzone. Consider establishing an appropriate mid-row cover crop. At the start and end of the growing season, collect soil samples and analyse them for salt, sodium and boron. Continuously monitor soil moisture. Rebuild mounds as needed. Consider trimming the roots in every second row: A D5 is the biggest crawler tractor that can fit between vine rows. Using a tine without wings, a D5 can rip to 65cm with one tine and to 50cm with two tines.

Soil 12 Sandy loam over poorly structured clay



<u>Landscape</u> Alluvial plains of the Angas-Bremer formed on medium textured silty sediments. Surface soil is hard setting and stone free.

<u>Profile</u> Sandy loam to loamy sand with a bleached A2 layer, over a coarsely structured brown mottled clay.

Depth (cm)	*Description*
0-12	Dark brown firm fine sandy clay loam with moderate granular structure (recent wash deposit). Clear to:
12-27	Dark brown firm massive light sandy clay loam (original soil surface). Abrupt to:
27-60	Bleached firm massive loamy sand. Abrupt to:
60-100	Dark brown, orange and red mottled extremely hard medium clay with very coarse prismatic structure. Gradual to:
100-140	Orange, greyish brown and dark red mottled extremely hard fine sandy light clay with weak coarse prismatic structure. Gradual to:
140-170	Orange, greyish brown and dark red mottled hard weakly structured silty clay loam.

Key properties

Drainage — Moderately well drained. Water perches on tight clayey subsoil for a week or so following prolonged or heavy rainfall, but depth to clay lessens impact of waterlogging. Deep drainage appears satisfactory.

Potential root zone — Some vine roots to 140 cm, but most are in the upper 27 cm of sampling pit.

Barriers to root growth

Physical: The tight clayey subsoil severely restricts root growth; most roots that do grow are confined to aggregate surfaces. The bleached layer with very poor moisture retention characteristics also limits root growth.

Chemical: There are no toxic limitations, but low nutrient retention capacity of the bleached subsurface layer impedes growth.

Water holding capacity : Estimated for the depth of the potential root zone of grapevines

Total available: 110 mm
Readily available: 55 mm

Fertility — Nutrient retention capacity is moderate in the surface soil, but very low in the bleached subsurface layer. The relatively clay rich layer of flood deposit on the surface helps maintain adequate nutrient reserves.

Erosion potential — Low potential for both water and wind erosion.

Laboratory data

Depth Cm	pH H_2O	pH $CaCl_2$	CO_3 %	ECe dS/m	Cl mg/kg	S mg/kg	B mg/kg	Ext P mg/kg	Ext K mg/kg	Org C %	Exchangeable cations - cmol(+)/kg Ca	Mg	Na	K	#CEC	#ESP
Target →	< 9.2	>5.0	na	< 2.0	< 350	10	< 3	80	200	> 1.0	% of (Ca+Mg+Na+K) 65-75	10-15	< 6	3-8	> 5	< 6
0-12	7.9	7.3	0	*3.3	-	258	1.7	11	407	1.71	11.64	3.39	1.09	1.03	17.2	6.4
12-27	8.1	7.1	0	*1.3	-	34.4	1.0	3	248	0.85	6.23	2.69	0.81	0.58	10.3	7.9
27-60	7.2	6.2	0	*0.5	-	10.1	0.5	3	136	0.21	1.95	1.26	0.34	0.36	3.9	8.7
60-100	7.9	7.0	0	*0.9	-	43.8	1.1	3	347	0.27	5.51	4.96	1.35	0.85	12.7	10.7
100-140	8.1	7.1	0	*1.0	-	53.4	1.2	3	291	0.16	4.43	3.91	1.39	0.74	10.5	13.3
140-170	8.0	7.1	0	*1.4	-	68.2	1.0	3	260	0.15	3.50	3.14	1.30	0.62	8.6	15.2

* ECe estimated from $EC_{1:5}$ # CEC estimated from sum (Ca+Mg+Na+K). # ESP estimated by = Na / (Ca+Mg+Na+K)

Explanation of highlighted data

ECe greater than 2.5 can cause yield loss in grape vines. Marginally high value here is due to surface concentration of salt from irrigation water.
Exchangeable sodium less than 6% of total of all four cations is desirable.
High surface sulphur and calcium concentrations indicates that gypsum has been applied.
Alkaline pH at surface above a neutral bleached subsurface layer indicates lime application.

Management of Soil 12

Sandy loam over poorly structured clay

by Rod Karger

Problems

Drainage and root growth are restricted in the sodic, hard, medium-clay layer at 60 to 100cm. Irrigation salts (including sodium) can build up above this layer. The increasing sodium can replace calcium and other cations from clay particles causing them to disperse. The dispersing clay particles can move into and block soil pores to further decrease drainage.

