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Comparison of the effectiveness of different geosynthetics as root barriers – final report

1. Introduction

We were asked by GeoFabrics to compare and contrast the effect of different geosynthetics on the growth of root and shoot systems of target plants. We particularly assessed their compliance to the PD CEN/TS 14416:2014 'Resistance to Roots' test standard. We also assessed the performance of the materials in the context of water movement in soil systems.

2. Test Specimens

We tested the following specimens:

- Control test (no specimen)
- GeoFabrics HPS6 Geotextile
- GeoFabrics CuTex Copper Composite
- GeoFabrics HPS3RE2 (base textile for CuTex)
- Impermeable Membrane A (IM A)
- Impermeable Membrane B (IM B)

3. Test system

To compare the specimens, we used a modified version of the protocol we used in our previous work for GeoFabrics (see "CuTex Final Report"). This used a disc of root barrier to separate an upper vermiculite layer from a lower soil layer. The vermiculite layer contains no nutrients, giving the plants an 'incentive' to growth through the specimens. We modified this protocol to be consistent with PD CEN/TS 14416:2014 'Resistance to Roots' test standard, by using silicone sealant to seal the specimens into the pots. We believe that the current PD CEN/TS 14416:2014 test standard is not sufficiently challenging for root barriers, since it uses young seedlings, growing in a top layer of soil. These plants have neither the time nor inclination to grow through a root barrier. Our test was designed to ensure that if plants were able to grow through the barrier, they would have time and reason to do so.

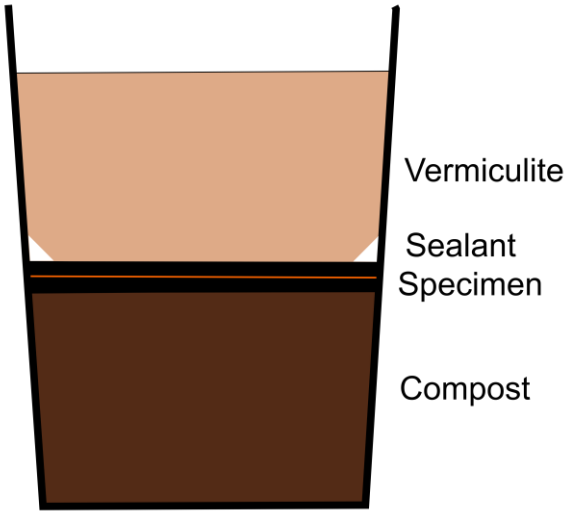

Figure 1: Set-up for experiments.

4. Measurements

To compare the specimens, we made a number of assessments:
a) **Shoot growth**, scored on a scale of 0 (weak) to 5 (vigorous).
b) **Root growth in the upper chamber** (present/absent).
c) **Root growth in the lower chamber** (present/absent).
d) **Visible penetration of specimen by roots** (present/absent).
e) **Drainage time in seconds for 400ml of water** (applied to the upper chamber, to be drained from the base of the pot)

5. Test on lupins to PD CEN/TS 14416:2014 test standard

We initially tested the specimens using lupins, as per PD CEN/TS 14416:2014. However, rather than growing many lupin seedlings for a short time, we grew a single lupin plant in each pot for 8 weeks, to give them the maximum possible time to grow through the barrier with strong adult roots.

Within a few weeks there was a clear difference in the growth of the plants with Impermeable Membrane A and Impermeable Membrane B compared to other specimens. The plants were very small with few leaves, yellow looking and ‘stressed’ in appearance. These are the classic symptoms of nutrient deprivation, and would be expected from plants that have not grown through the specimen to access the nutrients in the soil layer. Surprisingly, the CuTex plants were as healthy as all the other plants in the experiment (Figure 2, 3). This suggested the plants may have growth through the CuTex.

However, when we examined the specimens at the end of the experiment, this was clearly not the case. We did not observe any roots growing through any of the CuTex, Impermeable Membrane A and Impermeable Membrane B barriers (Figure 4). **Thus CuTex, Impermeable Membrane A and Impermeable Membrane B are all highly effective root barriers.** Conversely, roots had grown through all the HPS3RE2 and HPS6 specimens (Figure 4). Consistent with these observations, root growth in the lower chamber was absent in the CuTex and Impermeable Membrane A/B specimens.

