# The phytotoxicity of pre-emergence herbicides on mould boarded soils

**Derk Bakker and Grey Poulish.** Department of Agriculture and Food, Albany WA 6330

## Key messages

Mouldboard (MBP) ploughing can affect the phytotoxicity of soil active herbicides like Treflan®, Sakura® and Boxer® Gold.

A decrease in the OM and CEC and an increase in the wettability of the surface of MBP soils make them much more prone to leaching during rainfall, making pre-emergence herbicides more phytotoxic over a greater depth. This could result in crop damage.

Consider using only post-emergence herbicides when controlling weeds in MBP soils for some years after ploughing..

## Aims

Mouldboard ploughing of soil for the purpose of alleviating non-wetting and/or resistant weeds has become an acceptable practice in many areas of the agricultural areas of WA. This creates a rather unique soil profile that is very different from the original profile. The top soil bulk density, organic matter content, and nutrient levels are decreased while the wettability is increased. A decrease in the soil bulk density generally improves root growth and increases productivity. A decrease in the soil organic matter and nutrient levels only occurs at the surface of the new soil profile, because the original top sol is now buried and as such still accessible to roots. As long as enough nutrients are applied at seeding no detrimental effect should result from this decrease. While the overall crop productivity might not be affected, it can however affect absorption and leaching processes. The improvement in wettability of the soil profile by burying the non-wetting organic rich top soil generally leads to an improvement in the crop establishment because of better and more consistent seed-soil contact with damp soil. The improvement in the wettability and decrease in organic matter should also result in an increase in the ability to leach.

The implementation of several MBP trials across the high rainfall area of the Great Southern over about 4 years has resulted in a mix of yield responses, varying from very negative to very positive. Several trials stood out because of the almost spectacular failure of seed to germinate in the MBP plots, on white sand and on coarse sandy gravel both with cereals and canola. Originally seeding depth, soil re-compaction, and soil temperature were thought to have played in a role in this lack of establishment. While that might have been the case, poor establishment in 2014, two years after ploughing, prompted further investigation into the reason for such poor establishment.

The symptoms of the poorly germinating cereal seeds were originally identified as 'silly-seedling' syndrome (Sawkins, 2015), however alternative views pointed to herbicide damage. In order to investigate this further germination tests were conducted with wheat in a normal topsoil and a MBP top soil after an application of Treflan®, a commonly used pre-emergence herbicide (Experiment 1). This was later extended to similar pre-emergence herbicides (Boxer Gold® and Sakura®), a larger range of soil types and two different wetting regimes (Experiment 2).

## Method

### *Experiment 1*

Soil was collected from a farm in the Cordering area where MBP had resulted in a poor establishment of wheat in the first and the third year after ploughing. Two types of MBP soil were used: where the plough depth was about 30 cm and gritty sandy gravel was brought to the surface (T1 site), and where the plough depth was about 20 cm and more loamy clay was brought to the surface (T2 site). The 'Control' topsoil came from an adjacent unploughed plot. Some properties of the three different soils are presented in Table 1.

Table 1 Soil properties used in Experiment 1. MED = Molar Ethanol Droplet. 0 = wettable and 5 = extremely non-wetting. PBI = Phosphorus Buffer Index.

| Location | MED | pH CaCl2 | Gravel (%) | P (mg/kg) | K (mg/kg) | OC (%) | PBI | CEC (meq/100g) |
|---|---|---|---|---|---|---|---|---|
| **Control** | 2.7 | 5.1 | 66 | 87 | 77 | 4.32 | 134 | 12.3 |
| **T1 site** | 0.0 | 5.1 | 56 | 47 | 75 | 1.74 | 68 | 4.3 |
| **T2 site** | 0.3 | 6.0 | 57 | 58 | 117 | 1.94 | 96 | 8.3 |

The Control soil was high in organic carbon (OC), CEC and PBI, and moderately non-wetting. As expected the T1 site soil was fully wettable, much lower in OC, PBI and CEC. The T2 site contained a little more clay and had a higher OC, PBI and CEC than the T1 site. The gravel content of all the soils was high.