The Laboratory data shows that some gypsum has already been added to this soil. This has improved the infiltration of water to below 12cm.

Before irrigation, this soil was acid (pH below 7) at all depths. The acidity was not tackled before planting. The soil has become sodic at all depths because sodium from the irrigation water has replaced hydrogen from the clay particles.

Having lost hydrogen, the soil now has a high pH (above 7) and this will restrict the availability of nutrients.

Ripping in gypsum and lime down to 100cm will improve drainage and increase the depth of roots but, if drainage water cannot escape, salts will accumulate and the soil will become saline.

Pre-planting action that can be used to tackle the problems

When the clay below 60cm is dry enough to break up when it is ripped (e.g. during late summer), rip along each intended planting row to 1m deep using 2 rippers spaced 1m apart. Fit a former onto each ripper to leave open a “V” slot down to 0.5m deep. Into each metre length of each slot, apply a mixture of 1kg of Ag-lime (not dolomitic lime) plus 1kg of gypsum. This can be done with one pass of a belt spreader used without its spinner. Remove the “V” formers and re-rip along the rip lines to help to distribute and incorporate the gypsum and lime down through the soil profile. Use a disc cultivator to re-level the topsoil and leave a mound along each row to compensate for future settling. To improve topsoil fertility, broadcast additional gypsum at 5t/ha plus a special fertiliser mix containing nitrogen 50kg/ha, phosphorus 100kg/ha and insurance amounts of copper 4kg/ha, zinc 8kg/ha and manganese 30kg/ha. Use a rotary-hoe or discs to incorporate the broadcast gypsum and fertiliser down to only 20cm deep.

Soil management after planting

To improve the soil structure and to increase the levels of organic carbon, establish a mid-row permanent pasture or sow cereal cover crops.

At mid-flowering of the pasture or cover crop, slash it and throw it under the vines.

One application of urea at 125kg/ha in early spring will increase the amount of dry matter in the cover crop.

Use annual soil and petiole testing to determine appropriate fertiliser applications.

Management of Soil 12
Sandy loam over poorly structured clay
by John Rasic

Problems
Water and toxins can accumulate above the sealing prismatic clay (at 60cm in this soil photo). The limitations of this soil are significant due to the large thickness of the unstable, bleached layer and due to the mottled clay below it.

When the soil that is below the bleached sand is wetted, the cracks close in the prismatic clay (at 60cm) and water moves extremely slowly.

Even when the top layer is saturated, the sandy soil at only 27cm can remain dry.

When it is saturated, sand is unstable and it can collapse (slake), become a slurry and flow down through the profile. This slurry can block pores and then, when it dries, the slurry can become a sandy, impenetrable cap (capping) at 27cm.

Toxins, including sodium and other salts, can accumulate above the cap.

Pre-planting action that can be used to tackle the problems
Using at least two passes, mechanically mix the layers to 80cm to eliminate the sharp change (at 60cm) from sand into clay and make uniform the texture, structure, nutrient status and water holding capacity.

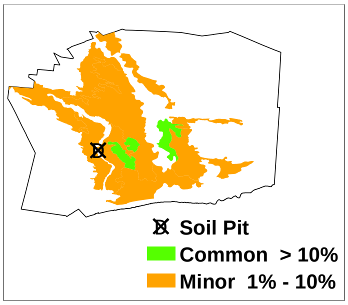
During mixing, incorporate slow-release fertilisers into the soil to address the low nutrient holding capacity of the bleached sand.

Soil management after planting
Even after mixing, this soil will slake and cap. Reduce this risk by avoiding rapid wetting and by establishing a fast-growing cover crop to increase soil organic matter.

Apply fertiliser to stimulate growth of the cover crop. Allow the cover crop to establish by excluding vehicle traffic and grazing animals.

Design and manage the irrigation system to achieve slow wetting and do not saturate the soil in order to avoid waterlogging that is caused by slaking and sealing of the soil pores.

Soil 13 Loamy sand over red sandy clay loam



Landscape Bremer River flood plain formed on clayey alluvium. Surface is soft and stone free.

Profile Thick brown loamy sand over a red and brown sandy clay loam, calcareous with depth, overlying a buried subsoil.

Depth (cm)	*Description*
0-20	Brown soft single grain loamy sand. Gradual to:
20-32	Light brown (bleached when dry) soft single grain light loamy sand. Abrupt to:
32-45	Yellowish red friable sandy clay loam with weak subangular blocky structure. Clear to:
45-80	Brown friable highly calcareous clay loam with moderate polyhedral structure and 10-20% soft carbonate segregations. Gradual to:
80-115	Dark yellowish brown and dark brown mottled friable slightly calcareous strongly structured light medium clay. Diffuse to:
115-150	Brown and dark yellowish brown mottled firm medium clay with strong polyhedral structure and 2-10% carbonate fragments.

