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## Soil Amelioration of a Magnesian Soil

**Trial ID:** BB1908      **Location:** Norwin      **Trial Year:** 2019  
**Investigator:** Brendan Burton

Management of hard setting soils is a relatively common issue in the northern grains region. Hard setting soils can be caused by a range of factors including sodicity, low organic matter, higher clay content and where exchangeable magnesium is high. Issues noticed in field are poor infiltration of rainfall, soils become boggy very quickly and the surface becomes very hard as it dries out. Trial programs are challenging as the site needs to be managed for multiple seasons to evaluate real benefits. Application of gypsum is the most likely effective amelioration but a range of other potential treatments were included in this trial including shallow or deep phosphorus application.

<b>Objective:</b>	<b>To evaluate the effects of soil amelioration in a high magnesian soil</b>	
<b>Previous Crop:</b>	<b>Sorghum 2018</b>	
<b>Soil Characteristics:</b>	<b>0-10 cm depth</b> Ca:Mg 0.7:1 ~55% exchangeable magnesium ~4% exchangeable sodium	<b>10-30 cm depth</b> Ca:Mg 0.65:1 ~56% exchangeable magnesium ~4% exchangeable sodium
<b>Ameliorants:</b>	<b>Gypsum, compost, Granulock Z, MAP, DAP</b>	
<b>Application Date:</b>	<b>15/11/2019</b>	
<b>Crop &amp; Variety:</b>	<b>2020: Wheat cv Suntop - sprayed out ~6 weeks after planting</b> <b>2021: Barley cv Maximus</b> <b>2022: Fallow</b> <b>2023: Barley cv Laperouse</b>	
<b>Planting Dates:</b>	<b>2020: 6/08/2020</b> <b>2021: 8/06/2021</b> <b>2023: 31/05/2023</b>	
<b>Harvest Dates:</b>	<b>2021: 17/11/2021</b> <b>2023: 26/10/2023</b>	
<b>Planting Details:</b>	<b>Disc planter on 37.5 cm row spacing</b>	
<b>Trial Design:</b>	<b>Randomised complete block of 16 treatments x 4 replicates</b>	
<b>Plot Size:</b>	<b>2.5 m x 12 m</b>	
<b>Keywords:</b>	<b>Soil water, fallow</b>	

This trial was conducted at a site on the Darling Downs with a history of hard setting surface soil. Commercially, the grower restricted cropping options to species such as barley to ensure adequate crop emergence. The dispersive/ hard setting nature of the soil appeared more influenced by high magnesium levels rather than sodium at this site.

**Fertiliser analysis:** Granulock Z - N 11, P 21.8, S 4, Zn 1, MAP - N 10, P 21.9, DAP - N 17.7, P 20

**Nutrient Rates**

Product	Rate	Nutrient kg/ha			
		N	P	S	Zn
Granulock Z	100 kg/ha	11	22	4	1
MAP	100 kg/ha	10	22		
DAP	109 kg/ha	19	22		
Granulock Z	200 kg/ha	22	44	8	2

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### Fallow Efficiency Measurement

An EM38 was used to assess electrical conductivity and can provide a relative measure of differences in soil water between treatments. Advantages of the EM38 are portability, the ability to rapidly capture multiple measurements in each plot and the lack of subsequent sample handling and drying. The EM38 provides a measurement of conductivity in three soil depths; to 37.5cm, to 75cm and to 1.5m.

The major disadvantage is that unless an accurate soil characterisation is available for the site, the results only show relative differences between treatments rather than an absolute quantity of soil water.