The soil was sieved through a coarse (5mm) sieve thus retaining most of the coarse gravel but eliminating large stones and much of the canola stubble from the previous year. The soil was placed in small bins, and 7 wheat seeds were placed in rows at depths of 0, 1, 2, 3, 4 and 5cm. All the rows were covered by 1 cm layer of soil after the Treflan® was applied at a rate equivalent to 2L/ha with 80L/ha of water. Three different moisture levels: high, medium and low were obtained by adding different amounts of water to the soil. Nine bins in total were used for this experiment. Measurements after 2 weeks consisted of a germination count in each row.

### *Experiment 2*

The second experiment consisted of four soils with different amounts of organic matter. This was obtained by mixing organic matter rich top soil with different amounts of filter sand using the following ratios: 1:0, 1:2, 1:4 and 0:1. Soil properties are presented in Table 2.

Table 2 Soil properties used in Experiment 2 prior to mixing the compound fertiliser.

| **Top soil : Filter sand** | **NH (mg/kg)** | **NO (mg/kg)** | **P (mg/kg)** | **K (mg/kg)** | **OC (%)** | **pH (CaCl2)** | CEC (meq/100gr) |
|---|---|---|---|---|---|---|---|
| **1 : 0** | 3 | 14 | 64 | 170 | 5.0 | 4.9 | 7.7 |
| **1 : 2** | 1 | 3 | 18 | 50 | 1.3 | 4.9 | 2.8 |
| **1 : 4** | 1 | <1 | 9 | 18 | 0.8 | 5.2 | 1.1 |
| **0 : 1** | <1 | <1 | <2 | <15 | 0.06 | 5.8 | 0.2 |

Seeding depth was 0, 1, 2 and 4cm. Two watering regimes were used: just moist soil at seeding and wetting up for 15 minutes to field capacity in a reticulated glass house using overhead sprays with a rate of 25mm/hr. Three pre-emergence herbicides were used: Treflan®, Boxer Gold® and Sakura®. Each has a slightly different mode of action. Treflan® with trifluralin(480g/L) as the active ingredient inhibits root development by affecting mitosis, Boxer Gold® with S-metolachlor(120g/L) and prosulfocarb(800g/L) as the active ingredients also inhibits mitosis as well as inhibiting the growth of growing points and Sakura® with pyrazole(850g/kg) as the active ingredient affecting meristematic growth as well disrupting shoot elongation. Each treatment combination was placed in one little tube (250mL), and three wheat seeds were placed at the required depth in each tube. All combinations were replicated twice, in total 256 tubes were used. The wetted up tubes had a hole drilled in the side just above the bottom to facilitate free drainage. No further watering of any of the tubes occurred after seeding. Germinating seeds were counted after 17 days. While preparing the soil mixes the equivalent of 100kg/ha of finely ground compound fertiliser (Agras®) was added to the soil.

## Results

### *Experiment 1*

The germination after 14 days is presented in Figure 1.

