Project KW11/12-1of1 GRDC Project code: SDI00006 (combined with three other non-wetting trials)

Farmer knowledge on methods to address non-wetting soils

Comparing Mouldboard Ploughing with other Techniques to Manage Non Wetting Grey Sandy Soils West of Corrigin, 2012

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Introduction

Non wetting soils are a major constraint to crop establishment and crop yield in the Corrigin region. This project investigates techniques to manage non wetting soils to improve crop establishment and crop yield.

Background to the project.

Non wetting soils pose a significant challenge to growing crops in the Corrigin region. Crops grown on soils with poor wet-ability can result in poor seedling establishment, poor weed control and depressed crop yield. Corrigin Farm Improvement Group (CFIG) has placed a high priority on researching techniques to manage this constraint. In recent years, research and farmer practice in other regions of the wheatbelt has demonstrated potential to manage non wetting soils with a range of techniques including mouldboard ploughing, sowing with modified, winged knife points, and applying soil wetting agents such as the humectant product, H2O Lure.

Mouldboard ploughing can bury the non wetting top soil and bring wet-able sub soil to the surface. Ploughing also can also bury the weed seed bank at a depth (30-40cm), too deep to emerge. In 2011, Corrigin farmer Neville Turner mouldboard ploughed 50 hectares of non wetting soil and sowed the area to wheat. Despite the crop being sown late in the season the crop yielded 3.8 tonnes per hectare, his highest yielding crop that season. This result demonstrated the potential for mouldboard ploughing to improve production in this paddock west of Corrigin which had been constrained by a very non wetting grey sandy soil. The non wetting soil has also lead to a rise in the population of brome grass weeds in the paddock as a result of poor early season emergence and knockdown control.

H2O Lure is a humectant liquid which has been shown to increase moisture infiltration and moisture storage of soils, particularly, non wetting forest gravels.

Modified winged knife points have been shown to improve establishment on non wetting soils by changing the flow of soil in the furrow and guide the non wetting soil away from the seed bed and throw this soil free of the furrow.

Objectives

The trial was designed to investigate a range of techniques that may improve crop establishment and performance on non wetting sandy soils. The techniques tested included mouldboard ploughing, winged knife points, and H2O Lure. The trial also compared the second year affect of mouldboard ploughing to first year response..

Methodology

The 2012 trial was designed to suit sowing, spraying and harvesting with farm size equipment. The treatments were replicated (Table 1).
The 2012 mouldboard ploughing was completed on 20th of May following 25 mm of rain in early May. The trial site was sown to Bullock Barley on the 15th of June. The pre-emergent herbicide, Trifluralin, was applied at 2 litres per hectare prior to sowing. The barley was sown at 70 kg/ha and compound fertilizer at 70 kg/ha and Urea at 70 kg/ha was also applied in the seeding process.
The mouldboard ploughing was conducted by two different contractors for 2011 and 2012 operations respectively.
The winged points treatment was achieved by sowing with modified knifepoints with wings welded half way up the blade (Photo 1). The H2O Lure treatments were sprayed onto the soil surface prior to sowing.

Table 1. Trial Design – Turner Site

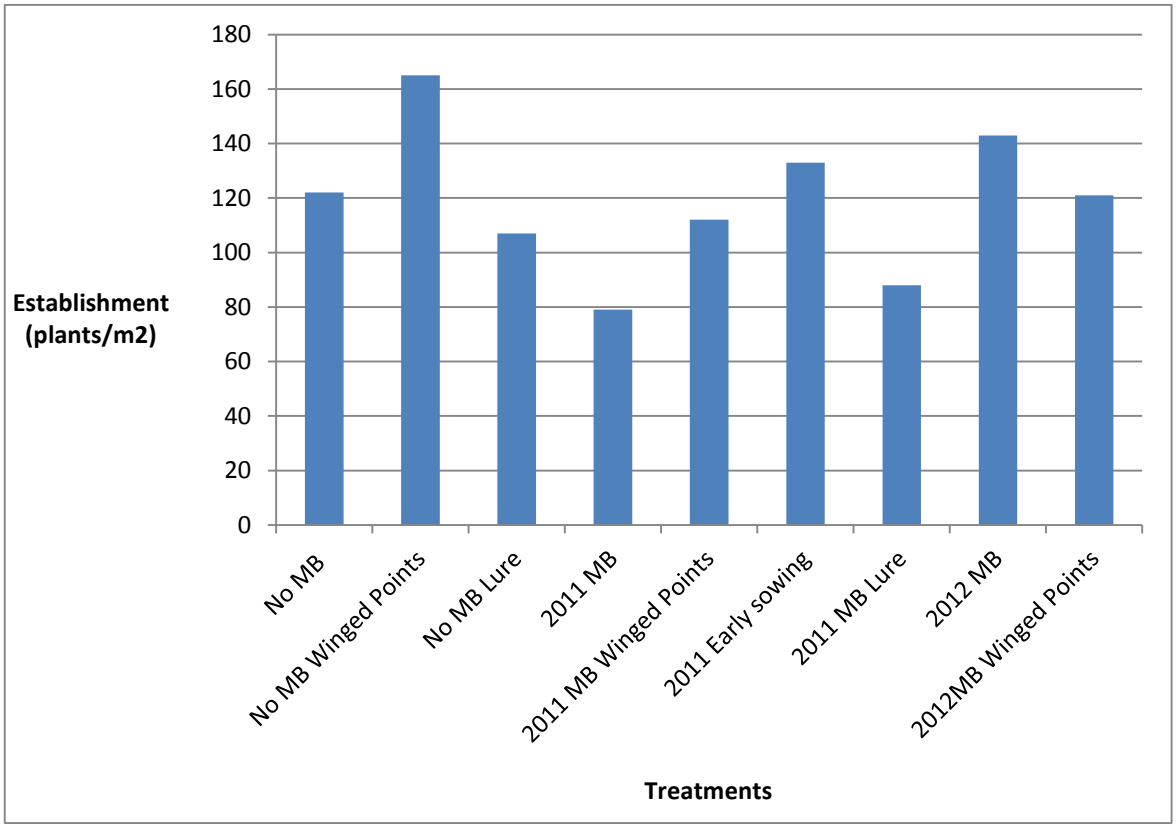
2012 Mouldboard	Winged Points
2012 Mouldboard	Untreated
2012 Mouldboard	Winged Points
2012 Mouldboard	Untreated
	Untreated
	Winged Points
	Untreated
	Lure
	Winged Points
	Lure
	Untreated
2011 Mouldboard	Lure
2011 Mouldboard	Winged Points
2011 Mouldboard	Early Sowing
2011 Mouldboard	Untreated
2011 Mouldboard	Lure
2011 Mouldboard	Winged Points
2011 Mouldboard	Untreated

