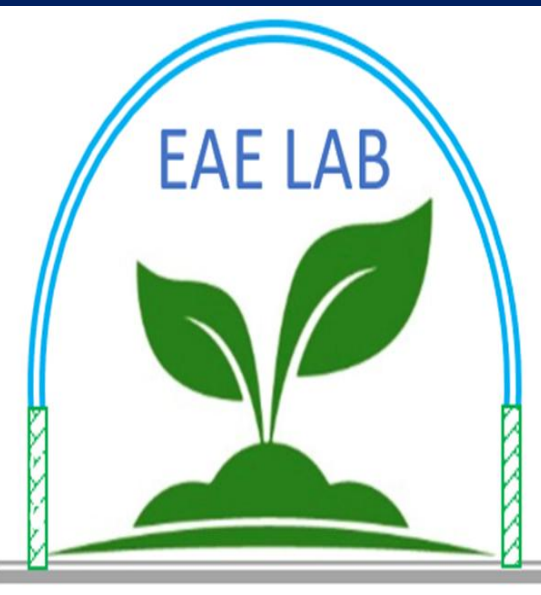


Effects of Root-Zone Aeration on Root Development and Yield of Greenhouse Lettuce (*Lactuca sativa* L.)



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Introduction

- Controlled-environment agriculture (CEA) enables efficient year-round lettuce production
- Poor aeration in soilless substrates can cause hypoxia, limiting root respiration
- Root-zone oxygen strongly affects plant growth and yield.

Knowledge gap

- Root-zone hypoxia limits soilless crop performance.
- Existing studies focus on high aeration in hydroponics, not leafy vegetables in substrates.
- Effects of airflow on the roots of leafy greens remain unclear.
- Substrate x aeration interactions are largely unexplored.

Objectives

- Evaluate the effect of root-zone aeration on lettuce
- To observe the root morphology trend
- To compare root aeration responses across different substrates
- Identify the optimal aeration-substrate combination

