Assessing pH and EC compatibility of alternative waste derived compost blended with carbon based products to meet Australian Standard for Potting mixes AS-3743-2003

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Tom Wagner

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Project team: Tim Richards[1], Troy Franks[1] (Industry guidance), Bede Mickan[1,2,3,4] (Research manager), Evonne Walker [2] (Technician), Tom Wagner[4] (Visitor Student placement), Megan Ryan [2,3,4].

[1] Richgro Garden Products, 203 Acourt Rd, Jandakot Western Australia 6164, Australia

[2] UWA School of Agriculture and Environment, The University of Western Australia, Perth WA 6009, Australia

[3] The UWA Institute of Agriculture, The University of Western Australia, Perth WA 6009, Australia

[4] Australian Research Council Industry Training Transformation Centre for Transformation of Australia's Biosolids Resource


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BACKGROUND

Home gardening is a key component of Australian culture with approximately 90% of the population maintaining their own private domestic garden (Parker, 2021). Whether growing in pots or in the ground, a crucial part of maintaining any garden begins with soil health. Potting media aids in optimizing root growth, physically supports the plant and provides the nutrients, water and air required for growth and survival (University of Maryland, 2023).

RICHGRO is an Australian-based company that specializes in the production and distribution of gardening and horticultural products, including bagged potting media (Richgro, 2023). The current composition of their potting media (and many others on the market), include a significant proportion of pine bark and sawdust that allows for increased water holding capacity and soil porosity (DPIRD, 2016). In recent years, acquiring affordable, consistent and high-quality pine bark and sawdust for potting mixes has proved challenging for RICHGRO and other companies servicing the production nursery and retail garden sectors. This issue may be explained by a chain reaction of a global shift towards sustainability including the official ban of native logging, timber shortages and the closure of sawmills around Western Australia (ABC News, 2023). Consequently, RICHGRO are seeking new, sustainable substitutes for pine bark and sawdust including using composted waste derived material as a nutrient base: Composted biosolids (COMBIO), Compost 1 (Comp1) and Compost 2 (Comp2). Compost blends 1 and 2 are proprietary blends to Richgro.

This background relates to a former project at the University of Western Australia (UWA) in which the three already mentioned waste derived compost materials ("nutrient bases": COMBIO, Comp1, Comp2) were combined with different waste derived Carbon substrates. The experiment which is subject of this report can be seen as an extension of this former project by adding three new "Carbon bases" (Carbon 1, Carbon 2, Carbon 3, Carbon 4) to the experimental design. It is important to mention that none of the composted substitutes are currently approved under the Australian Standard AS-3743-2003 for bagged retail potting mix. In the Standard protocol there can be found a strict guideline for the EC (Electrical Conductivity) and pH values permitted for potting mixes on the Australian market. Potting mixes are deemed compliant with the Standard if their Electrical Conductivity levels are below 2.2 dS/m, and their pH falls within the range of 5.3 to 6.5. Particularly, the high Electrical Conductivity (EC) of the compost base poses a problem. Consequently, the primary focus of this experiment revolves around reducing the EC, which appears notably high, especially in COMBIO and Comp2, based on the previous tests. This report recognizes other chemical, physical and biological components thresholds are required to meet the AS-3743-2003 requirement, and all of these requirements will need to be met ultimately to meet the standard.

Besides the lab testing, a glasshouse experiment was conducted at the plant growth facilities of University of Western Australia (UWA) to investigate the plant growth performance of Petunia as grown in different ratios of compost and Carbon base. The results will be presented in a different report.

PROJECT OBJECTIVES

1. To determine the EC (Electrical Conductivity) of the different nutrient and Carbon base mixtures.
2. Therefore, the primary aim is to lower the EC of the compost substrate by adding different amounts of Carbon base.
3. To determine the pH levels of the different nutrient and Carbon base mixtures.
4. To evaluate composted biosolids: COMBIO, Comp1 and Comp2 in combination with Carbon 1, Carbon 2, Carbon 3 or Carbon 4 as a suitable substitute for the commonly used base materials in market established Potting mixes.
5. To assess where any of the experimental mixes perform in compliance to the Australian Standard for Potting mixes AS-3743-2003.

ABBREVIATIONS

Composted Biosolids (COMBIO) - This compost involves the use of biosolids – the product of treated organic material from domestic sewage in wastewater treatment plants. These Biosolids can be mixed with other organic materials to create a nutrient-rich compost for gardening and landscaping.

Compost blend 1 (Comp1) - This compost is a proprietary product of Richgro

Compost blend 2 (Comp2) - This compost is a proprietary product of Richgro

Carbon blend 1 (Carbon1) – This Carbon base is derived from an existing waste source

Carbon blend 2 (Carbon2) - This Carbon base is derived from an existing waste source

Carbon blend 3 (Carbon3) - This Carbon base is derived from an existing waste source

Carbon blend 4 (Carbon4) - This Carbon base is derived from an existing waste source

EXECUTIVE SUMMARY

1. EC and pH comparison of the different nutrient and Carbon bases
    a. Comp1 has a significant lower EC (2.66 dS/m) compared to COMBIO (7.33) and Comp2 (7.07)
    b. Along the Carbon bases Carbon 1 shows the lowest EC with 0.14 dS/m and Carbon 4 the highest EC (2.27)
    c. COMBIO (pH = 5.88) has a pH that is located within the Standard area, the pH of Comp1 (7.86) and Comp2 (7.34) goes beyond the upper Standard limitation
    d. The pH of Carbon 1(4.06) and Carbon 2(4.13) is located below the Standard whereas the pH of Carbon 3 (7.01) and Carbon 4 (7.51) surpass the Standard
2. Carbon source 1 (Carbon 1) trial
    a. Carbon 1 has a dilution impact on EC of all three nutrient bases
    b. Concerning pH, it is the opposite. Carbon 1 shows NO dilution impact on COMBIO, Comp1 or Comp2
3. Carbon source 2 (Carbon 2) trial
    a. Carbon 2 demonstrates a dilution impact on EC of all three nutrient bases
    b. Carbon 2 shows a slightly lower pH of Comp1 but shows NO dilution impact on COMBIO and Comp2
4. Carbon source 3 (Carbon 3) trial
    a. Carbon 3 have a dilution impact on EC of all three nutrient bases
    b. Carbon 3 increases the pH of COMBIO, slightly lowers the pH of Comp1 and shows no effects on pH with Comp2
5. Carbon source 4 (Carbon 4) trial
    a. Carbon 4 has NO dilution impact of EC with Comp1 but lowers the EC of COMBIO and Comp2. Compared to the other Carbon bases this effect appears to be less marked
    b. Carbon 4 increases the pH of COMBIO and has NO effect on pH with Comp1 and Comp2

6. EC and pH compliance to AUS-3743-2003 Standard
    a. Many treatments show EC compliance to the Standard
    b. But pH is too high overall to meet the Standard guidelines
    c. Only two treatments pass the Standard in both EC and pH

Across all the experimental mixes performed in these experiments COMBIO with Carbon 1 (25% COMBIO, 75% Carbon 1) and COMBIO with Carbon 2 (25% COMBIO, 75% Carbon 2) performed the best. Both treatments show compliance to the pH and EC levels in the AUS Standard.