Key properties

<u>Drainage</u> Well drained. The profile rarely remains wet for more than a day or so. Deep drainage is impeded to some extent by the clay from 80 cm.

<u>Potential root zone</u> Root growth is strong to 45 cm, and moderate to 115 cm. Few roots occur below this depth in the sampling pit.

<u>Barriers to root growth</u>

<u>Physical</u>: There are no significant physical barriers.

<u>Chemical</u>: Elevated salinity, sodicity and boron concentrations from 80 cm restrict root growth.

<u>Water holding capacity</u> : Estimated for the depth of the potential root zone of grapevines

Total available: 130 mm
Readily available: 70 mm

<u>Fertility</u> Inherent fertility is low due to the low clay content of the surface soil. Test results indicate low phosphorus, potassium and sulphur levels.

<u>Erosion potential</u> Some potential for wind erosion due to sandy surface. Water erosion potential is low, except in severe flood events.

Laboratory data

Depth	pH	pH	CO_3	ECe	Cl	S	B	Ext P	Ext K	Org C	Exchangeable cations - cmol(+)/kg					#ESP
Cm	H_2O	$CaCl_2$	%	dS/m	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	Ca	Mg	Na	K	#CEC	
Target →	< 9.2	>5.0	na	< 2.0	< 350	10	< 3	80	200	> 1.0	% of (Ca+Mg+Na+K)				> 5	< 6
											65-75	10-15	< 6	3-8		
0-20	7.0	6.5	0	0.40	7	3.2	0.7	24	127	0.60	3.53	0.47	0.25	0.33	4.6	5.5
20-32	7.9	7.0	0	0.53	11	3.9	0.4	6	51	0.16	1.61	0.49	0.27	0.13	2.5	na
32-45	7.8	7.1	0	0.88	23	5.1	1.6	11	175	0.24	4.48	7.59	1.51	0.46	14.0	10.8
45-80	8.8	7.9	6.2	1.36	34	58.9	3.9	5	391	0.24	9.36	8.49	0.96	1.04	19.9	4.8
80-115	8.7	8.0	6.1	6.18	508	318	6.0	2	585	0.21	7.26	13.1	5.70	1.56	27.6	20.7
115-150	9.2	8.3	3.2	3.82	397	91.8	7.8	2	558	0.16	5.97	12.6	7.57	1.57	27.7	27.3

CEC estimated from sum (Ca+Mg+Na+K). # ESP is estimated by = Na / (Ca+Mg+Na+K)

Explanation of highlighted data

Grape vines can suffer 10% yield loss when ECe exceeds 2.5 dS/m, or chloride exceeds 350 mg/kg.
Exchangeable sodium less than 6% of total of all four cations is desirable.
Boron concentrations exceeding 3 mg/kg may be a problem for grape vines (American literature).
Levels of phosphorus, potassium and sulphur are marginal. Sum of exchangeable cations of less than 5 cmol(+)/kg is indicator of low inherent fertility.

Notes:

Management of Soil 13

Loamy sand over red sandy clay loam

by John Rasic

Problems

The abrupt change (at 32cm on the tape) from the sandy surface layer into the weakly structured clay loam causes a decrease in the speed of water movement (permeability) and an increase in wetness. Heavy machinery and smearing of the soil by implements, and particularly by spinning tractor wheels, can seal the network of soil pores to reduce drainage and cause collapse of the soil above 32cm.

Pre-planting action that can be used to tackle the problems

Eliminate the abrupt boundary at 32cm and prevent it from re-forming by ripping the contrasting layers and mixing them to a depth of 40 cm in order to increase uniformity, drainage and aeration. Trenching or slotting all the way through the mottled horizons (to 100cm) can permanently improve deep drainage and the leaching of salts and toxins.

Soil management after planting

Establish a drought resistant mid-row cover crop to hold the soil particles together and to increase the porosity of the subsoil (below 32cm).

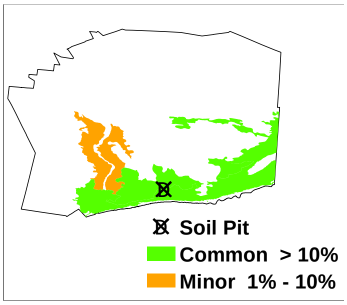
Apply fertiliser to achieve quicker and better growth of the cover crop. The cover crop can provide the much needed increase in soil organic matter. Organic matter helps to prevent slaking, capping and the formation of pans and it reduces compaction because it causes compressed soil to spring back (the rebound effect).