Effects of root hypoxia

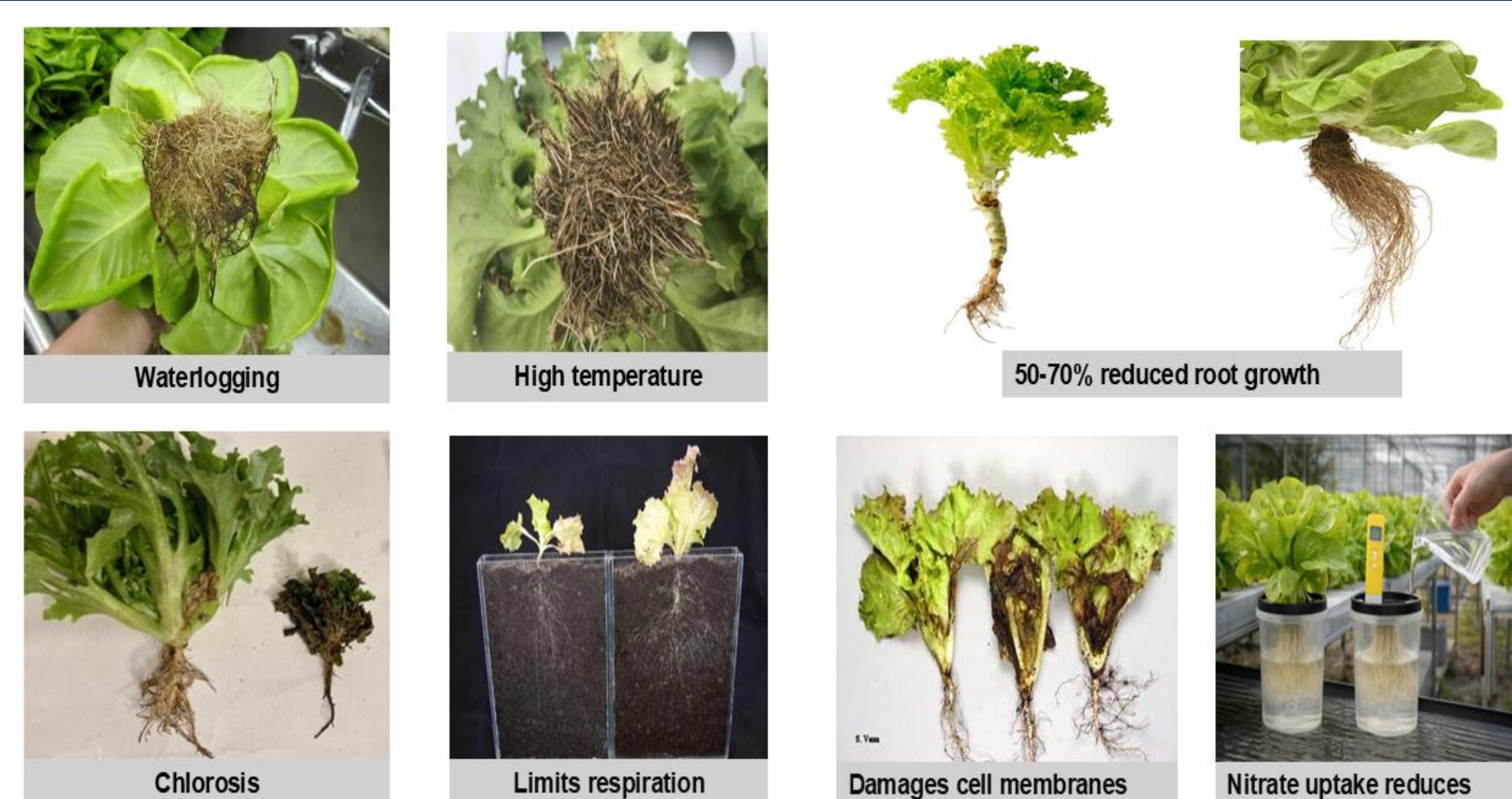


Figure 1: Effects of hypoxia on lettuce roots

Materials and methods



Figure 2: Substrates used in the experiment

- Experimental design: Factorial experiment (aerated, non-aerated)
- Treatments: Eight combinations: T1, T2, T3, T4 (aerated) and T1C, T2C, T3C, T4C (non-aerated controls).