EXPERIMENTAL DRAFT

In this experiment different compost base materials ("nutrient bases") (COMBIO, Comp1, Comp2) were combined with different "Carbon bases" (Carbon 1, Carbon 2, Carbon 3, Carbon 4). The mixtures differ in ratio from 100% nutrient base - 0% Carbon base to 0% nutrient base - 100% Carbon base in 25% percent steps.

In total, the experiment consists of 43 treatments with three reps each. The exact composition of the different treatments can be found in the spreadsheet on the following page.

Table 1: Composition of Experimental Treatments Combining Alternative Nutrient Bases (Compost) with Carbon Bases for Potting Media Development

Note: Due to commercial sensitivity, some blend names are non-descriptive or abbreviated.

Nutrient base	Carbon Base	Nutrient Fraction	Carbon fraction
COMBIO	Carbon 1	100%	0%
COMBIO	Carbon 1	75%	25%
COMBIO	Carbon 1	50%	50%
COMBIO	Carbon 1	25%	75%
COMBIO	Carbon 1	0%	100%
COMBIO	Carbon 2	100%	0%
COMBIO	Carbon 2	75%	25%
COMBIO	Carbon 2	50%	50%
COMBIO	Carbon 2	25%	75%
COMBIO	Carbon 2	0%	100%
COMBIO	Carbon 3	100%	0%
COMBIO	Carbon 3	75%	25%
COMBIO	Carbon 3	50%	50%
COMBIO	Carbon 3	25%	75%
COMBIO	Carbon 3	0%	100%
COMBIO	Carbon 4	100%	0%
COMBIO	Carbon 4	75%	25%
COMBIO	Carbon 4	50%	50%
COMBIO	Carbon 4	25%	75%
COMBIO	Carbon 4	0%	100%
Comp1	Carbon 1	100%	0%
Comp1	Carbon 1	75%	25%
Comp1	Carbon 1	50%	50%
Comp1	Carbon 1	25%	75%
Comp1	Carbon 1	0%	100%
Comp1	Carbon 2	100%	0%
Comp1	Carbon 2	75%	25%
Comp1	Carbon 2	50%	50%
Comp1	Carbon 2	25%	75%
Comp1	Carbon 2	0%	100%
Comp1	Carbon 3	100%	0%
Comp1	Carbon 3	75%	25%
Comp1	Carbon 3	50%	50%
Comp1	Carbon 3	25%	75%
Comp1	Carbon 3	0%	100%
Comp1	Carbon 4	100%	0%
Comp1	Carbon 4	75%	25%
Comp1	Carbon 4	50%	50%
Comp1	Carbon 4	25%	75%
Comp1	Carbon 4	0%	100%
Comp2	Carbon 1	100%	0%
Comp2	Carbon 1	75%	25%
Comp2	Carbon 1	50%	50%
Comp2	Carbon 1	25%	75%
Comp2	Carbon 1	0%	100%
Comp2	Carbon 2	100%	0%
Comp2	Carbon 2	75%	25%
Comp2	Carbon 2	50%	50%
Comp2	Carbon 2	25%	75%
Comp2	Carbon 2	0%	100%
Comp2	Carbon 3	100%	0%
Comp2	Carbon 3	75%	25%
Comp2	Carbon 3	50%	50%
Comp2	Carbon 3	25%	75%
Comp2	Carbon 3	0%	100%
Comp2	Carbon 4	100%	0%
Comp2	Carbon 4	75%	25%
Comp2	Carbon 4	50%	50%
Comp2	Carbon 4	25%	75%
Comp2	Carbon 4	0%	100%

MATERIALS AND METHODS

1) All nutrient, and Carbon base products (COMBIO, Comp1, Comp2, Carbon 1, Carbon 2, Carbon 3, Carbon 4) were prepared and produced at the RICHGRO facilities. After transport to University of Western Australia (UWA) campus Crawley, the material was manually sieved through an 8mm sieve at the UWA soil science facilities except COMBIO and Carbon 1. Both products were already screened at RICHGRO facilities.

2) After finalising the sieving process, the treatments have been mixed in 20l bag sizes in accordance with the table on the previous page.

3) For pH and EC testing, samples of 200ml size were premoistened eight days before testing and stored in a safe environment to prevent drying out.

4) All pH and EC analysis on organic substrates were performed at the University of Western Australia soil sciences laboratories, following Appendices D and G of the Australian Standard 3743-2003 procedures. All samples were analysed in triplicate and presented as the mean with the standard error of the mean in error bars.