Photo 1. Modified knife points with wings added to the blade.

During the growing season the trial was monitored for plant emergence, weed number, volumetric soil moisture measurements and crop biomass. Yield and quality data was collated at harvest with the CFIG weight trailer.

Results

Due to the trial layout and lack of randomization, statistical analysis was not possible. Results are presented as averages with no supportive statistics.
The no mouldboard, winged points treatment produced the highest plant establishment count. The 2011 mouldboarded treatment and the 2011 mouldboarded lure treatment produced the lowest plant number for plant establishment. In these treatments barley seed was observed on the soil surface (Photo 2).



Graph 1.Average plant establishment for each treatment on the 6th of July (crop stage 1.5-2 leaf). *MB = Mouldboard*

Photo 2. 6th July 2011 MB. Shallow sown barley seed on soil surface

There were differences in weed numbers across the trial site on the 6th of July (Table 2). In general, it was observed that the highest number of weeds (brome grass) were in the no mouldboard area of the trial. In particular the the no mouldboard, H2O Lure treatments seem to have the highest number of brome grass (Photo 3). The 2011 mouldboarded treatments were effectively weed free. The 2012 Mouldboarded treatment showed rows of brome every 40 cm though in general the number of these weeds were observed to be lower than the no mouldboarded area of the trial (Photo 4). The bromegrass were emerging from top soil on 40cm rows, the width of the plough rows indicating poor weed seed burial (Photo 5).

Table 2. Weed observations on the 6th July (MB = mouldboard)