### EM38 Readings 2020 and 2021

Assessment Date			5/05/2020		28/05/2021	
Treatment-Evaluation Interval			172 DAA		560 DAA	
Description			Shallow	Deep	Shallow	Deep
Assessment Depth			0 - 37.5 cm	0 - 1.5 m	0 - 37.5 cm	0 - 1.5 m
Assessment Unit			mS/m	mS/m	mS/m	mS/m
Assessment Area			4 samples/plot	4 samples/plot	4 samples/plot	4 samples/plot
Trt No.	Treatment	Product Rate				
1	Untreated	-	68a	136ab	105bcde	178-
2	Surface gypsum	5t/ha	69a	136ab	108abc	183-
3	Surface gypsum	10t/ha	70a	137a	112a	185-
4	Surface compost	10t/ha	63abcd	133abc	106abcde	178-
5	Deep ripping (25 cm)	-	58bcde	128cde	104cde	179-
6	Deep Granulock Z (25 cm)	100kg/ha	58bcde	129cde	101e	176-
7	Shallow Granulock Z (5 cm)	100kg/ha	65ab	134abc	106abcde	181-
8	Deep Granulock Z (25 cm)	200kg/ha	54e	126de	102de	174-
9	Surface gypsum	5t/ha	59bcde	130bcd	107abcd	180-
10	Deep Granulock Z (25 cm)	100kg/ha				
	Surface gypsum	5t/ha	56e	128cde	107abcd	179-
	Surface compost	10t/ha				
	Deep Granulock Z (25 cm)	100kg/ha				
11	Surface gypsum	10t/ha	60bcde	129cde	110ab	183-
	Deep Granulock Z (25 cm)	200kg/ha				
12	Surface gypsum	10t/ha	64abc	133abc	109abc	183-
	Surface compost	10t/ha				
	Deep Granulock Z (25 cm)	200kg/ha				
13	Deep MAP (25 cm)	100kg/ha	58cde	128cde	104cde	175-
14	Deep DAP (25 cm)	109kg/ha	56de	124e	104cde	176-
15	Deep Gypsum (25 cm)	10t/ha	65abc	133abc	108abcd	185-
16	Deep Compost (25 cm)	10t/ha	57cde	128cde	106abcde	180-
	LSD P=.05		7.4	6.2	5.9-6.2	nsd
	Treatment Prob.(F)=		0.0002	0.0011	0.0427	0.0864

Means followed by same letter or symbol (-) do not significantly differ (P=.05, LSD).

Mean comparisons performed only when AOV Treatment P (F) is significant at mean comparison OSL.

nsd – no significant difference

## Soil Amelioration of a Magnesian Soil

Trial ID: BB1908

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### EM38 Readings 2022 and 2023

Assessment Date			27/04/2022		22/06/2023	
Treatment-Evaluation Interval			894 DAA		1315 DAA	
Description			Shallow	Deep	Shallow	Deep
Assessment Depth			0 - 37.5 cm	0 - 1.5 m	0 - 37.5 cm	0 - 1.5 m
Assessment Unit			mS/m	mS/m	mS/m	mS/m
Assessment Area			4 samples/plot	4 samples/plot	4 samples/plot	4 samples/plot
Trt No.	Treatment	Product Rate				
1	Untreated	-	93bcde	185c-f	105cd	189-
2	Surface gypsum	5t/ha	98ab	192ab	106bc	190-
3	Surface gypsum	10t/ha	99a	195a	108ab	192-
4	Surface compost	10t/ha	93bcde	187b-f	104cd	187-
5	Deep ripping (25 cm)	-	93cde	186b-f	104cd	191-
6	Deep Granulock Z (25 cm)	100kg/ha	96abc	190a-d	104cd	189-
7	Shallow Granulock Z (5 cm)	100kg/ha	92cde	190a-e	105cd	190-
8	Deep Granulock Z (25 cm)	200kg/ha	91de	184ef	104cd	189-
9	Surface gypsum	5t/ha	96abc	192abc	104cd	190-
	Deep Granulock Z (25 cm)	100kg/ha				
10	Surface gypsum	5t/ha	92cde	189a-e	103d	187-
	Surface compost	10t/ha				
	Deep Granulock Z (25 cm)	100kg/ha				
11	Surface gypsum	10t/ha	96abc	190a-e	105cd	189-
	Deep Granulock Z (25 cm)	200kg/ha				
12	Surface gypsum	10t/ha	95abcd	192abc	105cd	189-
	Surface compost	10t/ha				
	Deep Granulock Z (25 cm)	200kg/ha				
13	Deep MAP (25 cm)	100kg/ha	90e	185def	104cd	189-
14	Deep DAP (25 cm)	109kg/ha	91de	183f	103d	187-
15	Deep Gypsum (25 cm)	10t/ha	99a	190a-e	109a	192-
16	Deep Compost (25 cm)	10t/ha	92cde	190a-e	103d	188-
	LSD P=.05		4.8	6.3	2.8	nsd
	Treatment Prob.(F)=		0.0024	0.0143	0.0024	0.3262