RESULTS

PH AND EC COMPARISON OF NUTRIENT AND CARBON BASES

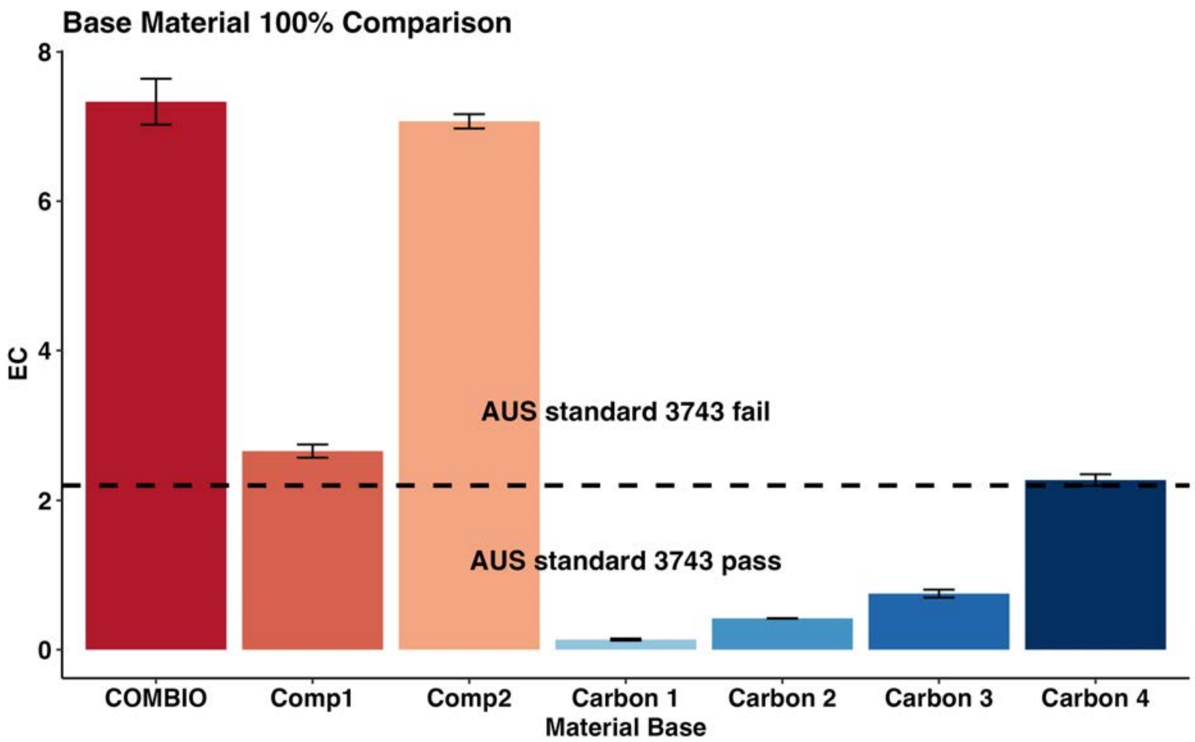

Figure 1 Substrate electrical conductivity (EC) comparison between the three compost materials as a nutrient base (Composted biosolids: COMBIO, Compost 1, Compost 2) and four different Carbon bases derived from organic waste material (Carbon 1, 2, 3, 4), EC in dS/m, bars are the mean of each treatment and the error bars are the standard error of the mean (n=3).

- Comp1 has a significant lower EC (2.66 dS/m) compared to COMBIO (7.33) and Comp2 (7.07).
- None of the nutrient bases pass the Standard (< 2.2 dS/m).
- Along the Carbon substrates Carbon 1(0.14) has by far the lowest level of EC.
- Carbon 4 itself shows a quit high EC with 2.27 dS/m and therefore doesn’t pass the Standard, albeit being close.

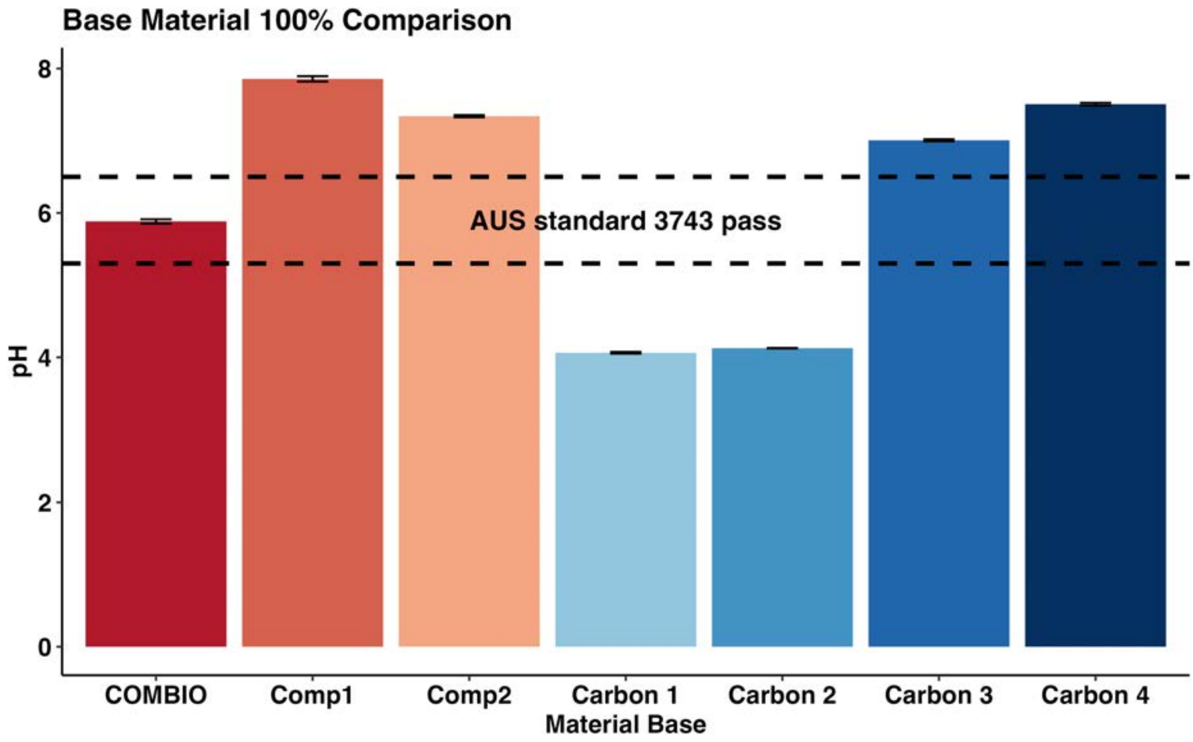

Figure 2 Substrate pH comparison between the three compost materials as a nutrient base (Composted biosolids: COMBIO, Compost 1, Compost 2) and four different Carbon bases derived from organic waste material (Carbon 1, 2, 3, 4), bars are the mean of each treatment and the error bars are the standard error of the mean (n=3).