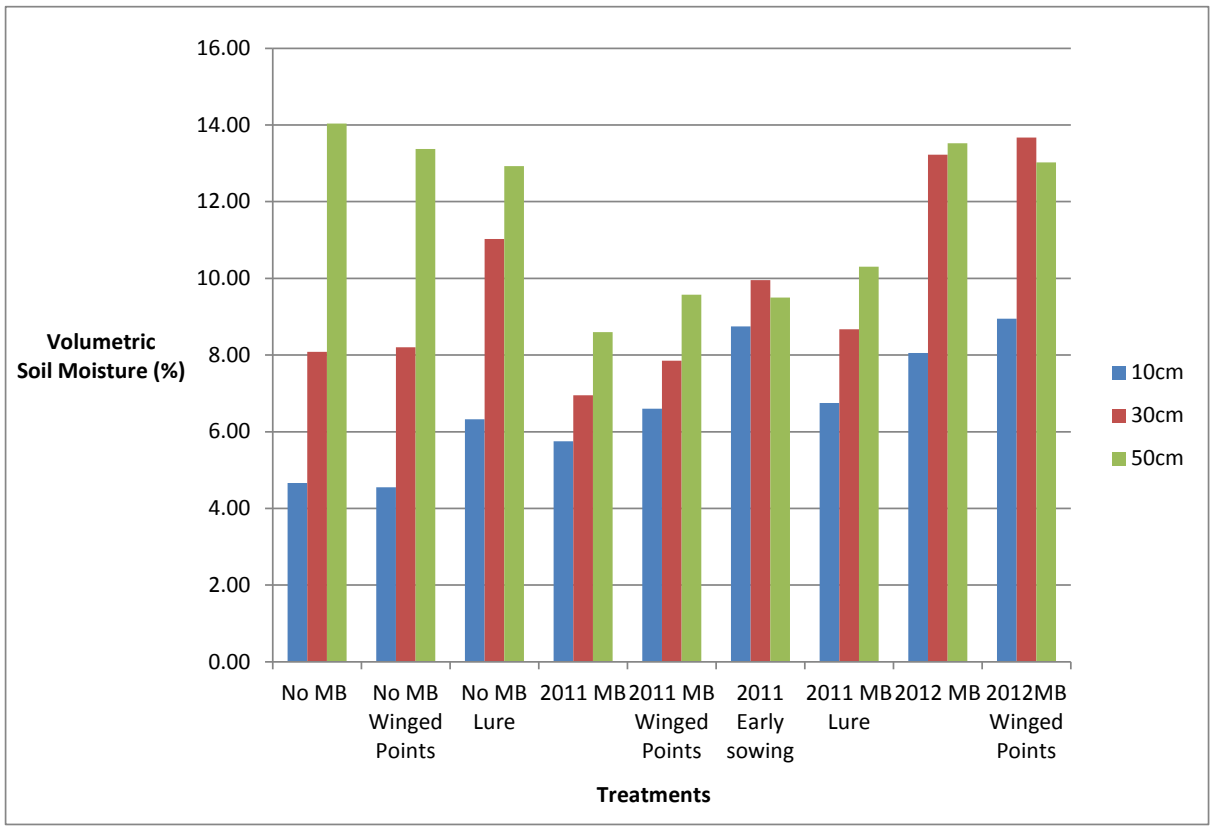
No MB	High number of Brome grass in inter-row
No MB Points	High number of Brome grass in inter-row
No MB H2O Lure	Higher number of Brome grass compared with No MB and No MB Winged Points
2011 MB	No weeds
2011 MB Winged Points	No weeds
2011 Early sowing	No weeds
2011 MB H2O Lure	No weeds
2012 MB	Some Brome grass in strips every 40cm
2012MB Winged Points	Some Brome grass in strips every 40cm

Photo 3 .6th July. No Mouldboard H2O Lure LHS and No Mouldboard RHS. Higher number of Brome grass observed in No Mouldboard Lure treatment.

Photo 4. 6th July 2012 Mouldboard. Rows of Brome Grass every 40cm.

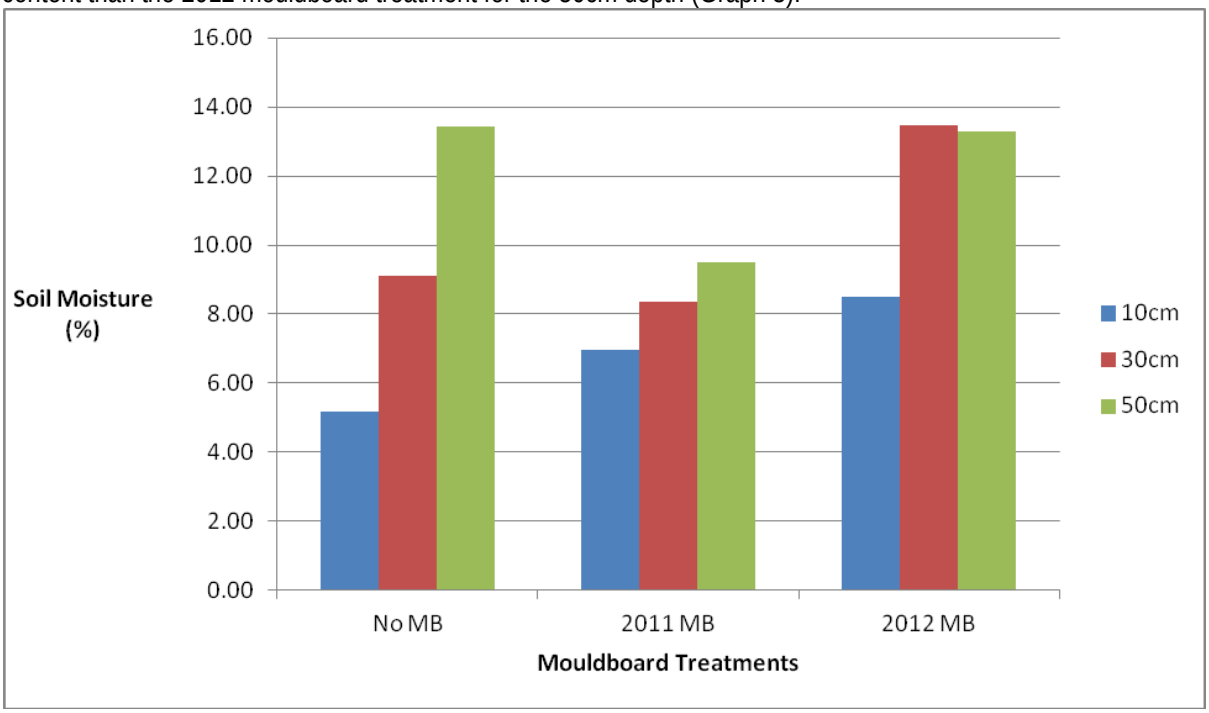
Photo 5. Top soil intercepting surface on 2012 mouldboard plots