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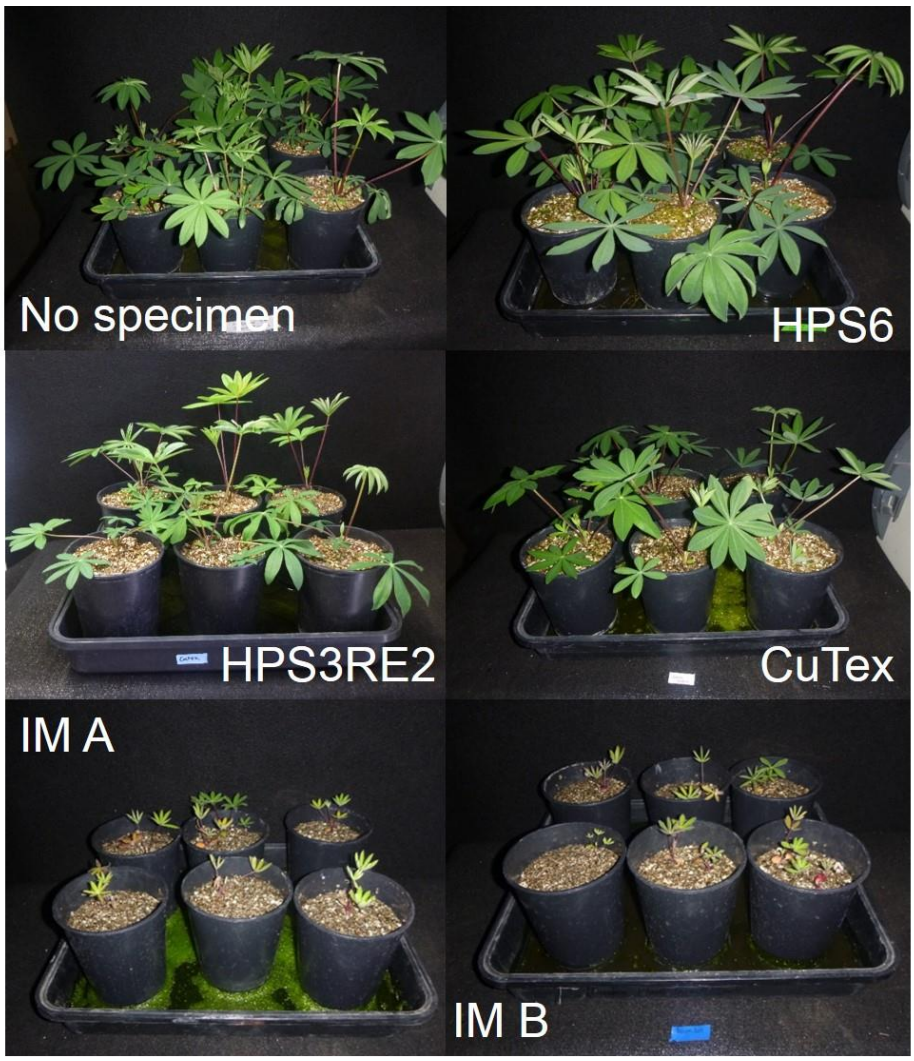