Experimental setup



Figure 3: Experimental bench

Root scanning procedure



Figure 8: Regent LA2400 Scanner

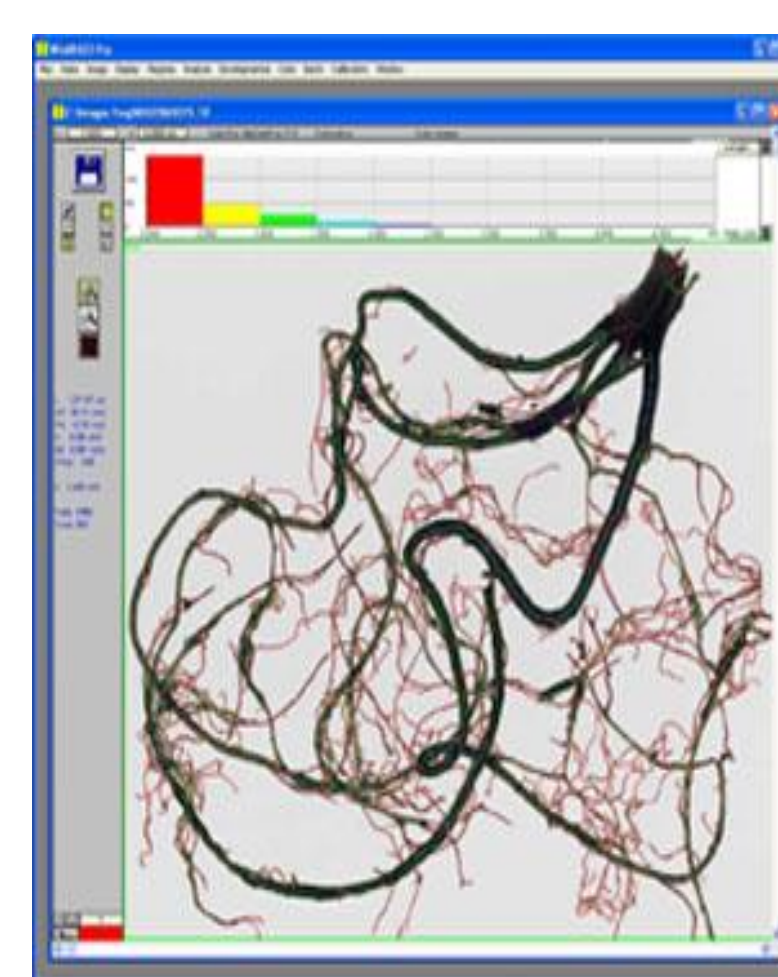