To minimise compaction and to allow the cover crop to establish, minimise vehicle traffic and the grazing of animals.

Avoid damage to the structure of this soil by continuously monitoring each of moisture, fertility, disease and fungus. Adjust individual irrigation valve times to match local water needs and control diseases and weeds. When soils that are heavier than sandy loam become too wet, their load-bearing capacity decreases causing compaction, slaking, puddling and smearing to become more likely. Compaction is most likely on a sandy loam or on a sand (Cass & Maschmedt 1998).

Design and manage the irrigation system to wet the soil only slowly. Do not saturate the soil. This will avoid the waterlogging that is caused by slaking and sealing of the soil pores and it will minimise re-compaction.

Soil 14 Black clay



Landscape: Low lying flats of the lower reaches of the Bremer River. Surface is hard, stone free and cracks when dry.

Profile: Well structured black seasonally cracking clay, becoming browner, mottled and less well structured with depth, over buried soils and river alluvium.

Depth (cm)	*Description*
0-10	Black firm light medium clay with moderate granular structure. Clear to:
10-25	Black firm light medium clay with strong fine structure. Gradual to:
25-55	Very dark grey firm medium clay with strong coarse structure. Gradual to:
55-80	Brown firm weakly structured fine sandy light clay. Diffuse to:
80-105	Dark brown, yellow and red mottled firm weakly structured light clay. Gradual to:
105-125	Brown and strong brown mottled firm medium clay with strong polyhedral structure and 10-20% soft carbonate segregations. Clear to:
125-160	Brown, yellowish brown and red mottled friable massive light sandy clay loam (old river alluvium).

Key properties

Drainage — Moderately well to imperfectly drained. The subsoil is may remain wet for a week or two following heavy or prolonged rainfall. Deep drainage is assisted by the relatively sandy material from 125 cm.

Potential root zone — Strong root growth to 55 cm, with a few roots extending to 105 cm.

Barriers to root growth

Physical: The clayey texture restricts even root distribution to some extent, but not considered significant.

Chemical: Marginally high salinity and sodicity from 55 cm may have some impact on root growth. High chloride from 105 cm is likely to have a greater effect.

Water holding capacity : Estimated for the depth of the potential root zone of grapevines

Total available: 110 mm
Readily available: 55 mm

Fertility — Inherent fertility is high, as indicated by the exchangeable cation data. Moderate to high clay content throughout ensures ample nutrient retention capacity. Apart from a possible zinc deficiency (common on black clays), the profile at the sampling site is well supplied with nutrient elements.

Erosion potential — Low potential for both wind and water erosion.

Laboratory data

Depth Cm	pH H_2O	pH $CaCl_2$	CO_3 %	ECe dS/m	Cl mg/kg	S mg/kg	B mg/kg	Ext P mg/kg	Ext K mg/kg	Org C %	Exchangeable cations - cmol(+)/kg Ca	Mg	Na	K	#CEC	#ESP
Target →	< 9.2	>5.0	na	< 2.0	< 350	10	< 3	80	200	> 1.0	% of (Ca+Mg+Na+K) 65-75	10-15	< 6	3-8	> 5	< 6
0-10	7.2	6.9	0	2.18	21	108	1.3	74	633	3.00	21.7	6.55	0.71	1.65	30.6	2.3
10-25	7.2	6.6	0	2.09	41	103	1.2	8	316	2.02	18.1	9.82	1.19	0.87	30.0	4.0
25-55	7.4	6.9	0	3.31	125	189	1.3	4	219	0.92	15.4	14.9	2.72	0.70	33.7	8.1
55-80	7.5	7.1	0	4.82	224	188	0.9	4	178	0.39	8.55	10.9	2.67	0.52	22.6	11.8
80-105	7.6	7.1	0	5.20	343	192	0.8	4	172	0.21	7.06	8.75	2.96	0.48	19.3	15.4
105-125	8.2	7.7	3.0	5.01	678	162	1.1	2	238	0.28	15.3	11.4	4.74	0.73	32.2	14.7
125-160	7.7	7.4	0.5	5.42	617	56.6	0.8	2	139	0.16	6.44	7.80	2.71	0.40	17.4	15.6

CEC estimated from sum (Ca+Mg+Na+K). # ESP is estimated by = Na / (Ca+Mg+Na+K)

Explanation of highlighted data

Grape vines can suffer 10% yield loss when ECe exceeds 2.5 dS/m, or chloride exceeds 350 mg/kg.
Exchangeable sodium less than 6% of total of all four cations is desirable.