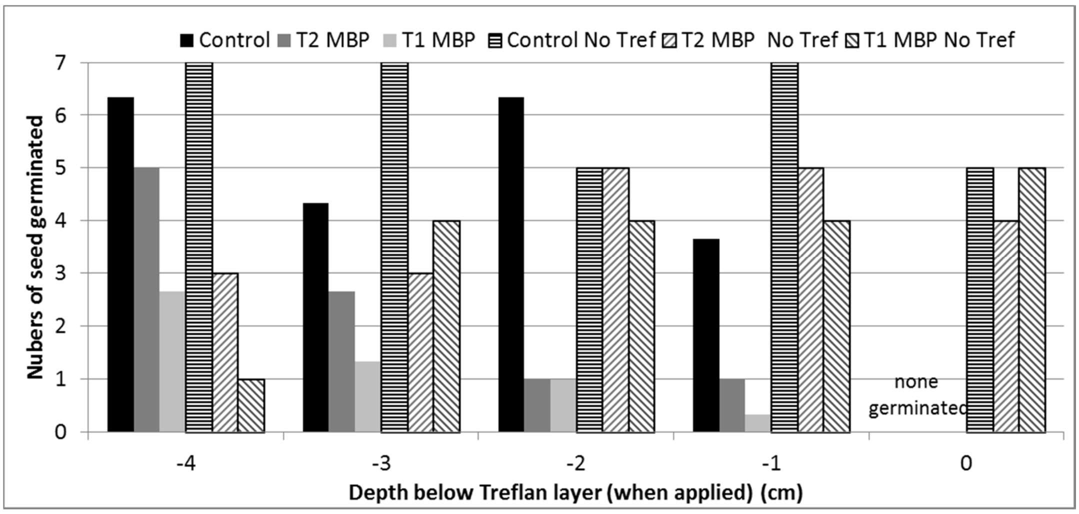


Figure 1. Germinated number of seed 14 days after seeding in Experiment 1.

Where the Treflan® had been applied on the seed (0 cm) no seeds germinated, seed that was placed below that layer of application (-1, -2, -3 and -4 cm) did germinate very well in the Control, less so in the T2 soil, and still less in the T1

soil. When no Treflan® was applied, germination in the Control was not affected by depth but in T1 and T2 seeding depth had some effect. Seed that had not emerged is portrayed in Figure 2.

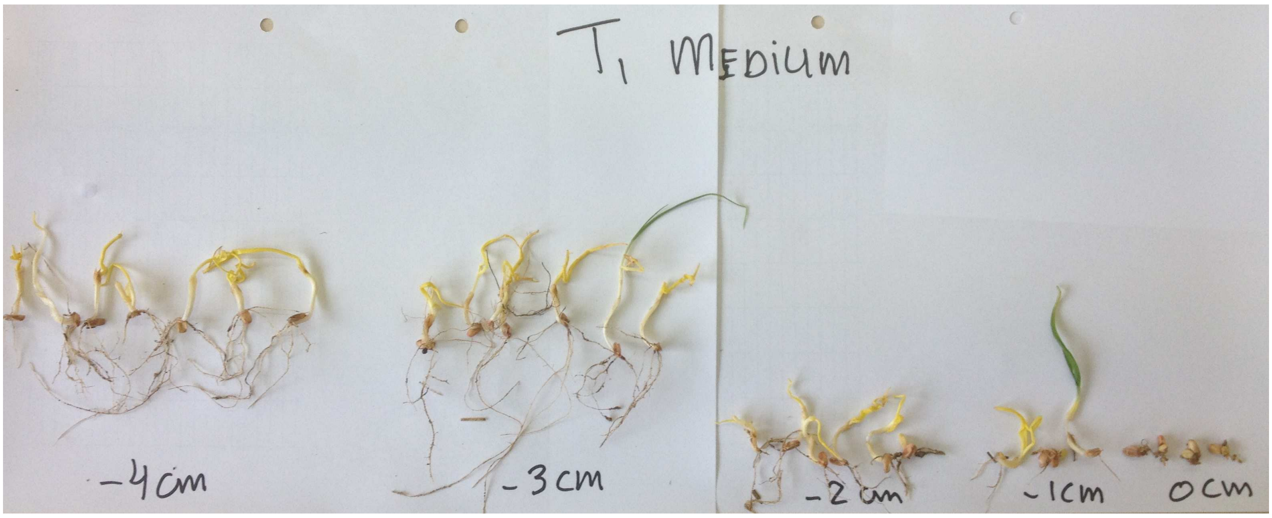


Figure 2. Poor germination and emergence at different seeding depths in the T1 soil with medium moisture levels.

The yellow gnarly coleoptiles have been typical of poor emergence in this soil. Similar looking seeds were found in the field. The burst seed at the 0 cm depth has been typical of Treflan® damage.

*Experiment 2*

The effect of the rain and the soil type on efficacy of the three herbicides in Experiment 2 is presented in Figure 3.