- Out of all of the nutrient bases only COMBIO passes the Standard (pH = 5.88) for pH
- The pH levels of Comp1 (7.86) and Comp2 (7.34) surpass the Standard
- Whereas Carbon 1(4.06) and Carbon 2 (4.13) display a lower pH due to their comparatively low pH levels, the pH of Carbon 3 (7.01) and Carbon 4 (7.51) goes beyond the upper limit of the Standard

BLENDING NUTRIENT BASE SUBSTRATES WITH CARBON BASE MATERIALS TO MEET EC AND PH REQUIREMENTS

CARBON 1 TRIAL

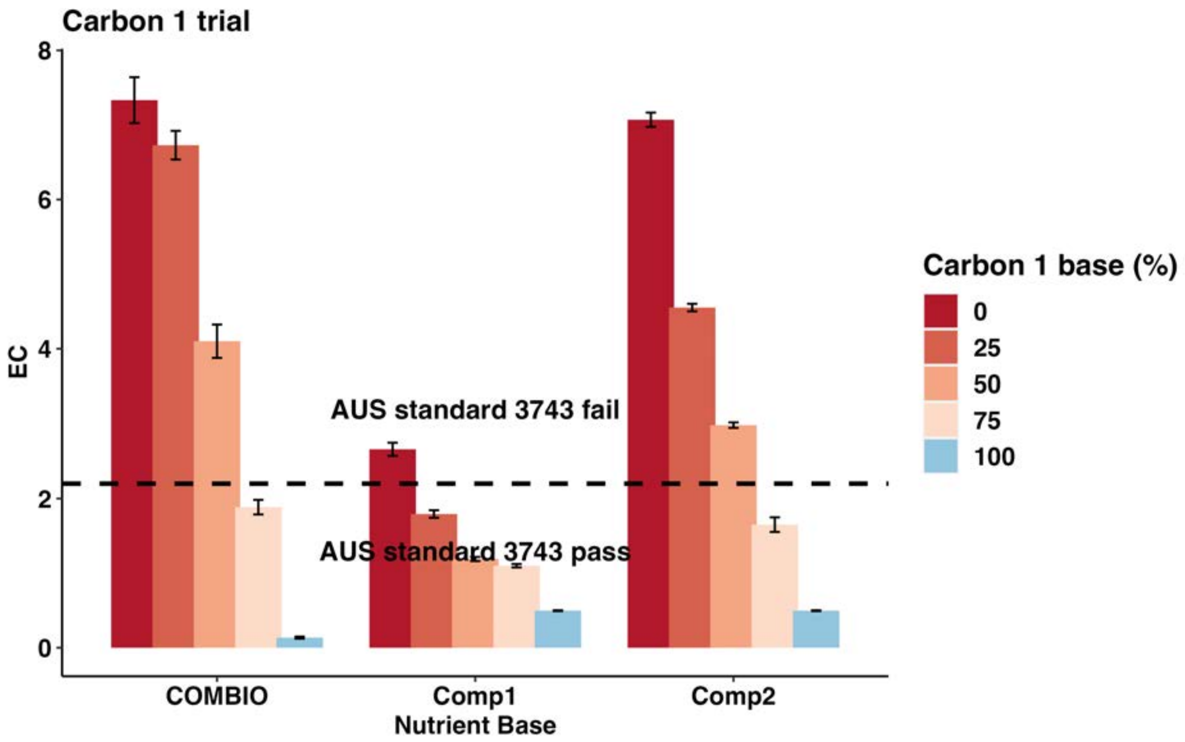

Figure 3 Overview of all Carbon 1 treatments blended with nutrient bases (v/v) EC in dS/m. Ratios of mixes are proportional to nutrient base (Composted biosolids: COMBIO, Compost 1, Compost 2), with a single Carbon base (Carbon 1 treatment). Bars are the mean of each treatment and the error bars are the standard error of the mean (n=3).

- Carbon 1 has a dilution impact on EC with COMBIO
- Carbon 1 has a dilution impact on EC with Comp1
- Carbon 1 has a dilution impact on EC with Comp2
- It is safe to mention that the EC of the different Carbon 1 mixed products showed slight differences; the observed differences are more extreme in pH
- Treatments COMBIO with Carbon 1(25% COMBIO, 75% Carbon1) and Comp2 with Carbon (25% Comp2, 75% Carbon1) pass the EC Standard requirements

- Because of the relatively low EC of Comp1, treatments Comp1 with Carbon 1 (50% Comp1, 50% Carbon1) and Comp1 with Carbon 1 (25% Comp1, 75% Carbon 1) pass the Standard on top of treatment Comp1 with Carbon 1 (75% Comp1, 25% Carbon 1)
- All treatments with the 75% Carbon base ratio pass the EC Standard requirements

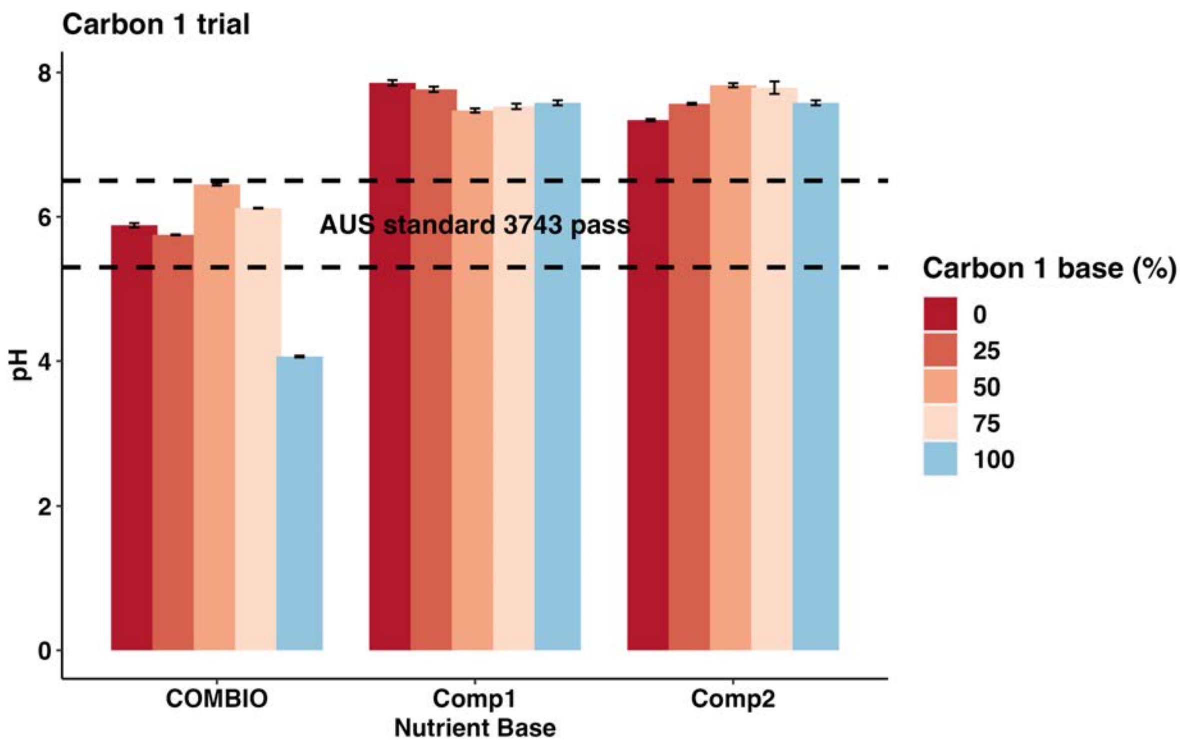

Figure 4 Overview of all Carbon 1 treatments blended with nutrient bases (v/v) pH. Ratios of mixes are proportional to nutrient base (Composted biosolids: COMBIO, Compost 1, Compost 2), with a single Carbon base (Carbon1 treatment). **B**ars are the mean of each treatment and the error bars are the standard error of the mean (n=3).