In general the no mouldboard treatments had lower levels of inter-row volumetric soil moisture at 10cm, particularly where H2O Lure was not applied. The soil at this depth was dry to touch for these treatments.
In general the soil moisture for all three no mouldboard treatments were relatively high at the depth, 50cm, when compared to all the 2011 mouldboard treatments. The no mouldboard, H2O Lure treatment has higher moisture at 30cm depth compared with the other no mouldboard treatments. The 2011 mouldboard treatments had lower volumetric soil moisture at 50 cm when compared with no mouldboard and 2012 mouldboard treatments. (Graph 2)



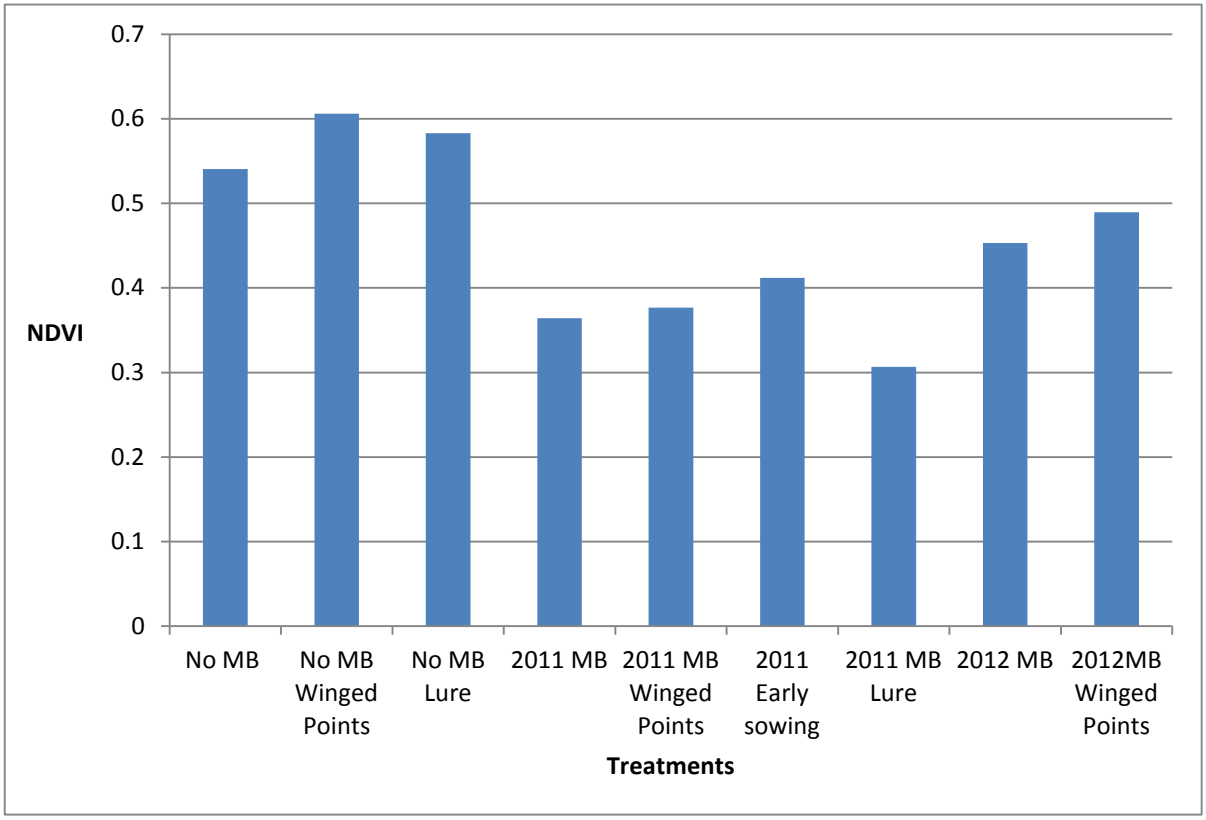
Graph 2. 7th August Inter-row Volumetric Soil Moisture Measurements for three different soil depths, 10cm, 30cm and 50cm. (MB = mouldboard)

On average, the 2012 mouldboard treatments had the highest average volumetric soil moisture content for 10 and 30 cm soil depths (Graph 3). On average, the no mouldboard treatments had slightly higher soil moisture content than the 2012 mouldboard treatment for the 50cm depth (Graph 3).



Graph 3. 7th August Inter-row average volumetric soil moisture measurements for mouldboard treatments at three different soil depths. (MB = mouldboard)

On the 13th of August NDVI (normalised difference vegetation index) measurements taken with a Greenseeker showed differences in plant biomass (inlcuding weed biomass) across the trial site. The no mouldboard treatments, in general, had the highest biomass but weed biomass was a significant contributor to these biomass readings.



Graph 4. 13th August. NDVI Readings measuring crop biomass. (MB = mouldboard)

A small sample of plants tissue tests taken on the 20th of September indicated lower level of nitrogen in the no mouldboard plants when compared with both 2011 and 2012 mouldboard plants.