Notes:

Management of Soil 14
Black clay
by John Rasic

Problems
Plants in this soil quickly become water stressed during hot, dry weather. When it dries, this soil becomes hard and brittle and it cracks at the surface. The cracks break the surface roots and they increase moisture loss. The reduced root volume and the loss of soil moisture cause rapid plant water stress.

With irrigation it is easy to apply water but, because the broken roots take time to re-grow, plants in this soil can suffer water stress even very soon after an irrigation.

The soil is soft, plastic, sticky and anaerobic. It has a low weight-carrying capacity and it is often impassable when wet.

Within soil depressions, high levels of salts (including sodium) and of other toxins may have accumulated and these can reduce plant growth.

Close to the river, if this soil becomes saturated by lateral flow of water from the river, the grapevines grow vigorously and they yield grapes that often produce low quality wine.

Pre-planting action that can be used to tackle the problems
Along each plant row, build a mound using only the fertile soil from the surface layer (top 25cm).

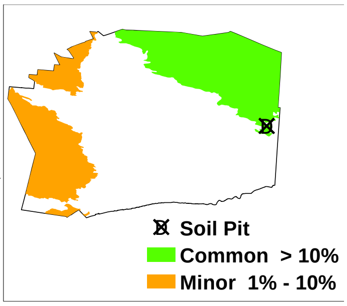
Ripping is not needed if the trellis posts are installed when the soil is moist, soft and friable.

Soil management after planting
To prevent the cracking that breaks roots and causes a loss of moisture from the deeper layers, apply mulches, including using clay as a mulch, and apply small and frequent irrigation applications to keep this soil permanently moist but not saturated.

The capacity of this soil to hold water is high but only a small fraction of the water can easily be extracted by plants. The plants can experience water stress even when the soil appears moist.

Use soil moisture monitoring equipment to measure and decide the amount of water needed at each irrigation and the time between irrigations. Irrigate with small volumes applied at short intervals and applied slowly, using low-discharge drippers at close spacings.

Soil 15 Shallow loamy sand over calcrete



Landscape: Gently undulating rises of the "mallee" component of the Langhorne Creek Region, formed on highly calcareous windblown deposits capped by calcrete. Surface soil is soft with up to 10% calcrete stones.

Profile: Up to 50 cm soft reddish loamy sand with variable rubble content, over rubbly to sheet calcrete.

Depth (cm)	*Description*
0-10	Light brown loose sand. Sharp to:
10-25	Reddish brown soft light loamy sand. Clear to:
25-40	Dark reddish brown soft loamy sand with 10-20% calcrete fragments. Depth varies from 40-50 cm. Clear to:
40-60	Rubbly calcrete. Gradual to:
60-80	Reddish yellow very highly calcareous clayey sand, cemented into a semi-hard calcrete pan. Gradual to:
80-130	Reddish yellow massive very highly calcareous light sandy clay loam with calcrete fragments. Diffuse to:
130-180	Brown and red mottled firm blocky heavy clay (Blanchetown Clay equivalent) with minor fine carbonate.

Key properties

Drainage — Well drained. Soil rarely stays wet for more than a day. Deep drainage is impeded by the clayey substrate.

Potential root zone — 130 cm in pit, but few roots below 80 cm.

Barriers to root growth

Physical: Calcrete is a variable barrier, depending on degree of cementation. Rubbly forms (as at this site) are only slightly limiting.

Chemical: There are no chemical barriers above the deep substrate clay (Blanchetown Clay equivalent) at 130 cm. However, root growth in the high carbonate layers diminishes as the rubble content decreases between 60 and 130 cm.

Water holding capacity : Estimated for the depth of the potential root zone of grapevines

Total available: 65 mm
Readily available: 40 mm

Fertility — Nutrient retention capacity is moderately low in the surface soil. The original surface loamy sand (10-40 cm), and the sandy top-dressing both have limited nutrient retention capacities.

Erosion potential — Potential for water erosion is low, and moderately low for wind erosion.