Figure 2: Plant growth with different specimens

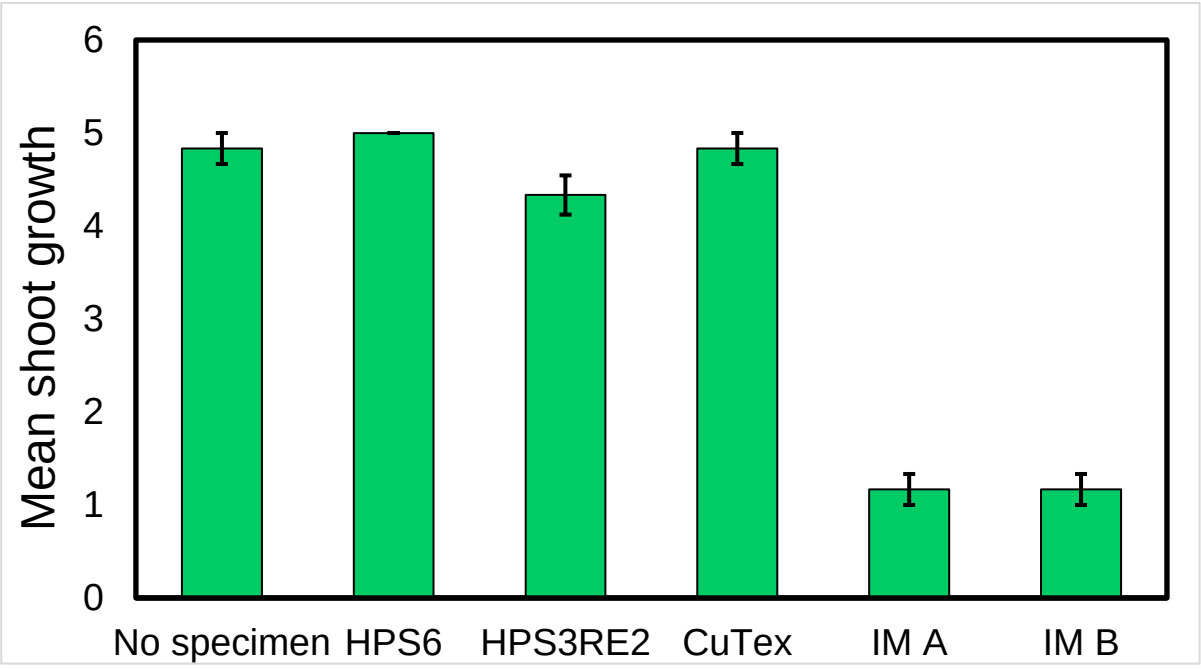

Figure 3: Mean lupin shoot growth (on a scale of 0-5) with different specimens.

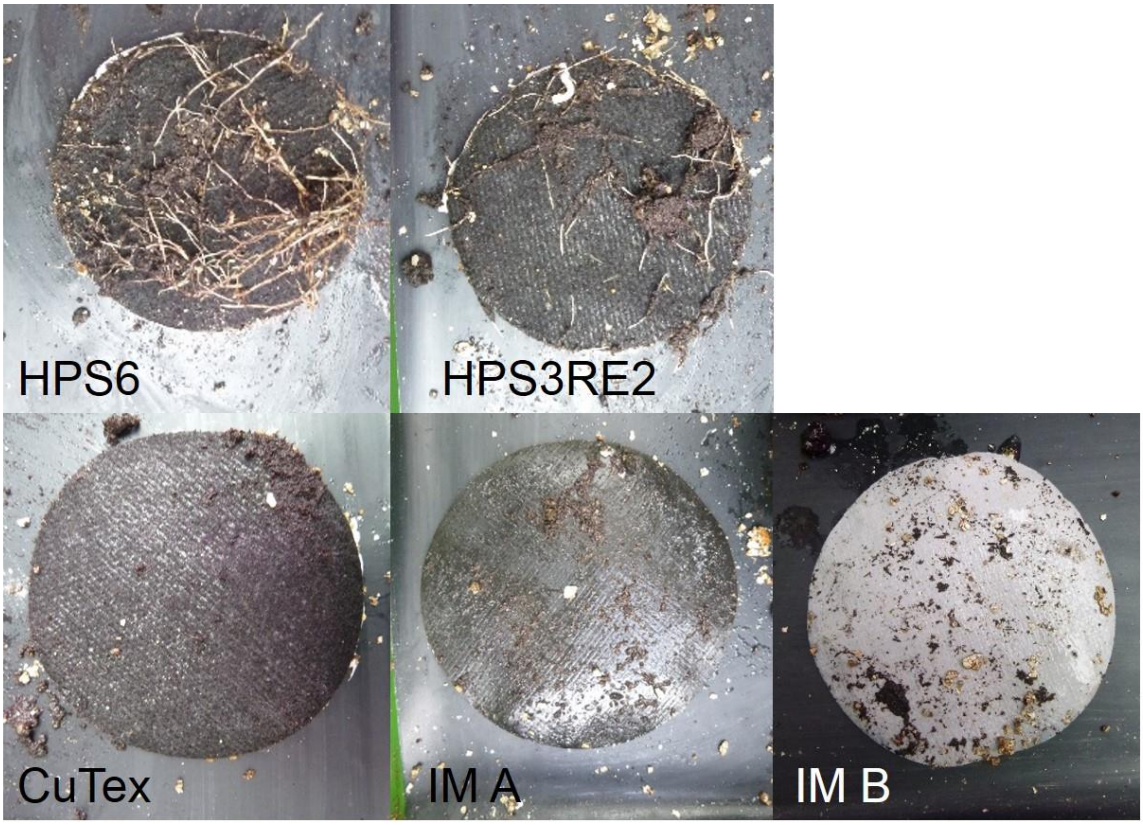

Figure 4: Example photographs of the under-side of specimens, showing presence or absence of lupin root penetration through the specimen.