Figure 1. 20th September. Plant tissue test results.

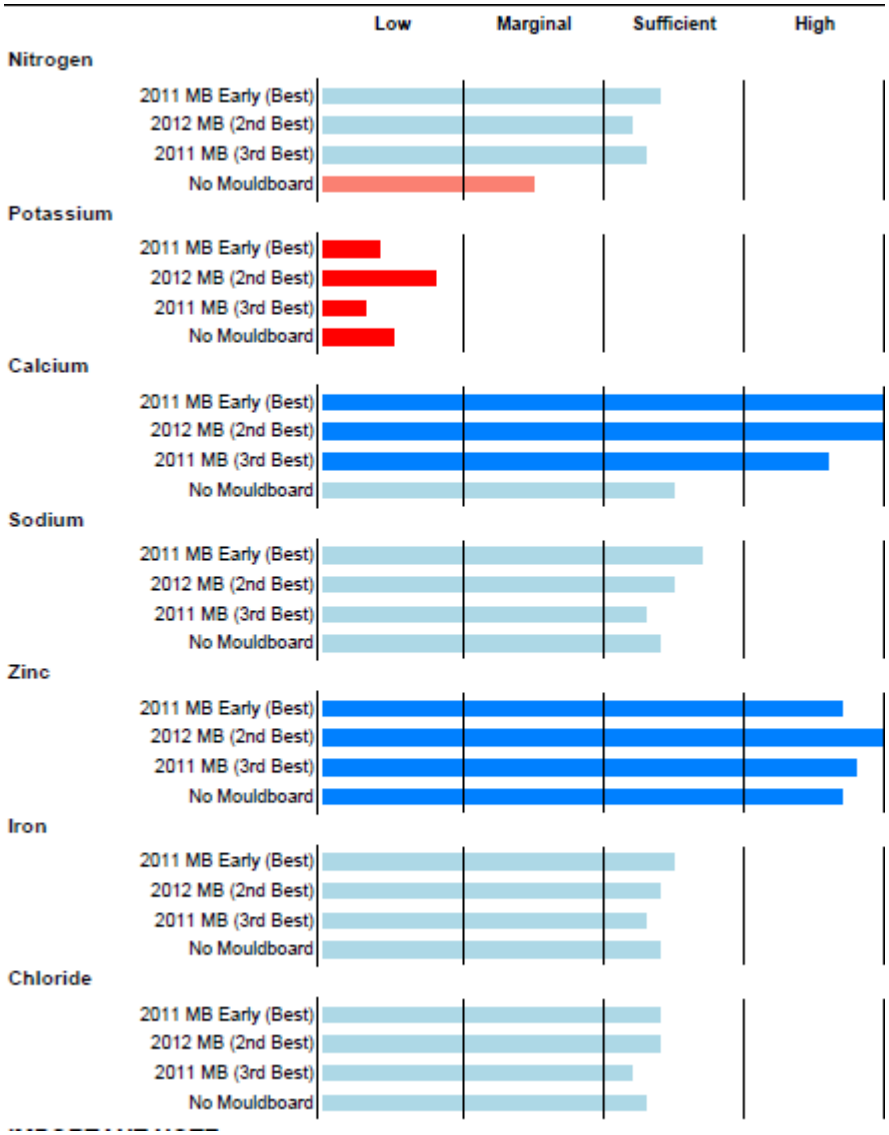
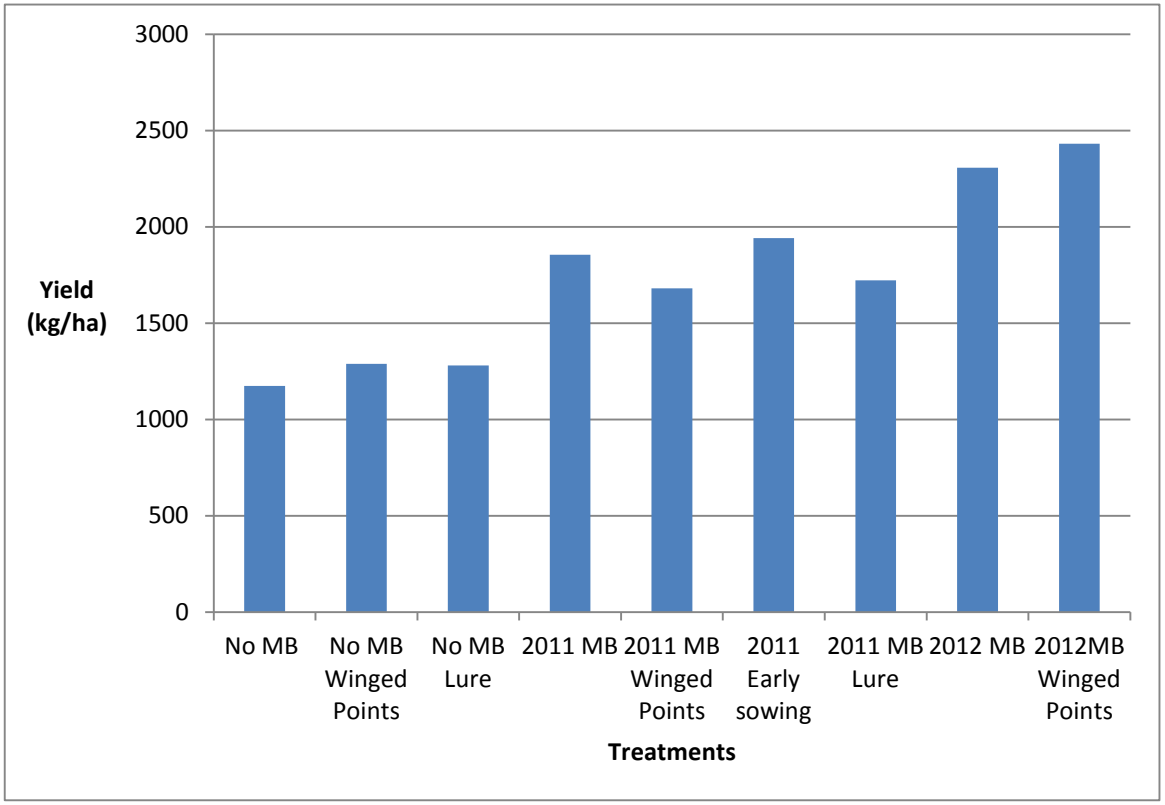