Laboratory data

Depth Cm	pH H_2O	pH $CaCl_2$	CO_3 %	ECe dS/m	Cl mg/kg	S mg/kg	B mg/kg	Ext P mg/kg	Ext K mg/kg	Org C %	Exchangeable cations - cmol(+)/kg Ca	Mg	Na	K	#CEC	#ESP
Target →	< 9.2	>5.0	na	< 2.0	< 350	10	< 3	80	200	> 1.0	% of (Ca+Mg+Na+K) 65-75	10-15	< 6	3-8	> 5	< 6
0-10	8.7	7.9	1.8	1.49	62	5.1	0.5	18	123	0.14	3.17	0.66	0.36	0.35	4.5	7.9
10-25	8.7	7.9	0.9	1.40	53	7.2	0.8	33	199	0.60	6.73	0.93	0.53	0.52	8.7	6.1
25-40	8.7	7.9	0.8	1.14	59	7.8	1.1	14	272	0.68	9.48	1.09	0.49	0.70	11.8	4.2
40-60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60-80	9.1	8.1	73.8	2.19	106	14.5	2.4	2	210	0.32	11.9	2.95	1.05	0.55	16.4	6.4
80-130	9.1	8.2	68.8	1.65	79	15.5	2.2	2	259	0.22	10.2	3.53	1.16	0.63	15.5	7.5
130-180	9.4	8.5	1.2	1.30	71	19.5	9.4	7	624	<0.05	5.69	8.85	5.22	1.60	21.4	24.4

CEC estimated from sum (Ca+Mg+Na+K). # ESP is estimated by = Na / (Ca+Mg+Na+K)

Explanation of highlighted data

Exchangeable sodium less than 6% of total of all four cations is desirable.
Root growth good in high carbonate layers where rubble content is high and clay content low (60-80 cm). Weaker root growth in 80-130 cm layer where content of clay is higher and rubble is lower.
Root growth generally poor where pH in water exceeds 9.2.
Boron concentrations exceeding 3 mg/kg may be a problem for grape vines (American literature).
Sum of exchangeable cations in surface of less than 5 cmol(+)/kg is indicator of low fertility – due to “imported” sand applied to reduce surface pH.

Notes:

Management of Soil 15
Shallow loamy sand over calcrete
by John Rasic

Problems
Expect low crop yields and high maintenance costs. Plants growing in this soil are likely to display symptoms called "lime-induced chlorosis" because high pH restricts the availability of elements that are vital for healthy plant growth. A pH in water that is above 8.5 is high. The high pH is caused by the large number of powder-sized particles of calcium carbonate. These are called "active carbonate" or "free lime".

In addition the heavy clay below 130cm will restrict deep drainage. If this soil is irrigated, its inadequate leaching capacity will cause existing plus additional salts and toxins to accumulate and reduce plant growth.

Pre-planting action that can be used to tackle the problems
Carbonates can be removed by applying acidifying materials but this is generally too expensive to be cost effective.
If carbonate has been removed from the top 30 to 40 cm of soil, the treated soil can be mounded to increase the depth of soil that is free from carbonate. Top dressing with non calcareous soil is an option if there is suitable soil nearby which can be safely removed and economically transported.

Mounding can be used to increase the depth of the root zone above the calcrete, particularly where the calcrete is shallower than 30cm.

In order to avoid adding more carbonate to the already carbonate-rich surface layer, soil mixing should be avoided.

Mechanical mixing of the soil layers is not needed because there are no physical limitations within the top 100 cm depth.

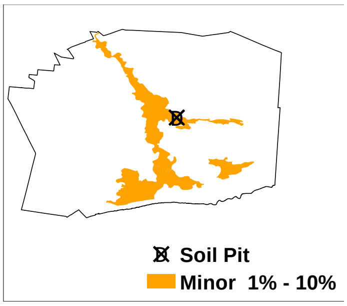
Ripping may be needed to break intermittent pans of calcrete

For easier trellising and planting, this soil can be ripped and the surface cultivated.

Soil management after planting
Use the irrigation system to inject frequent, precise amounts of fertilisers that provide those elements that are not available from the soil. This is likely to require large quantities of expensive fertiliser.

Manage the irrigation system to avoid over-watering because the drainage water can cause the re-introduction of carbonate in water that is wicked upwards from deeper carbonate-rich layers.

Soil 16 Brown clay



Landscape: Old alluvial flats and plains of the Bremer and Angas Rivers. Surface soil is hard setting and stone free.

Profile: Dark brown to black clay, becoming brown and grey mottled and weakly calcareous with depth. These soils may be less than a metre deep overlying older soils or sediments.

Depth (cm)	*Description*
0-12	Very dark grey brown light medium clay with strong granular structure. Clear to:
12-27	Black medium clay with strong polyhedral structure. Clear to:
27-40	Dark yellow brown and dark grey brown mottled well structured heavy clay. Gradual to:
40-65	Dark brown and brown mottled well structured heavy clay. Gradual to:
65-115	Brown, dark brown and red mottled well structured calcareous heavy clay. Gradual to:
115-180	(Older, unrelated sediment) Yellow, brown and orange mottled hard sandy clay with weak coarse prismatic structure.