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## Soil Amelioration of a Magnesian Soil

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Location:

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Trial Year:

2019

**2021 Crop Performance**

Crop Name Crop Variety Assessment Date Treatment-Evaluation Interval Assessment Type Assessment Unit Assessment Area			Barley Maximus 17/11/2021 733 DAA				
Trt No.	Treatment	Product Rate	YIELD t/ha Plot	PROTEIN % 1 kg grain	TEST WEIGHT kg/hL 1 kg grain	SCREENING % 1 kg grain	RETENTION % 1 kg grain
1	Untreated	-	1.79-	12.5 d	62.5cd	2.8-	96.2c-f
2	Surface gypsum	5t/ha	1.81-	12.6 cd	62.4d	2.8-	98.5abc
3	Surface gypsum	10t/ha	1.84-	12.5 d	62.6bcd	3.0-	98.7a
4	Surface compost	10t/ha	1.46-	13.1 ab	62.8a-d	2.8-	97.6a-e
5	Deep ripping (25 cm)	-	1.55-	12.7 bcd	62.7bcd	2.7-	98.0a-d
6	Deep Granulock Z (25 cm)	100kg/ha	1.84-	12.8 a-d	62.4d	2.7-	97.8a-d
7	Shallow Granulock Z (5 cm)	100kg/ha	1.61-	12.7 bcd	62.2d	2.8-	96.3b-f
8	Deep Granulock Z (25 cm)	200kg/ha	1.51-	12.8 a-d	62.6bcd	2.6-	98.8a
9	Surface gypsum	5t/ha	1.73-	12.6 cd	62.6bcd	2.8-	97.4a-f
10	Deep Granulock Z (25 cm)	100kg/ha	1.62-	13.1 a	63.1abc	2.8-	96.0def
	Surface gypsum	5t/ha					
	Surface compost	10t/ha					
11	Deep Granulock Z (25 cm)	100kg/ha	1.73-	13.0 abc	63.5a	2.7-	97.2a-f
	Surface gypsum	10t/ha					
12	Deep Granulock Z (25 cm)	200kg/ha	1.45-	12.8 a-d	63.3ab	3.0-	98.3a-d
	Surface gypsum	10t/ha					
	Surface compost	10t/ha					
13	Deep Granulock Z (25 cm)	200kg/ha	1.64-	12.6 cd	62.3d	2.8-	95.3ef
	Deep MAP (25 cm)	100kg/ha					
14	Deep DAP (25 cm)	109kg/ha	1.69-	12.7 bcd	62.2d	2.9-	96.0def
15	Deep Gypsum (25 cm)	10t/ha	1.87-	12.5 d	62.8a-d	2.7-	98.6ab
16	Deep Compost (25 cm)	10t/ha	1.66-	13.1 a	63.1abc	2.8-	95.1f
LSD P=.05			nsd	0.41	0.71	nsd	2.42
Treatment Prob.(F)=			0.9593	0.0145	0.0155	0.9740	0.0215

Yield CV = 24.6%

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## Soil Amelioration of a Magnesian Soil