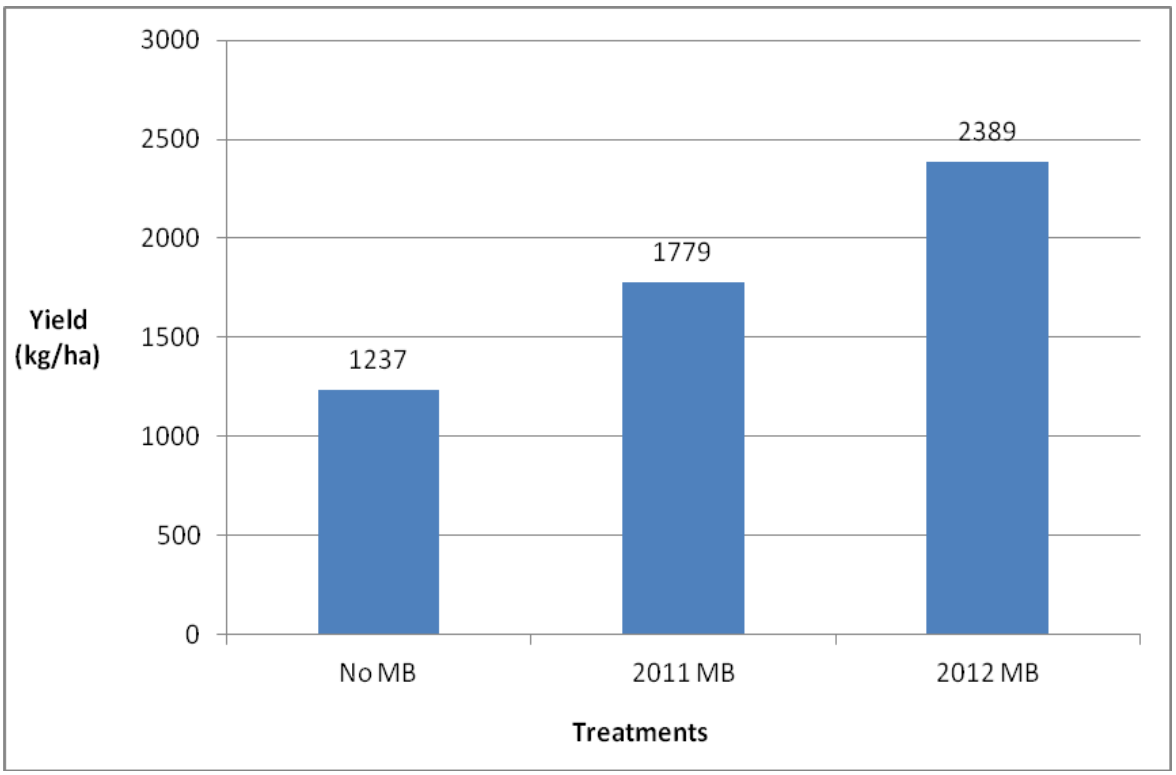
Photo 6. 2011 mouldboad RHS, no mouldboard LHS

The two 2012 mouldboard treatments produced the two highest grain yields in the trial. The three no mouldboard treatments produced the lowest grain yields (Graph 5).



Graph 5. Average yield for each individual treatment in trial (MB = mouldboard)

The 2012 mouldboard treatments produced the highest average grain yield when compared by mouldboard treatment. The 2012 mouldboard treatments were on average 85% higher yielding than no mouldboard. The 2011 mouldboard treatments were on average 44% higher yielding than no mouldboard.



Graph 6. Average of treatments for three different mouldboard applications. (MB = mouldboard)

On average the 2011 mouldboard treatments produced higher protein and screenings than no mouldboard and 2012 mouldboard treatments. Based on protein and screenings all the 2011 mouldboard treatments were feed quality barley while the no mouldboard and 2012 mouldboard treatments were malt quality (Table 3).