Figure 9: WinRhizo software

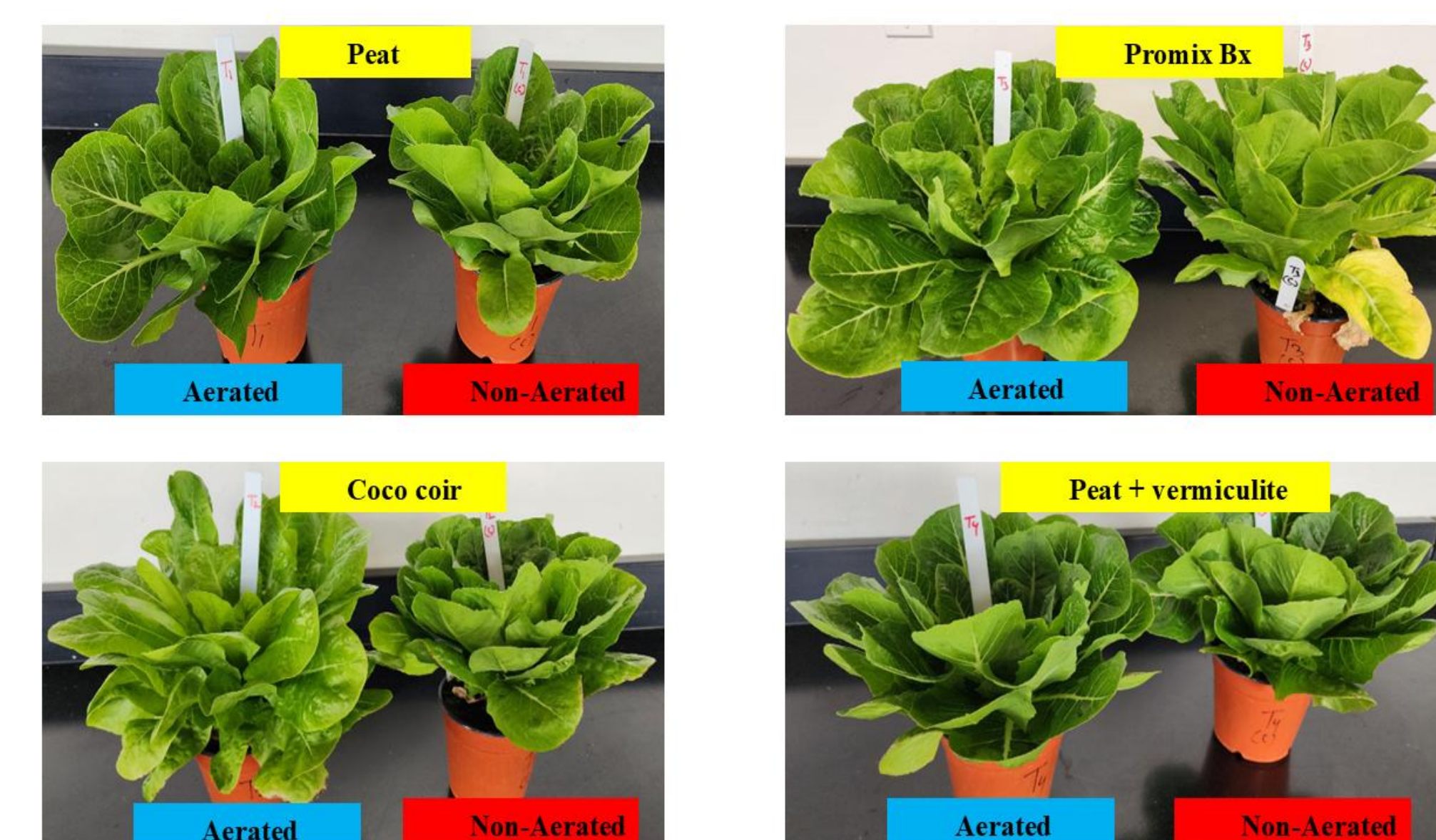


Figure 10: Lettuce at harvesting

Results