Trial ID: BB1908

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Trial Year: 2019

**2023 Crop Performance**

Crop Name Crop Variety Assessment Date Assessment Type Assessment Unit Assessment Area Treatment-Evaluation Interval			Barley Laperouse					
			19/06/2023 EMERGENCE /m <sup>2</sup> 4 m row 1312 DAA	26/10/2023 YIELD t/ha Plot 1441 DAA	26/10/2023 PROTEIN % 1 kg grain 1441 DAA	26/10/2023 TEST WEIGHT kg/hL 1 kg grain 1441 DAA	26/10/23 SCREENING % 1 kg grain 1441 DAA	26/10/23 RETENTION % 1 kg grain 1441 DAA
Trt No.	Treatment	Product Rate						
1	Untreated	-	73-	3.16-	12.1-	67.6-	1.3-	95.0-
2	Surface gypsum	5t/ha	69-	3.27-	12.1-	66.2-	1.4-	94.9-
3	Surface gypsum	10t/ha	66-	3.39-	11.5-	66.1-	1.4-	93.4-
4	Surface compost	10t/ha	71-	3.08-	12.2-	68.2-	1.0-	94.5-
5	Deep ripping (25 cm)	-	69-	3.27-	12.3-	66.2-	1.6-	93.0-
6	Deep Granulock Z (25 cm)	100kg/ha	67-	3.22-	12.7-	67.0-	1.3-	94.5-
7	Shallow Granulock Z (5 cm)	100kg/ha	66-	3.11-	12.1-	66.9-	1.6-	94.2-
8	Deep Granulock Z (25 cm)	200kg/ha	70-	3.10-	12.2-	67.8-	1.1-	95.7-
9	Surface gypsum Deep Granulock Z (25 cm)	5t/ha 100kg/ha	66-	3.28-	11.8-	66.5-	1.5-	94.2-
10	Surface gypsum Surface compost Deep Granulock Z (25 cm)	5t/ha 10t/ha 100kg/ha	64-	3.34-	12.5-	65.2-	2.0-	93.3-
11	Surface gypsum Deep Granulock Z (25 cm)	10t/ha 200kg/ha	69-	3.59-	12.3-	65.1-	2.3-	93.7-
12	Surface gypsum Surface compost Deep Granulock Z (25 cm)	10t/ha 10t/ha 200kg/ha	64-	3.40-	12.6-	66.2-	1.5-	94.3-
13	Deep MAP (25 cm)	100kg/ha	69-	3.25-	11.9-	67.9-	1.1-	94.8-
14	Deep DAP (25 cm)	109kg/ha	74-	3.24-	12.3-	67.4-	1.0-	95.7-
15	Deep Gypsum (25 cm)	10t/ha	67-	3.27-	12.2-	66.9-	1.1-	95.4-
16	Deep Compost (25 cm)	10t/ha	66-	3.25-	12.2-	67.3-	1.4-	93.8-
LSD P=.05			nsd	nsd	nsd	nsd	nsd	nsd
Treatment Prob(F)			0.9166	0.1402	0.0836	0.3289	0.2267	0.8436

Yield CV = 6.4%

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nsd – no significant difference

## Soil Amelioration of a Magnesian Soil

Trial ID: BB1908

Location:

Norwin

Trial Year: 2019

### Conclusions:

This trial was conducted near Norwin, on the Darling Downs in Southern Queensland. The site had a hard setting black Vertosol with a history of poor rainfall infiltration. Soil testing showed a very low Ca:Mg ratio of 0.7:1 at 0-10 cm and 0.65:1 at 10-30 cm. Ideally Ca:Mg ratios should be >3:1. Exchangeable Mg levels were ~55-56%. Exchangeable Na levels were ~4-6%. The protocol was designed to evaluate the impact of a range of amelioration practices on soil water accumulation (as assessed by EM38) and crop performance.

Treatments were applied in mid November 2019. Surface treatments were hand spread evenly over the plots. Sub surface applications were in 50 cm bands at either shallow (~5 cm) or deep (~25 cm) depths. Deep ripping alone was an additional check treatment.

An EM38 survey was conducted at 172 DAA (172 days after application). A total of ~320 mm of rainfall had been received since treatment application. 9 of the 11 treatments that included deep ripping had significantly lower conductance (~soil moisture) than the untreated at shallow depth (0-37.5 cm) and 8 of the 11 treatments lower conductance at deep depth (0-1.5 m). There was no significant difference in conductance between the untreated and any treatment with surface or shallow application alone. This data reinforces the long period of soil moisture recharge that may be required following deep ripping.