Table 3. Grain quality for each treatment (MB = mouldboard)

	Protein (%)	Screenings (%)	Grade (CBH)
No MB	10.8	21	Malt
No MB Winged Points	10.9	20	Malt
No MB Lure	10.7	25	Malt
2011 MB	12.2	39	Feed
2011 MB Winged Points	12.4	39	Feed
2011 Early sowing	12.3	38	Feed
2011 MB Lure	12.6	38	Feed
2012 MB	10.7	14	Malt
2012MB Winged Points	10.4	11	Malt

On an average basis the no mouldboard treatments were malt grade, 2011 mouldboard feed grade and the 2012 mouldboard treatments malt grade. The 2011 mouldboard treatments had the highest average screenings and protein (Table 4).

Table 4. Average grain quality for mouldboard treatments (MB = mouldboard)

	Protein (%)	Screenings (%)	Grade (CBH)
No MB	10.8	22.2	Malt
2011 MB	12.4	38.5	Feed
2012 MB	10.5	12.3	Malt

Photo 7. Typical head size for 2012 mouldboard LHS, no mouldboard RHS.

Discussion of Results

The mouldboard treatments were the most dominant influence in this trial. The results show crop performance in the second year after mouldboarding may not be as successful as the first year.
Mouldboarding has potential to alleviate non wetting soils and reset the weed seed bank to very low levels. The differences in biomass in this trial as measured by the Greenseeker (NDVI readings) are likely most influenced by the level of brome grass. The 2011 mouldboarded plot had the lowest biomass readings with 100% weed control in comparison to the no mouldboard plots, with highest biomass and highest brome levels (Graph 4).
While the 2012 mouldboarding operation produced the highest yield, they did not achieve 100% weed control which was achieved with the 2011 mouldboarding treatments. Different operators in different years produced

different outcomes. The 2012 mouldboard machine did not have stripper plates which are essential for complete turnover of top soil and deep burial of weed seeds (Photo 5). Also the 2012 mouldboard operation occurred after only 25mm of rain. In 2011 the mouldboard operation occurred after 75mm of rain. These details need consideration which hiring contractors or operating ploughs to do this work.

Moisture measurements in this trial show higher accumulation of moisture in the top soil with mouldboarded soil compared with no mouldboard, non wetting soil (Graph 2). In comparison, moisture in the no mouldboard, non wetting soil is accumulated at depth and the topsoil remained mainly dry. Perhaps one exception to this was the no mouldboard H2O Lure treatment which had higher soil moisture at 10cm and 30cm depth compared with the other two no mouldboard treatments. The moisture measurements were taken from the inter-row which supports the idea that much of the H2O Lure spray on the soil surface prior to seeding would have moved into the inter-row during the seeding process. This raises the issue that better techniques should be investigated to apply this product, and perhaps sprayed behind the press wheel into the seeding row maybe a better option.

This relatively high moisture at depth for no mouldboard soil is most likely the result of a combination of moisture travelling deep down through the seeding furrow and also an accumulation of subsoil moisture which is unused from year to year.

Top soil that wets up evenly and stays moist is likely to have better mineralization of nutrients such nitrogen. There is some evidence from the tissue tests that this occurs with mouldboard ploughing but this needs more investigation (Figure 1).

The yield produced in the second year after mouldboarding is not as high as the first year. This trial shows that subsoil (50cm) moisture can be lower in the second year possibly because the high water use of the first crop after mouldboarding. The high water use by a high yielding crop is likely to drain the subsoil in this first year and have carryover effect into the next season, particularly with a dry season, as in 2012. This drier subsoil can also affect grain quality and this case, produce higher screenings (Table 3 & 4).

An important consideration when sowing into mouldboarded soil is seeder set up. Mouldboarding effectively changes the soil profile and can bring lower organic matter soil and clay to the surface. This clay bought to the surface with mouldboarding helped formed a crust on the surface which was the likely cause of shallow seeding, particularly on the 2011 mouldboard treatments. The shallow sowing and low organic matter is likely to have contributed to damage by the chemical, trifluralin. This reduced the vigour of the crop and subsequent growth and probably affected yield.

Within the no mouldboard treatments there was some evidence that winged sowing points can improve crop establishment (Graph 1). Also there was evidence of the product H2O Lure affecting top soil (10cm) moisture and subsequent weed numbers (Graph 2&3). The influence of these two treatments was minor in comparison to the effect of mouldboarding in this trial.

Mouldboarding can be an expensive operation with current contract cost of $120 per hectare and approximately $20 per hectare of diesel fuel. Based on the average yield and quality response of the mouldboard treatments this trial demonstrates that this cost can be recouped in the first season of cropping on mouldboarded land (Table 5).