- Carbon 1 has NO dilution impact on pH with COMBIO
- Carbon 1 has NO dilution impact on pH with Comp1
- NO changes in pH with adding Carbon 1 in Comp2
- BUT: significant differences in pH could be observed in different bags of Carbon 1 (4.06 vs. 7.58)

- Treatments COMBIO with Carbon 1 (75% COMBIO, 25% Carbon1), COMBIO with Carbon 1 (50% COMBIO, 50% Carbon1) and COMBIO with Carbon 1 (25% COMBIO, 75% Carbon 1) pass the pH Standard requirements

- None of the other treatments with Comp1 or Comp2 pass the Standard

CARBON 2 TRIAL

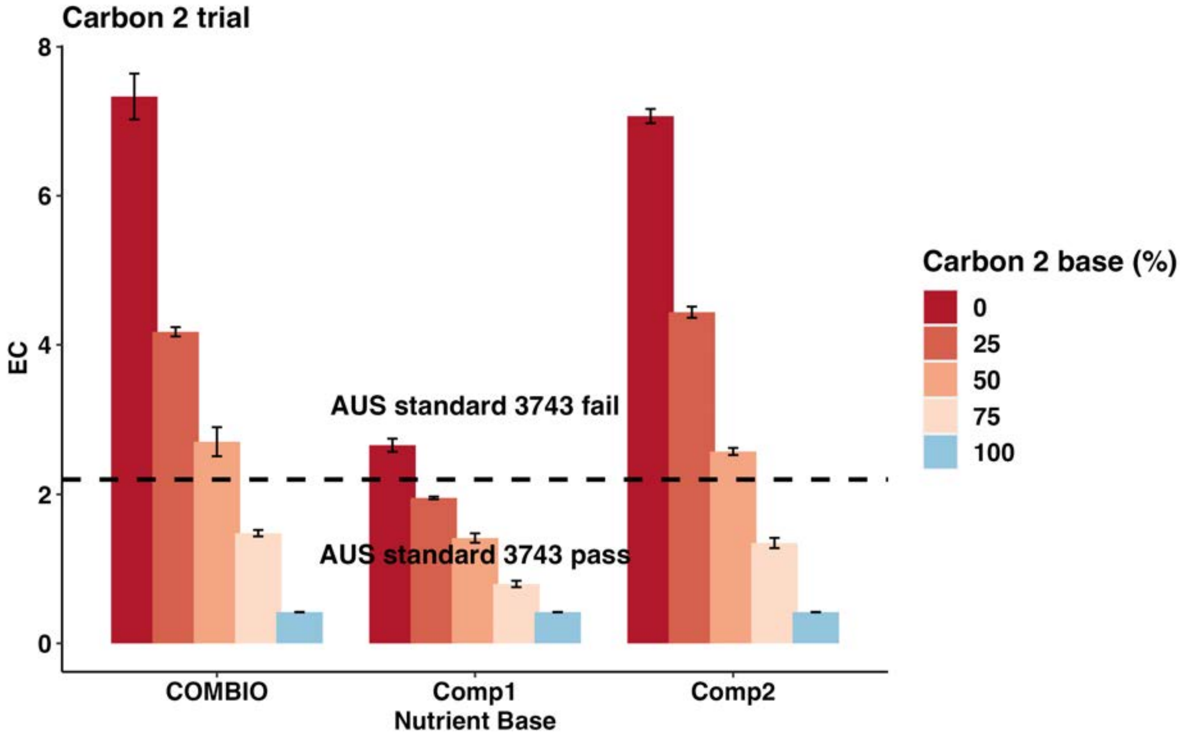

Figure 5 Overview of all Carbon 2 treatments blended with nutrient bases (v/v) EC in dS/m. Ratios of mixes are proportional to nutrient base (Composted biosolids: COMBIO, Compost 1, Compost 2), with a single Carbon base (Carbon 2 treatment). Bars are the mean of each treatment and the error bars are the standard error of the mean (n=3).

- Carbon 2 have a dilution impact on EC with COMBIO
- Carbon 2 have a dilution impact on EC with Comp1
- Carbon 2 have a dilution impact on EC with Comp2

- All treatments with the 75% Carbon base ratio pass the EC Standard
- On top of that, the 50% and 25% Comp1 ratios show lower EC levels than 2.2 dS/m