A late planting of Suntop wheat was attempted in early August 2020. The wheat was sprayed out after ~6 weeks with an intention to plant sorghum in summer 2020/21. Sorghum was not planted due to dry conditions during the 2020 spring.

A 2<sup>nd</sup> EM assessment was conducted at 560 DAA, in late May 2021. A total of ~490 mm of rain had been received after the 'groundcover' wheat crop was terminated. Treatment differences were only evident at the 0-37.5 cm depth with gypsum 10 t/ha surface applied having significantly higher conductance than the untreated.

The trial was planted to barley in early June 2021. The crop was lodging badly at harvest with disappointing and highly variable yields. There were no significant differences between treatments with the untreated only averaging ~1.8 t/ha.

The untreated had 12.5% protein, 62.5 kg/hL test weight and ~96% retention. Analysis showed 3 of 4 treatments that included compost 10 t/ha, significantly increased protein by ~0.5% compared to the untreated. Small benefits were measured in test weight (up to 1 kg/hL) and retention (up to 2%) but not at a level that impacted on receival quality.

A 3<sup>rd</sup> EM assessment was conducted at 894 DAA, in late April 2022. A total of 740 mm of rain had been received after the 2021 barley harvest. Both surface and deep gypsum 10 t/ha significantly increased conductance compared to the untreated at 0-37.5 cm. Surface gypsum at both 5 and 10 t/ha also had significantly increased conductance compared to the untreated at 0-1.5 m depth. No other treatment was significantly different to the untreated at either depth. No winter crop was planted in 2022 due to the paddock remaining too wet to plant.

A 4<sup>th</sup> EM assessment was conducted at 1315 DAA, in late June 2023. A total of ~1450 mm of rain had been received after the 2021 barley harvest. Both surface and deep gypsum 10 t/ha had significantly increased conductance compared to the untreated at 0-37.5 cm. No other treatment was significantly different to the untreated at either depth.

Barley cv. Laperouse was planted in late May 2023. There was no significant difference in emergence, yield or grain quality between treatments. The untreated averaged 3.16 t/ha with ~12% protein, ~68 kg/hL test weight and 95% retention. There was an apparent trend to a small yield increase in plots treated with gypsum with yields averaging 3.36 t/ha compared to 3.19 t/ha for all treatments without gypsum application.

At this site, only two crops were taken to harvest in the four years of evaluation. Although significant yield impacts due to soil amelioration were not achieved, there was a trend to ~5% yield increases in the 2023 crop in treatments that included gypsum. EM38 surveys indicated an increase in electrical conductance (~soil moisture), particularly from the gypsum 10 t/ha treatments either surface or deep applied. In both cases a significant increase in shallow soil moisture was measured in 3 of 4 surveys but only in 1 of 4 over the full 1.5 m depth. All treatments that provided a significant increase in soil moisture included gypsum.

Results at this site were disappointing. There were indications of soil moisture benefit from gypsum (particularly 10 t/ha) but no indication of any benefit from compost or deep ripping. Crop performance over the four years was poor with only a trend to improved yield (~5%) from gypsum application. There was no indication of any yield response to the compost or fertilisers applied.

## Soil Amelioration of a Magnesian Soil

Trial ID: **BB1908**

Location:

**Norwin**

Trial Year:

**2019****Assessment Type**

EM38 = Soil conductivity

**Assessment Unit**

mS/m = milli siemens per metre

DAA = Days after Application

**Soil tests**

	Depth (cm)	0-10	10-30
Colour		DKGR	DKGR
Gravel	%	0	0
Texture		3.5	3.5
Ammonium Nitrogen	mg/kg	4	2
Nitrate Nitrogen	mg/kg	18	8
Phosphorus Colwell	mg/kg	23	8
Potassium Colwell	mg/kg	362	230
Sulfur	mg/kg	94.2	57.8
Organic Carbon	%	1.38	0.97
Conductivity	dS/m	0.385	0.359
pH Level (CaCl <sub>2</sub> )		6.3	6.7
pH Level (H <sub>2</sub> O)		7.2	8.3
DTPA Copper	mg/kg	2.07	1.89
DTPA Iron	mg/kg	34.90	39.50
DTPA Manganese	mg/kg	25.36	8.58
DTPA Zinc	mg/kg	1.04	0.60
Exc. Aluminium	meq/100g	0.030	0.060
Exc. Calcium	meq/100g	21.54	21.64
Exc. Magnesium	meq/100g	29.97	33.45
Exc. Potassium	meq/100g	0.98	0.71
Exc. Sodium	meq/100g	2.19	3.78
Boron Hot CaCl <sub>2</sub>	mg/kg	1.98	3.39
BSES Phosphorus	mg/kg		9.45