The only possible explanation for the differences in shoot growth between the CuTex and Impermeable Membrane A/B plants is that the CuTex plants were able to draw water and nutrients from the lower chamber, through the specimen, and into the top chamber. Conversely, the Impermeable Membrane A/B plants were not able to do this and 'starved' as a result. This is consistent with the permeable nature of CuTex, and the impermeable nature of the Impermeable Membrane A/B barriers. **These results imply that Impermeable Membrane A and Impermeable Membrane B barriers block the normal circulation of water/nutrients that occurs in soil systems, but CuTex does not, and allows normal patterns of nutrient movement to occur.**

To demonstrate the differences in the basic material properties of these specimens, we conducted simple 'inundation-drainage' tests, to simulate the effect of heavy rainfall (or equivalent) on ground installed with these different barriers. We applied 500ml of water to each pot in the upper chamber, and tested the time taken for 400ml of water to drain from the base of the pot.

HPS6 offered almost no obstacle to drainage, compared to the no barrier specimens. CuTex and HPS3RE slowed drainage by approximately 4-fold compared to the no-barrier specimens. Consistent with the advertised status, Impermeable Membrane A and Impermeable Membrane B impeded drainage indefinitely. **All specimens reduced drainage; however, while the effect of Impermeable Membrane A and Impermeable Membrane B on water drainage in soil is severe, the effect of CuTex is only moderate.**

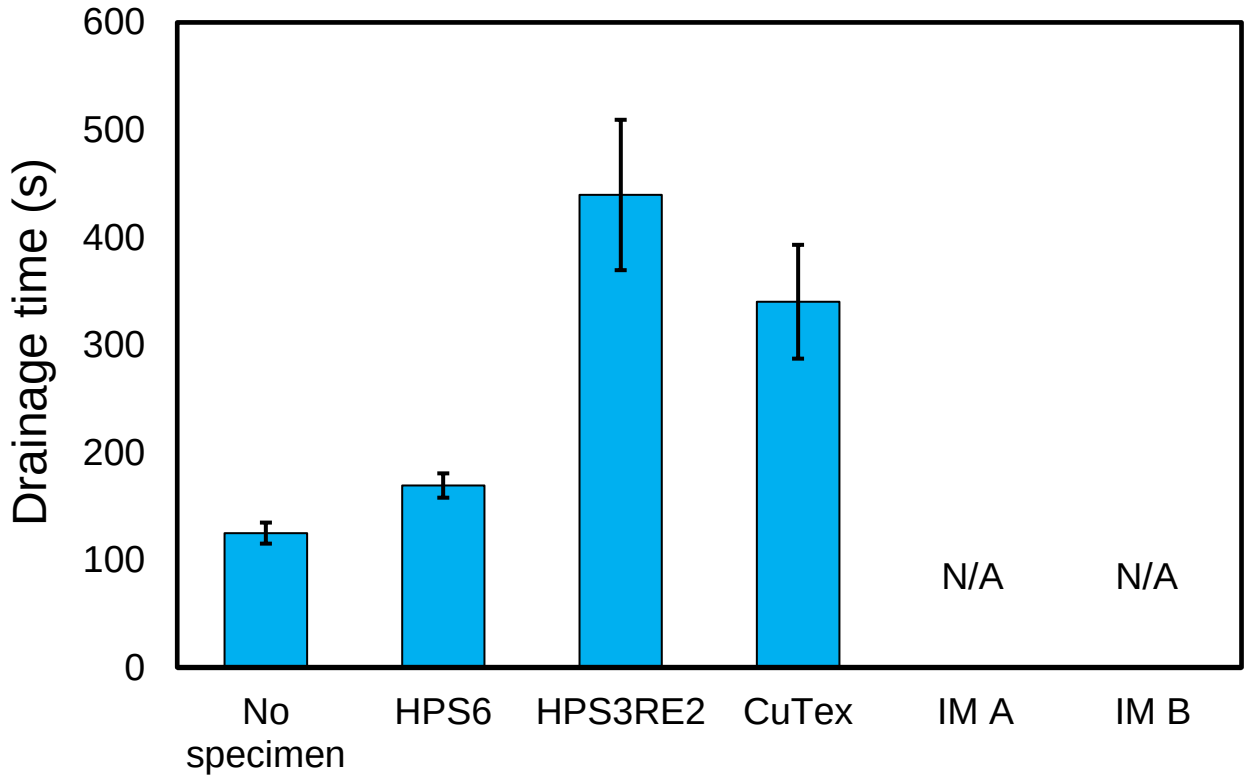

Figure 5: Mean drainage time for 400ml of water from different specimens. N/A – drainage of 400ml did not occur.