Key properties

Drainage — Moderately well to imperfectly drained. Parts of the profile may remain wet for a week to several weeks, due to high clay content. Deep drainage is somewhat impeded by clayey substrate.

Potential root zone — 115 cm in the pit, mostly concentrated in the upper 40 cm.

Barriers to root growth

Physical: The high strength of the clay may restrict growth in some rootstocks.

Chemical: There are no apparent chemical barriers to root growth, although low quality irrigation water will cause salts and exchangeable sodium to accumulate over time. Sodicity and salinity levels are marginally high in deep subsoil.

Water holding capacity (Estimates for potential root zone of grape vines – 115 cm)

Total available: 105 mm
Readily available: 50 mm

Fertility — Inherent fertility of the soil is high, as indicated by the exchangeable cation data.

Erosion potential — Low potential for both water and wind erosion.

Laboratory data

Depth cm	pH H_2O	pH $CaCl_2$	CO_3 %	ECe dS/m	Cl mg/kg	S mg/kg	B mg/kg	Ext P mg/kg	Ext K mg/kg	Org C %	Exchangeable cations - cmol(+)/kg					ESP
											Ca	Mg	Na	K	CEC	
Target →	< 9.2	>5.0	na	< 2.0	< 350	10	< 3	80	200	> 1.0	% of (Ca+Mg+Na+K)				> 5	< 6
											65-75	10-15	< 6	3-8		
0-12	7.5	7.1	0.1	1.31	-	-	2.9	50	758	3.0	18.4	7.02	1.41	1.72	26.6	5.3
12-27	7.7	7.0	0	0.78	-	-	2.3	15	422	2.2	16.0	5.78	1.46	0.78	21.0	7.0
27-40	7.8	7.0	0	0.90	-	-	2.1	5	333	0.7	13.1	6.67	2.09	0.69	22.9	9.1
40-65	7.9	7.2	0	0.94	-	-	2.6	5	382	0.5	14.0	8.25	2.65	0.83	26.0	10.2
65-115	8.4	8.0	3.8	1.75	-	-	2.3	<4	346	0.1	10.6	6.50	2.27	0.66	17.7	12.8
115-180	8.5	8.0	1.6	3.17	-	-	2.1	<4	266	0.1	7.26	4.89	1.95	0.52	12.1	16.1

Explanation of highlighted data

Grape vines can suffer 10% yield loss when ECe exceeds 2.5 dS/m, or chloride exceeds 350 mg/kg. Flushing to remove deep subsoil salts is unlikely to work due to low permeability of the substrate. Careful irrigation practices are required.
Exchangeable sodium less than 6% of CEC is desirable.
Apply gypsum to increase the low ratio of Ca to Mg.

Notes:

Management of Soil 16
Brown clay
by John Rasic

Problems
Without leaching, salts will accumulate in this soil causing it to become saline and sodic. Leaching will be prevented by the prismatic clay below 115cm.

Pre-planting action that can be used to tackle the problems
Mechanical mixing of the soil layers is not needed because there are no physical limitations within the top 100 cm depth.

For easier trellising and planting, this soil can be ripped and the surface cultivated.

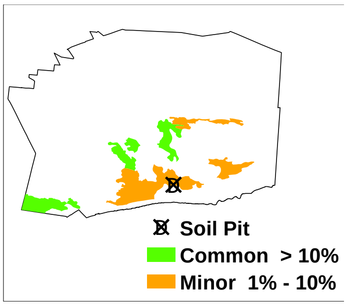
Soil management after planting
This soil resists compaction and it can accommodate regular cultivation because it self-repairs when it shrinks and swells at all depths down to 115cm.

Manage the closing and sealing of the prismatic clay below 115cm by establishing a deep-rooting cover crop combined with applications of gypsum in liquid form. Use soil tests to determine the application dates and the amounts of gypsum to apply.

The soil's water holding capacity is high but only a small fraction of this water can be extracted easily by plants. The plants can be affected by water stress even when the soil appears moist.

The surface soil can quickly change between saturated to cracking. To ensure that the moisture content in the soil below 115cm will change only slowly, keep this soil moist but not saturated by applying small irrigations at short time intervals.

Soil 17 Sandy clay loam over dark heavy clay



Landscape: Old alluvial plains of the lower reaches of the Bremer River. Surface soil is hard, seasonally cracking and stone free.

Profile: Hard sandy clay loam with a bleached subsurface layer over a black to brown dispersive heavy clay, calcareous with depth.