### Crop Description

<b>Crop 1:</b>	<b>Barley cv Maximus</b>
<b>Planting Date:</b>	<b>8/06/2021</b>
<b>Row Spacing:</b>	<b>37.5 cm</b>
<b>Harvest Date:</b>	<b>17/11/2021</b>
<b>Harvest Equipment:</b>	<b>Small Plot Harvester</b>
<b>Harvested Width:</b>	<b>2 m</b>
<b>Harvested Length:</b>	<b>9 m</b>
<b>Crop 2:</b>	<b>Barley cv Laperouse</b>
<b>Planting Date:</b>	<b>31/05/2023</b>
<b>Row Spacing:</b>	<b>37.5 cm</b>
<b>Harvest Date:</b>	<b>26/10/2023</b>
<b>Harvest Equipment:</b>	<b>Small Plot Harvester</b>
<b>Harvested Width:</b>	<b>2 m</b>
<b>Harvested Length:</b>	<b>9 m</b>

## Soil Amelioration of a Magnesian Soil

Trial ID: BB1908

Location:

Norwin

Trial Year: 2019

**Monthly Rainfall:**

Weather Station Name:	SILO grid pt -27.50, 151.35
Distance:	~1 km

Date	Monthly Total	Unit	Comments
15/11/2019	-		Treatments applied
30/11/2019	0	mm	
31/12/2019	16	mm	
31/01/2020	135	mm	
29/02/2020	152	mm	
31/03/2020	15	mm	
30/04/2020	5	mm	
05/05/2020	-		EM38 survey
31/05/2020	19	mm	
30/06/2020	44	mm	
31/07/2020	43	mm	
06/08/2020	-		Wheat cv. Suntop cover crop planted; EM38 survey
31/08/2020	38	mm	
15/09/2020	-		Wheat sprayed out
30/09/2020	4	mm	
31/10/2020	61	mm	
30/11/2020	4	mm	
31/12/2020	73	mm	
31/01/2021	77	mm	
28/02/2021	18	mm	
31/03/2021	181	mm	
30/04/2021	21	mm	
28/05/2021	-		EM38 survey
31/05/2021	51	mm	
08/06/2021			Barley cv. Maximus planted
30/06/2021	61	mm	
31/07/2021	47	mm	
31/08/2021	12	mm	
30/09/2021	8	mm	
31/10/2021	61	mm	
17/11/2021	-		Barley harvested
30/11/2021	192	mm	
31/12/2021	125	mm	
31/01/2022	36	mm	
28/02/2022	199	mm	
31/03/2022	154	mm	
27/04/2022	-		EM38 survey
30/04/2022	34	mm	
31/05/2022	87	mm	
30/06/2022	27	mm	
22/07/2022	-		No winter crop due to paddock saturation
31/07/2022	41	mm	
31/08/2022	58	mm	
30/09/2022	73	mm	
31/10/2022	109	mm	
30/11/2022	43	mm	
15/12/2022	-		No summer crop due to paddock saturation
31/12/2022	62	mm	
25/01/2023	-		Paddock commercially cultivated
31/01/2023	18	mm	
28/02/2023	21	mm	
31/03/2023	100	mm	
30/04/2023	16	mm	
31/05/2023	56	mm	Barley cv. Laperouse planted
19/06/2023	-		Barley emergence count
22/06/2023	-		EM38 survey
30/06/2023	1	mm	
31/07/2023	11	mm	
31/08/2023	1	mm	
30/09/2023	1	mm	
26/10/2023	-		Barley harvested
31/10/2023	5	mm	