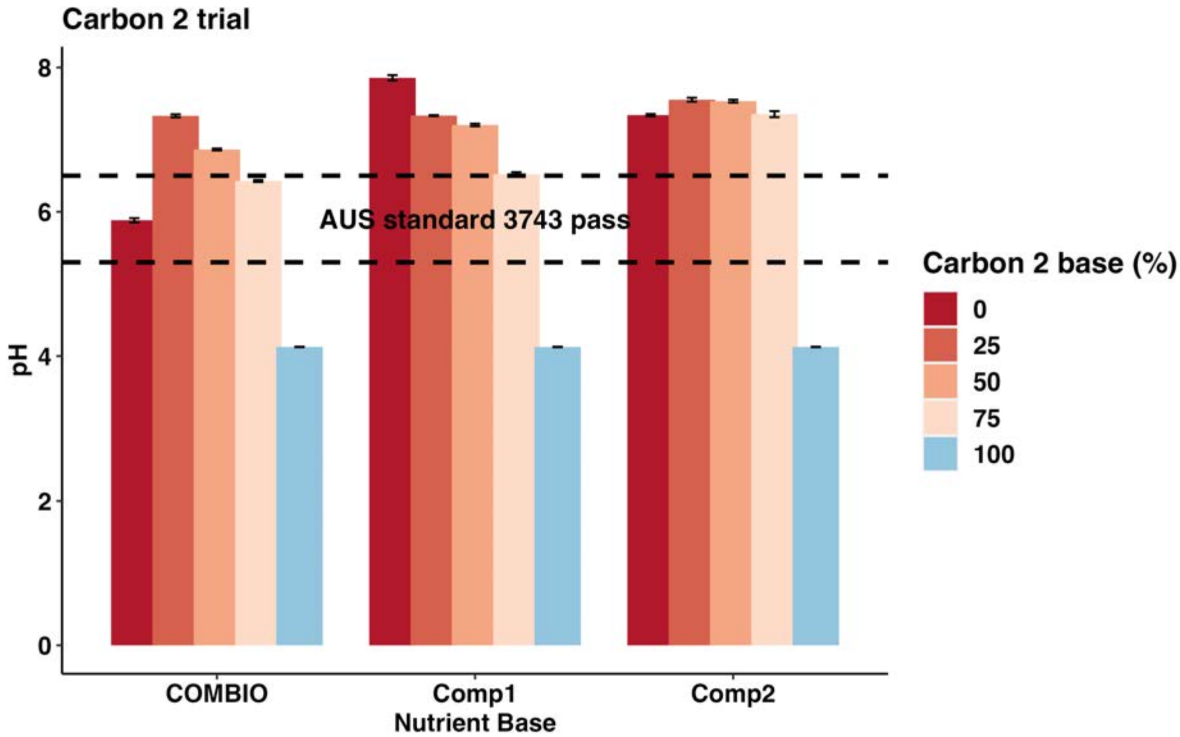

Figure 6 Overview of all Carbon 2 treatments blended with nutrient bases (v/v) pH. Ratios of mixes are proportional to nutrient base (Composted biosolids: COMBIO, Compost 1, Compost 2), with a single Carbon base (Carbon 2 treatment). Bars are the mean of each treatment and the error bars are the standard error of the mean (n=3).

- Crushed Logs have NO dilution impact on pH with COMBIO
- Crushed Logs slightly lowers the pH of Comp1
- NO changes in pH with adding Carbon 2 in Comp2 – Comp2 has a strong buffer against capacity acidity with Carbon 2

- Only treatment COMBIO with Carbon 2 (25% COMBIO, 75% Carbon 2) is located in between the Standard borders

CARBON 3 TRIAL

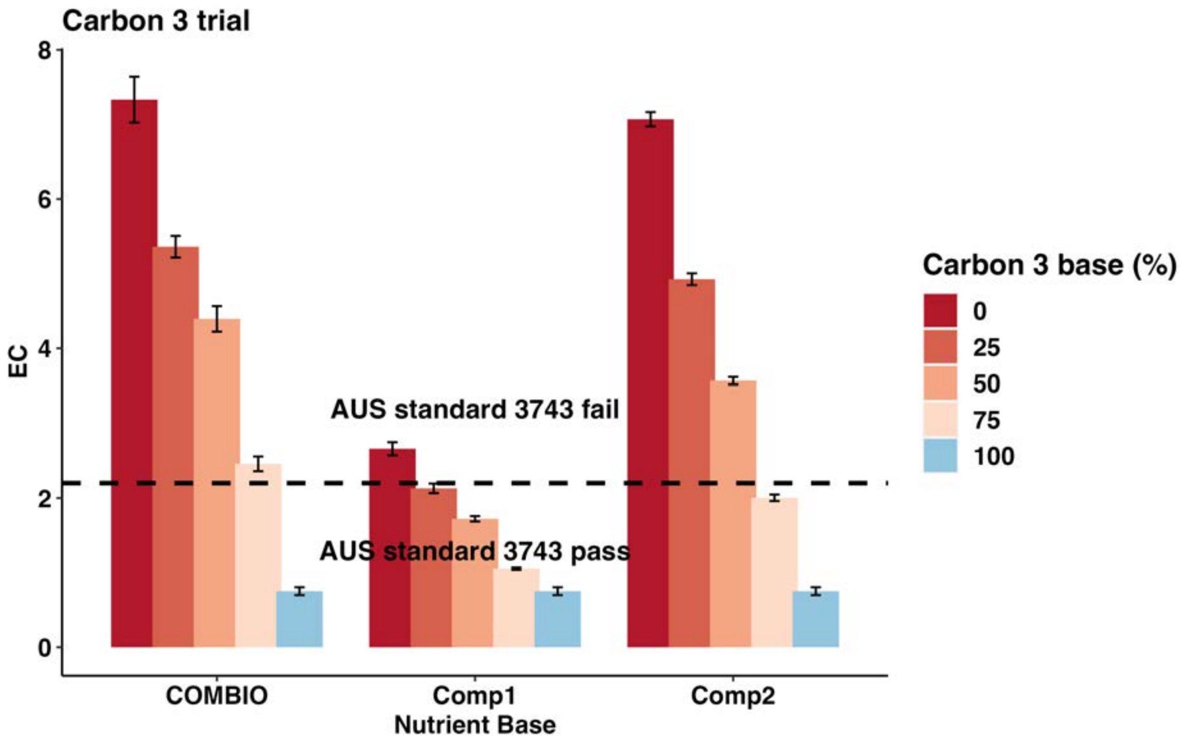

Figure 7 Overview of all Carbon 3 treatments blended with nutrient bases (v/v) EC in dS/m. Ratios of mixes are proportional to nutrient base (Composted biosolids: COMBIO, Compost 1, Compost 2), with a single Carbon base (Carbon 3 treatment). Bars are the mean of each treatment and the error bars are the standard error of the mean (n=3).

- Carbon 3 have a dilution impact on pH with COMBIO
- Carbon 3 have a dilution impact on pH with Comp1
- Carbon 3 have a dilution impact on pH with Comp2

- Comp1 with Carbon 3 (75% Comp1, 25% Carbon 3), Comp1 with Carbon 3 (50% Comp1, 50% Carbon 3), Comp1 with Carbon 3 (25% Comp1, 75% Carbon 3) and treatment Comp2 with Carbon 3 (25% Comp2, 75% Carbon 3) pass the Standard for EC requirements.