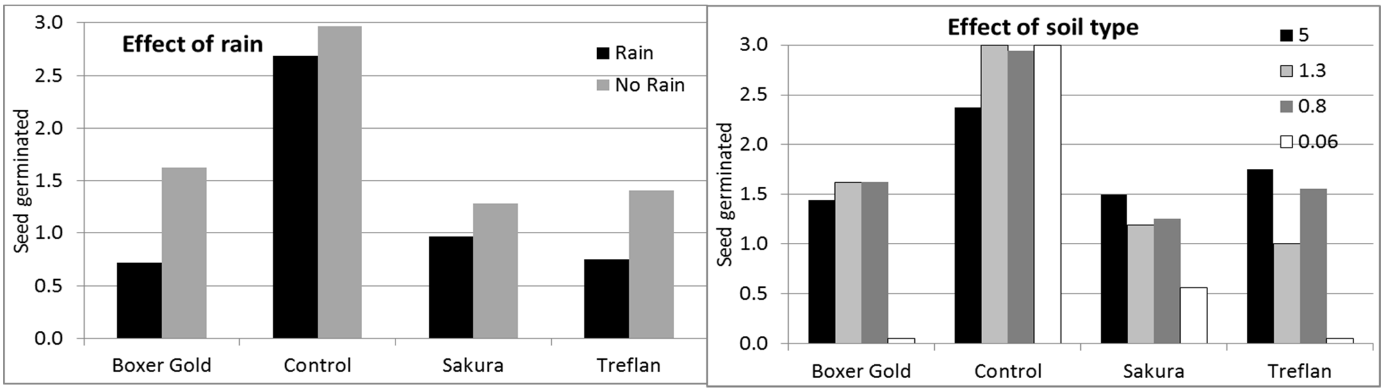


Figure 3. Effect of rain (left) and the effect of soil organic matter (right) on effectiveness of 3 herbicides. Note where germination is 0.1 the measured germination was 0.0.

The combined effect of wetting regime, seeding depth and soil carbon on the effectiveness of the three herbicides is presented in Figure 4.

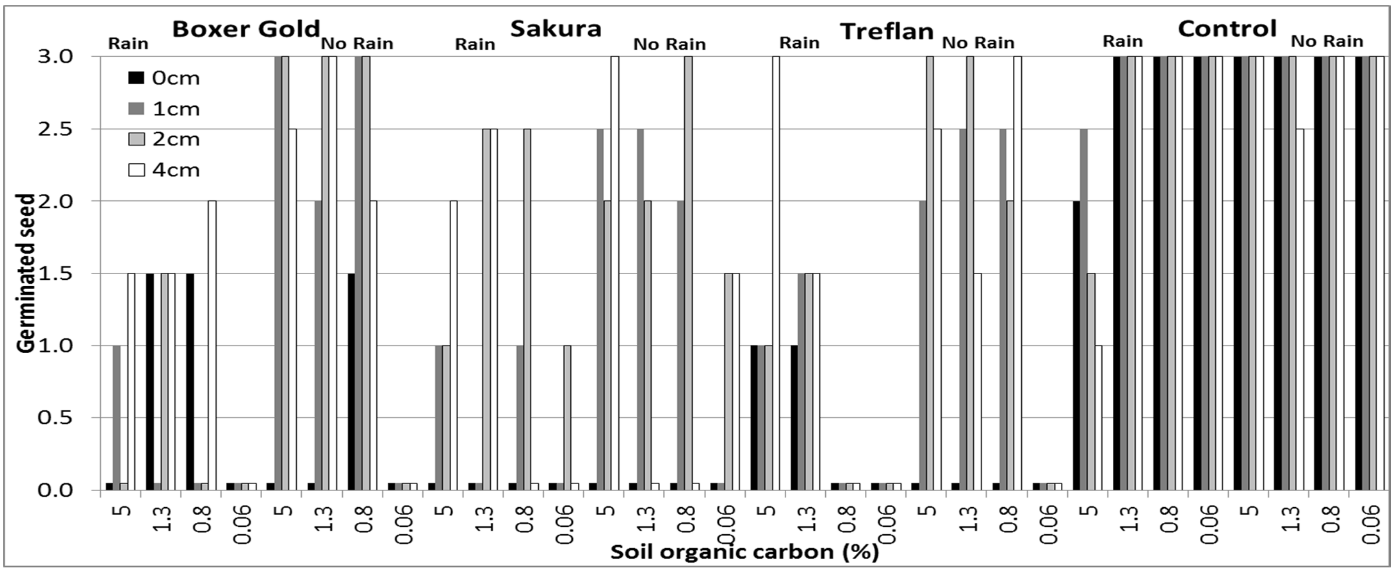


Figure 4. Combined effect of wetting regime, 4 seeding depths and 4 different levels of organic soil carbon on the phytotoxicity of three herbicides. Note where germination is 0.1 the measured germination was 0.0.