Depth (cm)	*Description*
0-17	Dark greyish brown hard light fine sandy clay loam with weak granular structure and minor gypsum. Clear to:
17-24	Bleached hard massive fine sandy clay loam with minor gypsum. Abrupt to:
24-55	Dark grey brown and yellowish brown mottled coarsely prismatic hard medium heavy clay. Clear to:
55-85	Dark yellowish brown and brown mottled hard blocky moderately calcareous medium heavy clay. Gradual to:
85-130	Yellowish brown and yellowish red mottled very hard slightly calcareous heavy clay with lenticular structure. Gradual to:
130-160	Red, brown and grey mottled hard blocky medium clay.

Key properties

Drainage — Imperfectly drained. The subsoil perches water for periods of up to several weeks following heavy or prolonged rainfall during winter. Deep drainage is also impeded by the heavy clay substrate.

Potential root zone — 130 cm in pit, but few roots below 85 cm.

Barriers to root growth

Physical: The heavy clay subsoil restricts even root distribution. Effective root zone depth is 85 cm.

Chemical: Marginally high salinity and sodicity from 55 cm may have some impact on root growth. Sodicity and slight boron toxicity from 85 cm are likely to have a greater effect.

Water holding capacity : Estimated for the depth of the potential root zone of grapevines

Total available:	115 mm
Readily available:	50 mm

Fertility — Nutrient retention capacity is moderately high. Moderate to high clay content throughout ensures ample nutrient retention capacity.

Erosion potential — Low potential for both water and wind erosion.

Laboratory data

Depth cm	pH H_2O	pH $CaCl_2$	CO_3 %	ECe dS/m	Cl mg/kg	S mg/kg	B mg/kg	Ext P mg/kg	Ext K mg/kg	Org C %	Exchangeable cations - cmol(+)/kg					#ESP
											Ca	Mg	Na	K	#CEC	
Target →	< 9.2	>5.0	na	< 2.0	< 350	10	< 3	80	200	> 1.0	% of (Ca+Mg+Na+K)				> 5	< 6
											65-75	10-15	< 6	3-8		
0-17	8.1	7.6	0	2.35	103	69.6	1.5	84	531	1.81	11.7	1.96	0.44	1.32	15.4	2.9
17-24	7.9	7.6	0	2.34	31	106	1.0	6	278	0.81	8.51	2.27	0.41	0.65	11.8	3.5
24-55	7.6	7.0	0	2.06	36	137	1.5	4	431	0.36	12.1	6.37	1.00	1.09	20.6	4.9
55-85	8.6	8.0	4.8	2.63	85	177	1.7	2	476	0.15	10.0	7.26	1.82	1.13	20.2	9.0
85-130	8.8	8.1	1.8	2.67	167	183	3.1	2	537	0.07	8.17	9.60	3.59	1.38	22.7	15.8
130-160	8.9	8.1	0.5	2.96	250	93.0	3.4	5	483	0.06	5.37	7.98	3.36	1.21	17.9	18.8

CEC estimated from sum (Ca+Mg+Na+K). # ESP is estimated by = Na / (Ca+Mg+Na+K)

Explanation of highlighted data

Grape vines can suffer 10% yield loss when ECe exceeds 2.5 dS/m, or chloride exceeds 350 mg/kg.
Exchangeable sodium less than 6% of total of all four cations is desirable.
Boron concentrations exceeding 3 mg/kg may be a problem for grape vines (American literature).
Slightly elevated surface pH probably due to road dust.

Notes:

Management of Soil 17

Sandy clay loam over dark heavy clay

by John Rasic

Problems

Water, salts and toxins can accumulate above the clay layer at 24cm because the distinct boundary between the open (permeable) surface layer and the mottled clay subsoil marks an increase in density, a decrease in pore-size and a decrease in the speed of water movement.

Any smearing caused by implements or by spinning tractor wheels is particularly damaging because it seals the network of connecting soil pores. Any seal prevents drainage and this may cause the saturation and collapse of overlying soil into a slurry that can then dry to form a hard, sealed pan that further restricts the penetration of roots and of water.

Pre-planting action that can be used to tackle the problems

Eliminate the distinct boundary at 24cm and permanently increase the uniformity down to 55cm by mechanical mixing of the soil layers and incorporating gypsum.

Soil management after planting

Grow a mid-row cover crop to increase the organic matter in the soil. Organic matter reduces the risk that the sand will become a slurry when it is saturated (slaking) and it can reduce compaction because it causes compressed soil to spring back (the rebound effect).

Reduce compaction and allow the cover crop to establish by minimising vehicle traffic and excluding grazing animals.

After the cover crop has become established, the rooting depth can be increased by mounding the root-filled layer of soil.

Control the depth of soil that is wetted at each irrigation by using equipment that frequently records soil moisture to decide how much irrigation water to apply and when to apply it.