6. Test on Japanese knotweed to PD CEN/TS 14416:2014 test standard

We next tested the specimens using freshly extracted Japanese knotweed rhizomes, to test the specimens against a problematic invasive species with a very strong root system. Again, we grew a single plant in each pot for 8 weeks, to give them the maximum possible time to grow through the specimen with strong adult roots.

The results were essentially the same as previously observed with lupins:
a) Shoot growth was strongly inhibited with Impermeable Membrane A and Impermeable Membrane B specimens, consistent with nutrient deprivation in the upper chamber. This was not the case in the CuTex, HPS3RE2 and HPS6 specimens (Figure 6).
b) Roots did not grow through the Impermeable Membrane A, Impermeable Membrane B and CuTex specimens, but did grow through the HPS6 and HPS3RE2 specimens. Correspondingly, there was no root growth in the lower chamber in each of these specimens.

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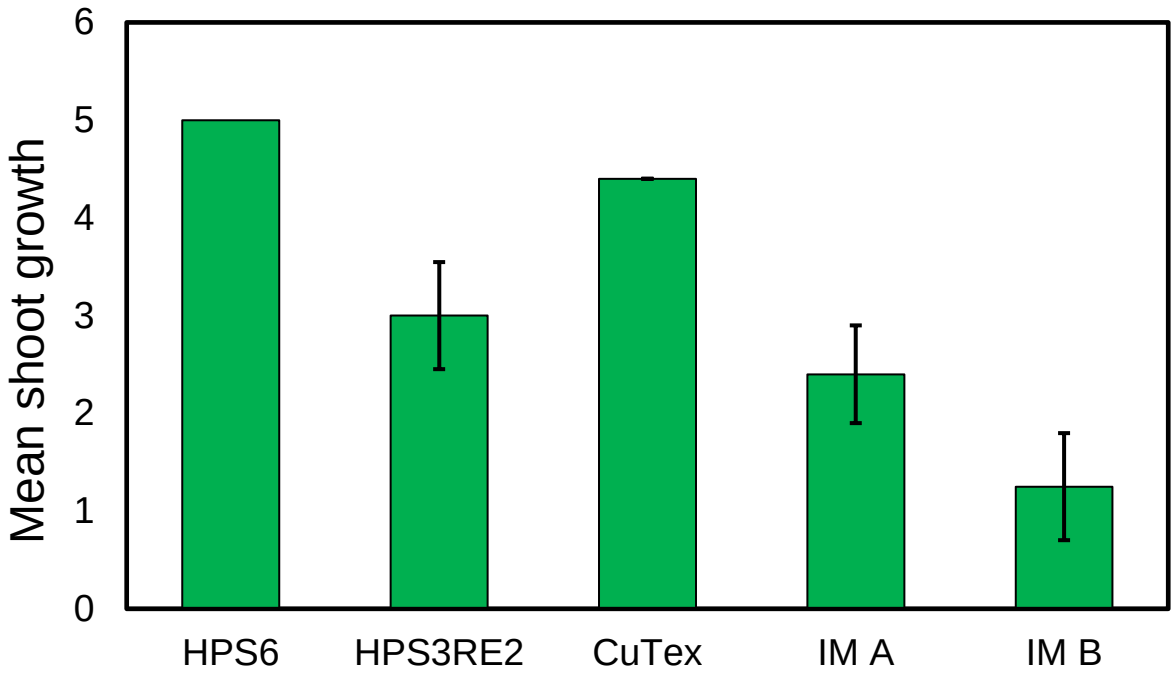

Figure 6: Mean Japanese knotweed shoot growth (on a scale of 0-5) with different specimens.

7. Overall conclusions

From the data we have collected, it is clear that CuTex, Impermeable Membrane A and Impermeable Membrane B are all highly effective root barriers. However, there is a clear difference in the material properties of CuTex and Impermeable Membrane A/B with the permeable nature of CuTex allowing effective drainage through the barrier. Furthermore, CuTex also allows the normal circulation of water and nutrients in the soil, which is strongly inhibited by Impermeable Membrane A and B. It can be assumed that CuTex would also allow efficient exchange of air across the barrier ('breathability') in a way that Impermeable Membrane A/B would not. Thus, while there is little to choose between the materials in terms of their efficiency as root barriers, there is a clear difference between the physical properties of the materials that should be used to inform their installation and use.

Material	Prevents root growth?	Allows shoot growth?	Allows drainage?
HPS6	✗	✓	✓
HPS3RE2	✗	✓	✓
IM A	✓	✗	✗
IM B	✓	✗	✗
CuTex	✓	✓	✓