Table 5. Comparison of the effect on income with mouldboard treatments. (MB = mouldboard)

Treatment	Average Yield (kg/ha)	Grade	Price	Income ($)	Change ($)
No MB	1237	Malt	250	309	0
2011 MB (2nd crop after MB)	1779	Feed	230	409	100
2012 MB (1st Crop after MB)	2389	Malt	250	597	288

The contract cost of the Mouldboard Plough operation was $120 per hectare with approximately $20 per hectare of diesel so a total cost of $140 per hectare.

Compared with the objectives.

Corrigin Farm Improvement Group (CFIG) has successfully completed a large scale trial with farmer equipment and testing a range of techniques. The trial does demonstrate that mouldboard ploughing can successfully alleviate a non wetting problem. The other techniques of winged point sowing and H2O Lure did not seem to have a significant bearing on the non wetting soil or improve crop yield. The success of this trial has encouraged CFIG to continue investigating mouldboard ploughing over season 2013 and 2014. These trials will be a good opportunity for farmers to observe the technique and learn where it best fits their farming system.

Implications

Mouldboard ploughing has potential to significantly improve production of non wetting soils in the central wheatbelt of Western Australia. It is also has potential to help farmers manage difficult to control weed populations that can occur on non wetting soils. While this trial had very large crop yield responses (44 to 85%) Corrigin Farm Improvement Group aims to retest these techniques over the next two seasons to confirm the benefits. It is unusual to get such large yield responses in crop trials and so this provides a good incentive for farmers to test and trial the technique for themselves.

Recommendations

The results of this trial will interest growers particularly farming non wetting soils. The results should be extended further to the Western Australian farming community through GRDC publications. Corrigin Farm Improvement Group will be conducting a similar project over the next two season will assist local grower to learn more about the technique of mouldboard ploughing. CFIG regularly runs field days and the results of this project will be further extended to growers at these field days.

Appendices

Field days were held at the trial site in late 2012 including a spring field walk for local farmers and another field walk for farmers from other areas of the wheatbelt. The results of this trial were presented at the Corrigin GRDC regional Crop Updates. Articles have also been published concerning this trial.

Acknowledgements

Corrigin Farm Improvement Group would like to acknowledge the effort and input of the following people in the implementation of this trial; Neville Turner and Kent Stone.

Project Title:	Comparing Mouldboard Ploughing with other Techniques to Manage Non Wetting Grey Sandy Soils in the Corrigin District in 2012
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Objectives	The trial was designed to investigate a range of techniques that may improve crop establishment and performance on non wetting sandy soils. The techniques tested included Mouldboard ploughing, winged knife points, and the humectants (soil wetting agent) H2O Lure. The trial also compared the second year affect of mouldboard ploughing to the first year affect.
Background	Non wetting soils are a major challenge to farmers in the West Australian wheatbelt. Non wetting soils cause poor crop establishment and can lead to an increase in weed numbers over time. Non wetting soils is very challenging in dry seasons and maybe getting worse with no tillage farming systems. Mouldboard ploughing is adopted by some W.A. farmers to manage non wetting soils but also to bury weed seeds deep (30-40cm) into the soil profile where they are unable to emerge to the soil surface. Mouldboard ploughing is an expensive operation at approximately $140 per hectare. Other techniques may also be useful to manage non wetting soils such as modified seeding points and soil wetters.
Research	This large scale demonstration tested mouldboard ploughing in comparison with other techniques including applying a soil wetting agent / humectant (H2O Lure) and sowing with modified winged sowing points. Also the second year affect of mouldboard ploughing was investigated in this trial.
Outcomes	Mouldboarding was the driver of crop yield in the trial with 2012 mouldboard treatments producing, on average, 85% higher yielding than no mouldboard. The 2011 mouldboard treatments were on average 44% higher yielding than no mouldboard. The results show that the second year after mouldboarding may not be as successful as the first year for yield gain. While the 2012 mouldboarding operation produced the highest yield they did not achieve 100% weed control like the 2011 mouldboarding. Different operators in different years produced different outcomes so quality of ploughing is important. Mouldboard ploughing was shown to affect the way rainfall enters the soil profile. The results indicate that mouldboard ploughing can improve the evenness of soil wetting from the top soil to the subsoil. The unmouldboarded, non wetting soil was shown to remain mainly dry on the top soil but wet up deeper down in the sub soil. This dryer top soil is likely to cause a buildup of weed numbers, less nutrient mineralization and subsequently lower crop yield potential. The second year after mouldboard ploughing produced a lower yield than the first year of mouldboarding. Soil moisture measurements showed drier subsoil for the second year after mouldboarding compared to the first year. The large crop yield response in the first year is likely to use stored moisture from the subsoil and so have carryover effects of less subsoil moisture for the second year crop.
Implications	Mouldboard ploughing has potential to significantly improve production of non wetting soils in the central wheatbelt of Western Australia. It is also has potential to help farmers manage difficult to control weed populations that can occur on non wetting soils. While this trial had very large crop yield responses Corrigin Farm Improvement Group aims to retest this techniques over the next two seasons to confirm the benefits of this technique. It is unusual to get such large yield responses in crop trial and so this provides a good incentive for farmers to test and trial the technique for themselves.
Publications	The results were presented at 2013 Corrigin Regional Crop Updates.