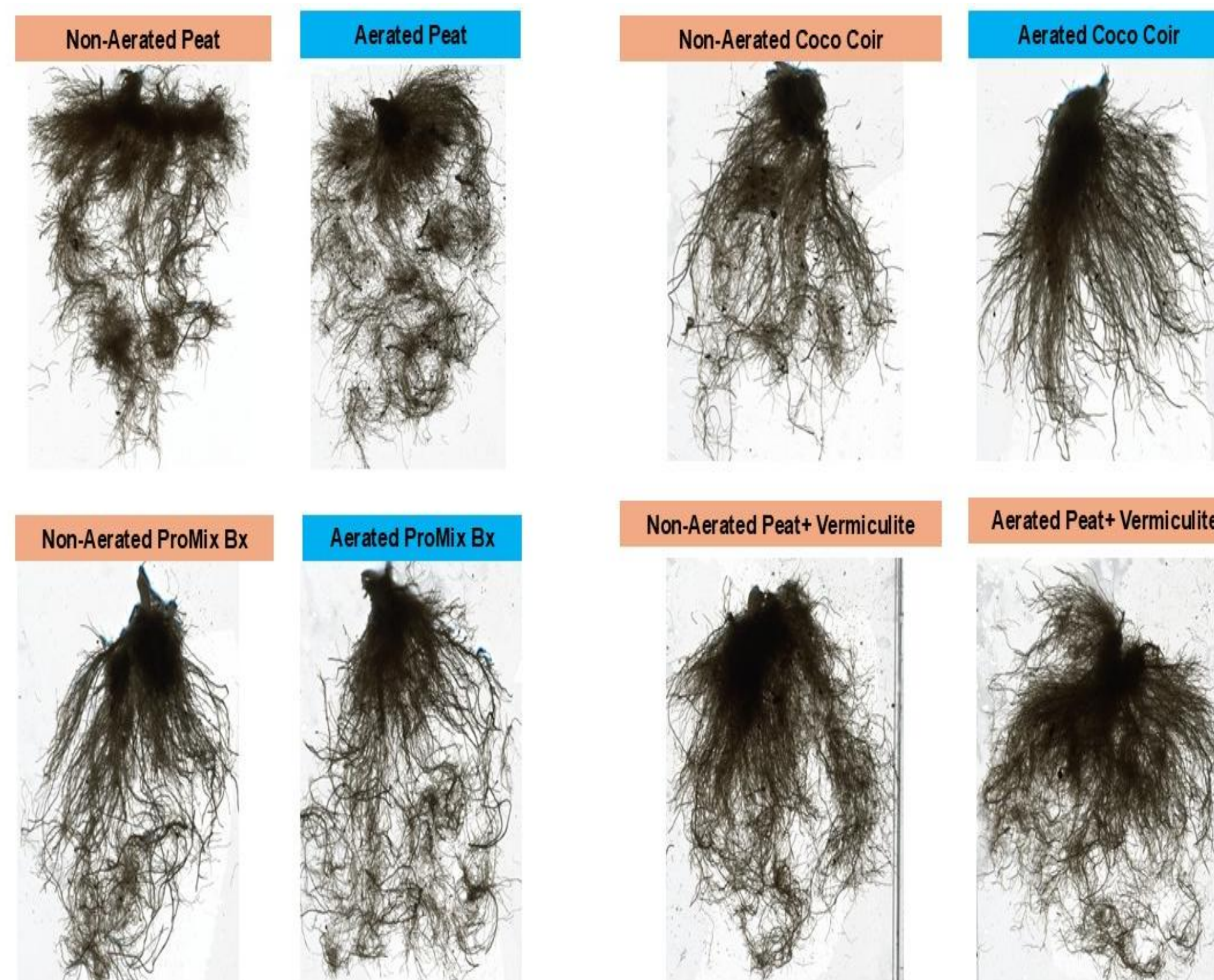


Figure 4: Scanned root architecture

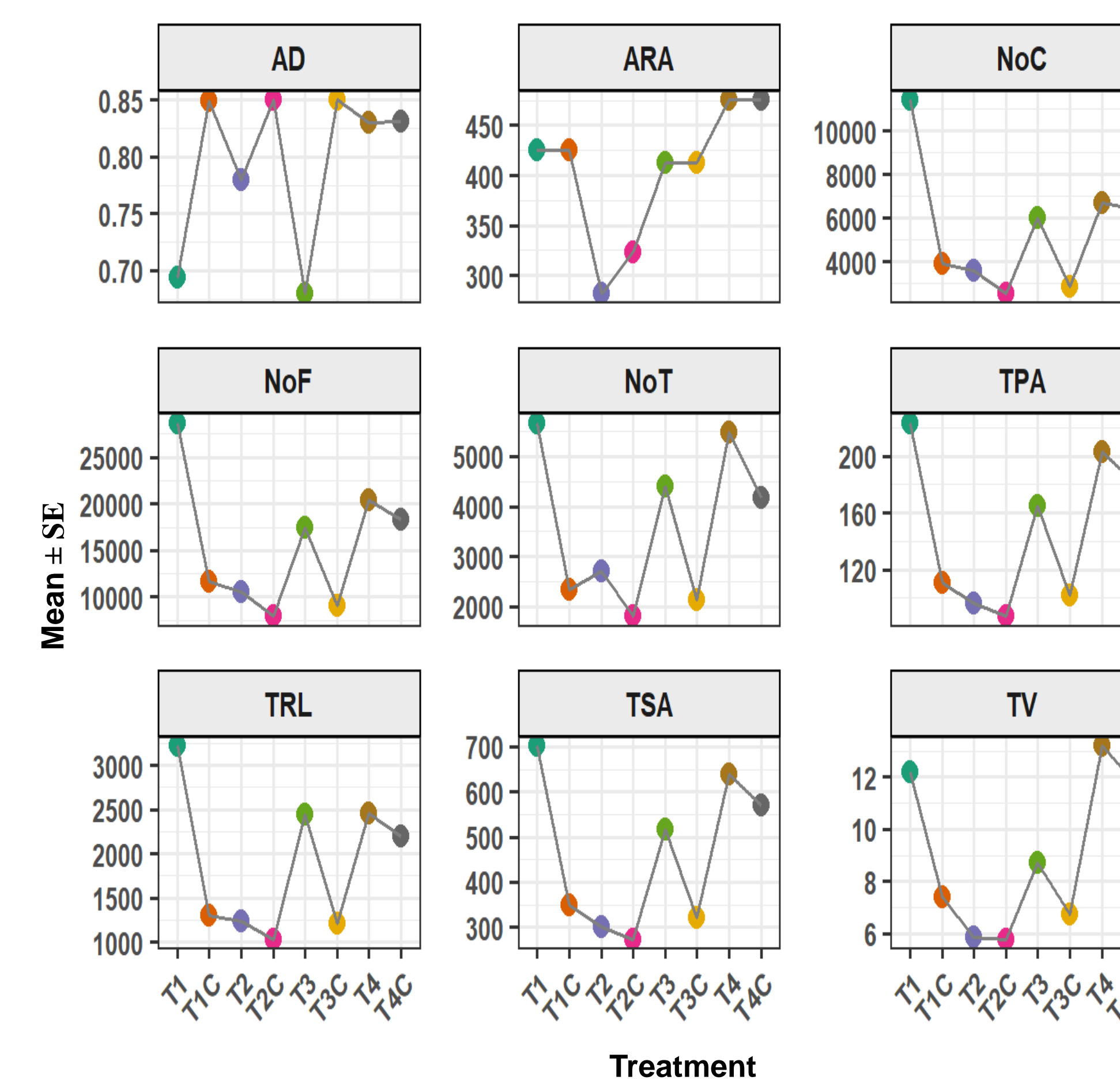