The addition of rain (Fig 3.) immediately after application increased the phytotoxicity of the herbicides as did the level of organic carbon. Higher levels of soil carbon reduced the phytotoxicity of the herbicides. Boxer Gold® was the most sensitive to the levels of organic carbon, followed by Sakura® with Treflan® being the least sensitive. This is interesting because the LogP (Octanol-water partition coefficient, a factor used in leaching studies) for Trifluralin is 5.3 while the LogP for metolachlor and pyroxasulfone is 3.4 and 2.4 respectively. Treflan® is more likely to be bound to soil organic carbon (bio accumulation) than the other two herbicides, which would make it much more sensitive to levels of organic carbon. Unless it is more easily bound to dissolved organic carbon which might make it more mobile but exploring these aspects are at the moment beyond the scope of this work.

Combining the organic carbon with seeding depth relative to the layer of herbicide application revealed a strong interaction between the depth and the organic carbon. Lower levels of soil carbon significantly increased the range of depths the herbicides were phytotoxic. This effect was greater when rain was applied to the soil immediately after application of the herbicides. When no rain was applied the effectiveness was merely restricted to the 0 cm seeding depth, i.e. when the seed was in contact with the herbicide. This was however not the case for the very low soil carbon level where at all depths all the herbicides were very phytotoxic. In the absence of soil organic carbon the herbicides most likely move by gaseous diffusion to lower layers affecting the seed placed at a lower depth.

Of interest in Experiment 2 was the absence of yellow gnarly seedlings found in Experiment 1. The Experiment 2 soil did not have any gravel. Where the seed did not germinate in Experiment 2 in the Treflan® treatment no root growth was observed and the seed was burst and soft. In the Boxer Gold® treatment more root development had occurred but still the seed failed to germinate. In the Sakura® treatment most seed had developed substantial roots but with very little shoots. In none of the treatments were gnarly yellow shoots observed at any depth. It appears therefore that the gnarly symptoms were the results of presence of gravel with an interaction with the herbicide

## Conclusion

It has been shown that the soil applied pre-emergence herbicides have a strong interaction with the soil organic carbon, seeding depth and the watering regime (i.e. rainfall and wettability). These findings are consistent with work reported elsewhere (Hollist, 1971) and provide a good explanation for the very poor establishment in some of the MBP trials where Treflan® was used on gritty gravel (Cordering) with a low OC followed by substantial rain shortly after seeding and possibly RoundupReady® canola on white sand (Frankland). Those applications of Treflan® on the trials sites were applied because the MBP trials were part of a larger paddock where Treflan® could be used without any detrimental effects.

When using soil active pre-emergence herbicides such as Treflan®, Sakrua® or Boxer® Gold on MBP soil the need to apply these herbicides should be seriously considered because the weed pressure is not there for several years when MBP is applied correctly. If weeds are expected then consider the use of post-emergence herbicides particularly when low OC with a low clay content soil is brought to the surface. Alternatively reduce the rate of the pre-emergence herbicides because the soil conditions have been altered dramatically in MBP soil.


## Key words

Mould boarding, soil organic carbon-herbicide interaction, leaching.



## Acknowledgments

A thank you to Tim and Ray Harrington from Cordering and Doug Sawkins (DAFWA, Narrogin) for taking an interest in this work. This research is partly funded by the GRDC. Project code: DAW00204 “Delivering agronomic strategies for water repellent soils in Western Australia”. Project leader: Dr. Steve Davies, DAFWA Geraldton.

**GRDC Project Number: DAW00204**

**Paper reviewed by: John Moore, DAFWA Albany.**


### Reference


Hollist, R. L. and C. L. Foy. 1971. Trifluralin Interactions with Soil Constituents. Weed Science, Vol. 19, No. 1. pp. 11-16.

Sawkins, D. 2015. http://www.agric.wa.gov.au/mycrop/silly-seedling