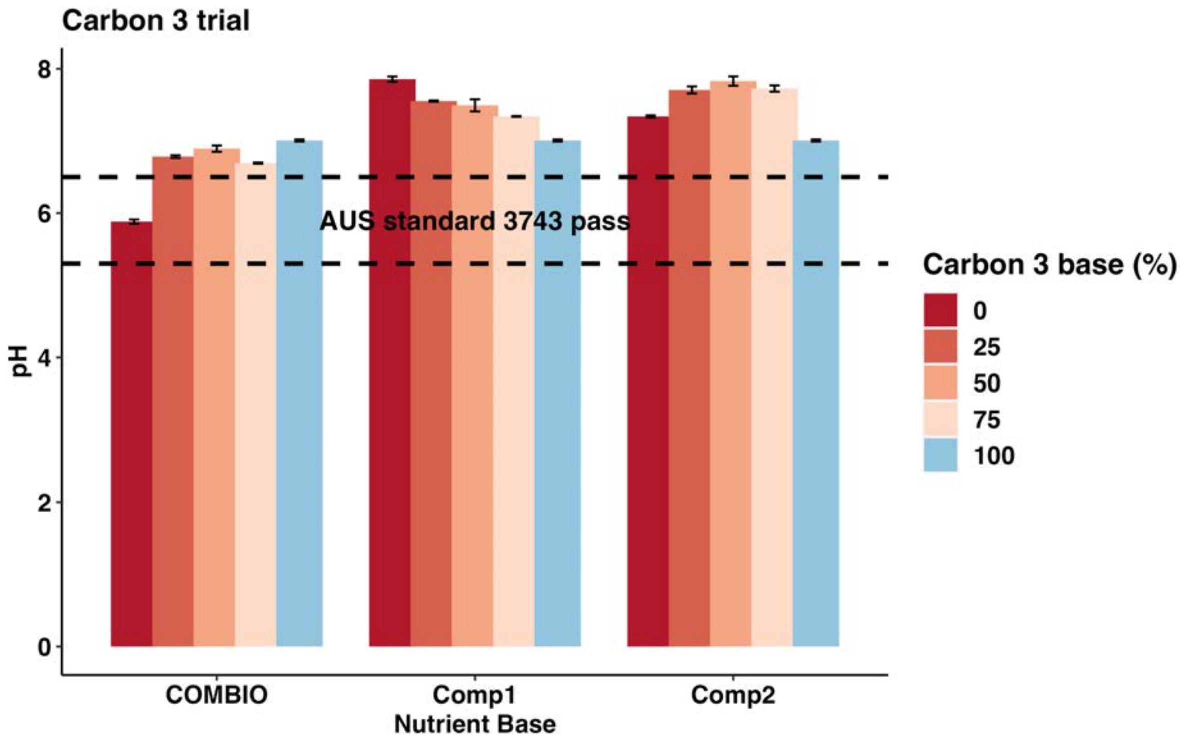

Figure 8 Overview of all Carbon 3 treatments blended with nutrient bases (v/v) pH. Ratios of mixes are proportional to nutrient base (Composted biosolids: COMBIO, Compost 1, Compost 2), with a single Carbon base (Carbon 3 treatment). Bars are the mean of each treatment and the error bars are the standard error of the mean (n=3).

- Carbon 3 substrate have an increasing effect on pH with COMBIO
- Carbon 3 substrate have a slightly dilution impact on pH with Comp1
- NO changes in pH with adding Carbon 3 substrate in Comp2
- None of the Carbon 3 materials in combination with any of the nutrient base treatments pass the Standard!

CARBON4 TRIAL

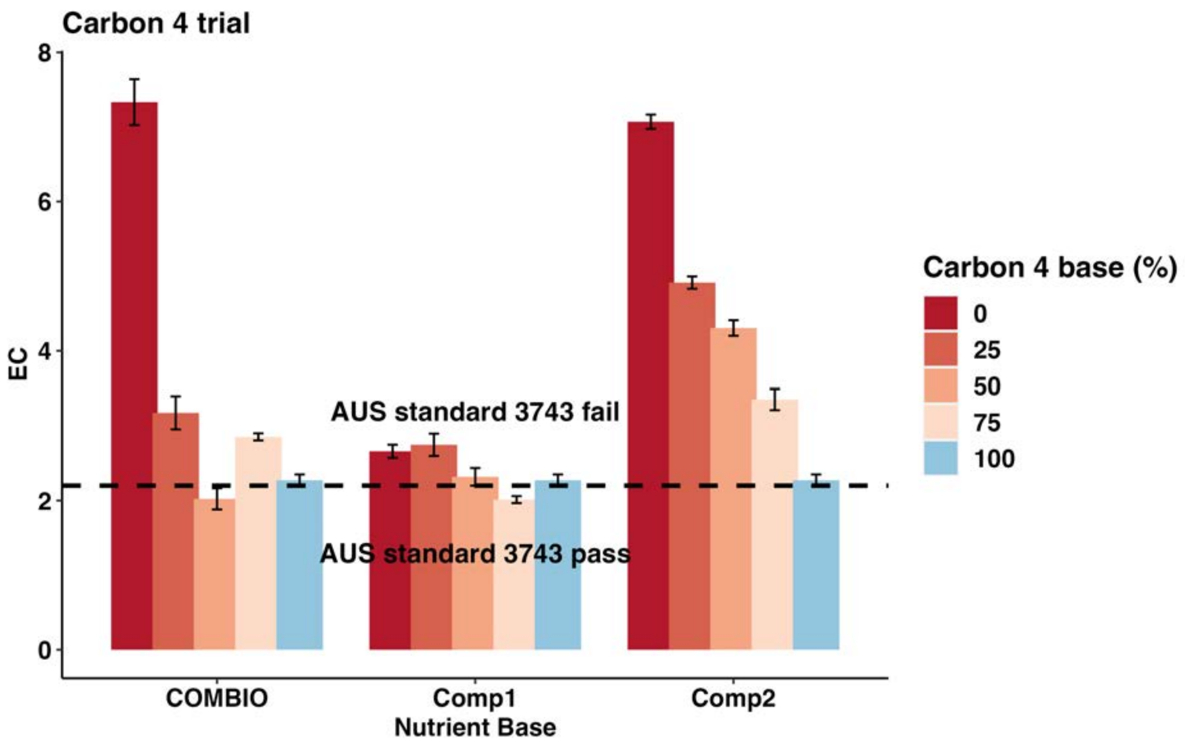

Figure 9 Overview of all Carbon 4 treatments blended with nutrient bases (v/v) EC in dS/m. Ratios of mixes are proportional to nutrient base (Composted biosolids: COMBIO, Compost 1, Compost 2), with a single Carbon base (Carbon 4 treatment). Bars are the mean of each treatment and the error bars are the standard error of the mean (n=3).

- Carbon 4 has a dilution impact on EC with COMBIO and Comp2 – but not that strong compared to the other Carbon bases
- Carbon 4 has <u>NO</u> dilution impact of EC with Comp1

- Treatment COMBIO with Carbon 4 (50% COMBIO, 50% Carbon 4) passes the EC Standard requirement
- Treatment Comp1 with Carbon 4 (25% Comp1, 75% Carbon 4) passes the EC Standard requirement

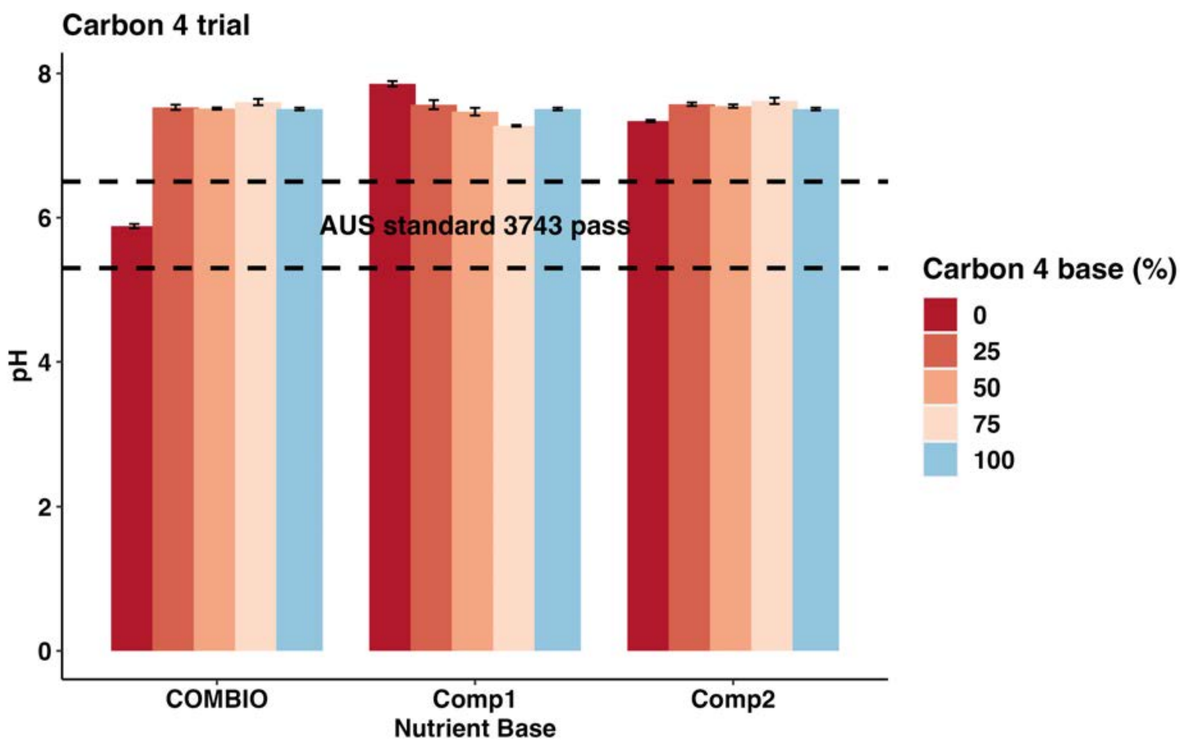

Figure 10 Overview of all Carbon 4 treatments blended with nutrient bases (v/v) pH. Ratios of mixes are proportional to nutrient base (Composted biosolids: COMBIO, Compost 1, Compost 2), with a single Carbon base (Carbon 4 treatment). Bars are the mean of each treatment and the error bars are the standard error of the mean (n=3).

- Carbon 4 has an increasing effect on pH with COMBIO.
- NO changes in pH with adding Carbon 4 in Comp1 and Comp2.
- None of the treatments with the addition of Carbon 4 treatments pass the Standard.

CONCLUSIONS

The results show a successful trial of a wide range of potting mixes to meet the EC, and pH Standard requirement. According to the project objectives several treatments could be identified which pass the Australian Standard for potting mixes in terms of Electrical Conductivity (EC). The aim of this experiment was to lower the ordinarily high EC of the three compost materials by adding different Carbon bases.

Out of the Carbon bases Carbon 1 and Carbon 2 performed best and show a great ability to lower the EC, especially with COMBIO and Comp2. In contrast, Carbon 4 has a significant higher EC itself and therefore appears not to be a suitable Carbon substrate in regards to the EC and pH requirements.

Considering that most treatments that meet the Standard EC regulations consist of 75% Carbon base ratio or relate to Comp1, the corresponding glasshouse experiment at UWA should investigate in what plant growth performance these treatments lead. On top of that, consideration may be given to increase the EC limitation in the Standard protocol if the glasshouse trial shows good performance results in treatments that don't meet the Standard guidelines.

Concerning pH, nearly all treatments show a pH that is too high overall and therefore need some work to pass the Standard. Out of all treatments, the COMBIO-Carbon 1 mixtures performed well and meet the Standard guidelines.

In conclusion, only two treatments could be identified which pass the Australian Standard for potting mixes in both EC and pH.

RECOMMENDATIONS

- Market ready products:
  Treatments COMBIO with Carbon 1(25% COMBIO 75% Mixed Sawdust)

and COMBIO with Carbon 2 (25% COMBIO 75% Crushed Logs)

- To manipulate pH in treatments that pass the Standard in EC
- References

- Parker https://www.theconnective.co/2021/02/17/the-value-of-backyards/#:~:text=Today%2C%20nearly%2090%25%20of%20Australians,their%20main%20form%20of%20exercise

- University of Maryland https://extension.umd.edu/resource/growing-media-potting-soil-containers#:~:text=Growing%20media%20(medium)%20or%20potting,Physically%20supports%20the%20plant

- Richgro https://www.richgro.com.au/about-us/

- DPIRT https://www.agric.wa.gov.au/nursery-cutflowers/potting-mixes

- ABC News https://www.abc.net.au/news/rural/2023-05-04/great-southern-sawmill-to-close-june-ahead-of-native-logging-ban/102297442

- EMRC 2023 https://www.emrc.org.au/operations-and-projects/fogo-food-organics-and-garden-organics/fogo.aspx