Figure 5: Root morphological traits

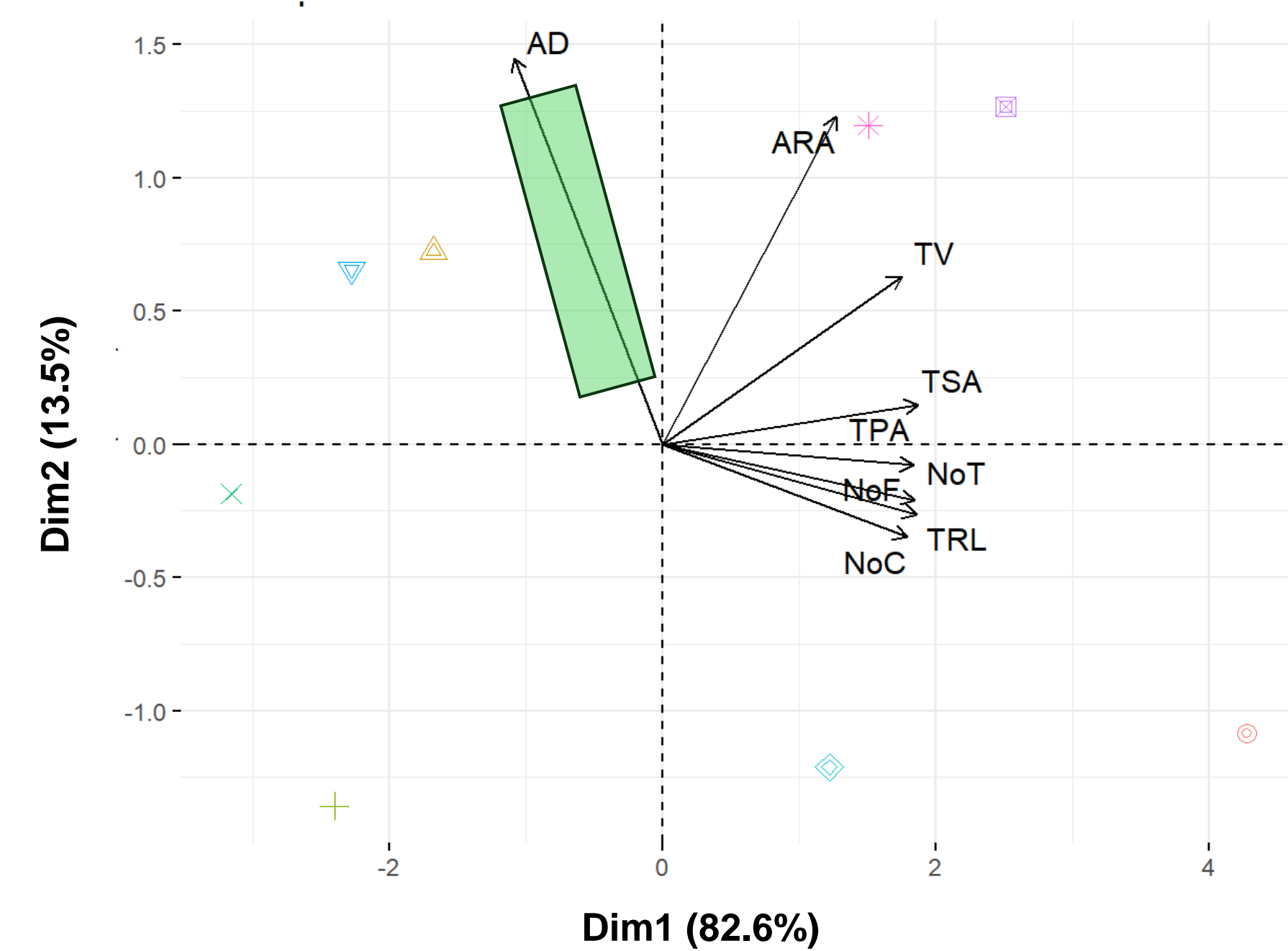


Figure 6: PCA biplot for root traits

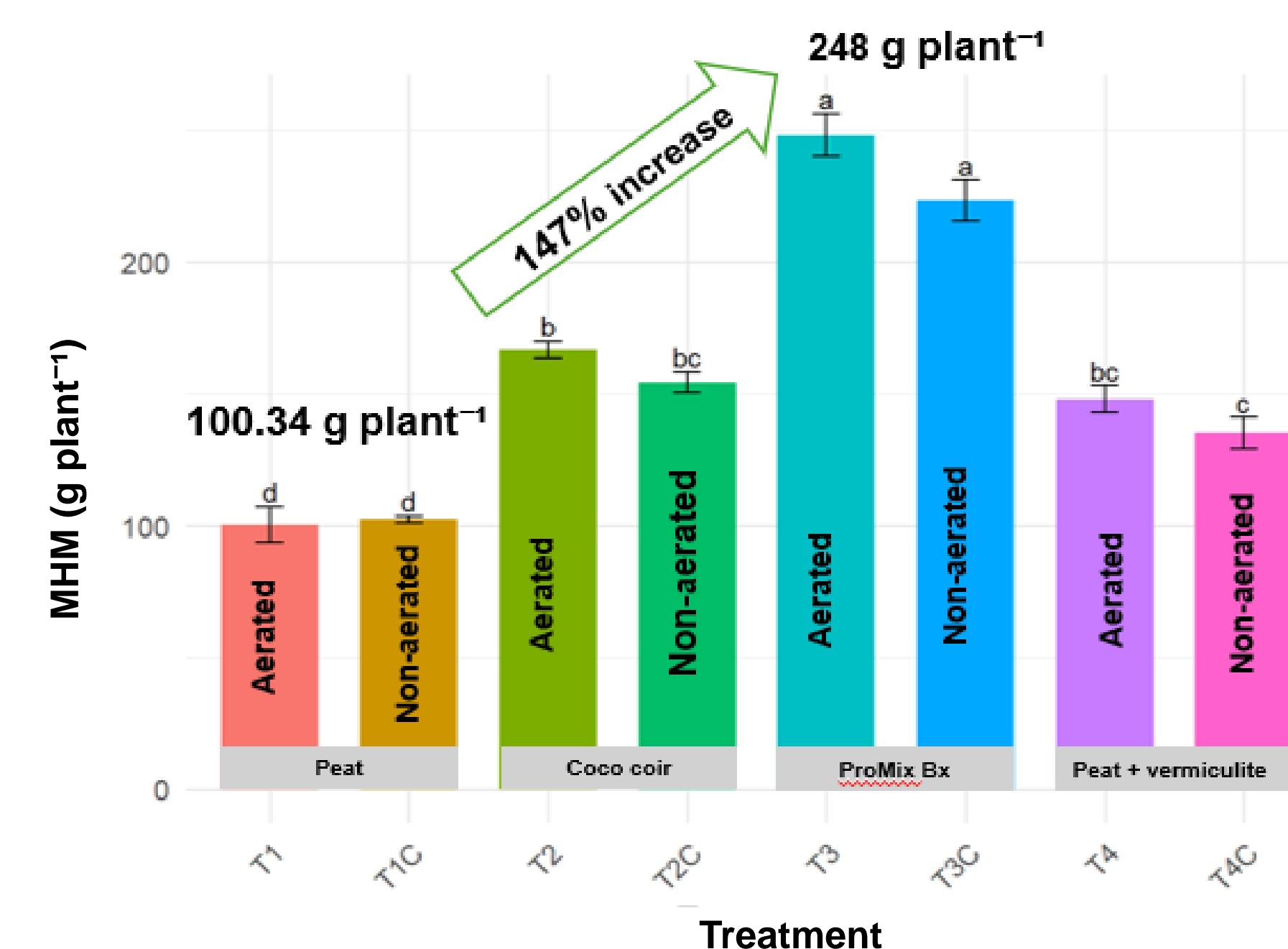


Figure 7: Marketable head mass g plant⁻¹

Discussion

	ARA	TRL	TSA	TPA	TV	AD	NoT	NoF	NoC	MHM
ARA	1.00	0.59	0.71	0.71	0.80	0.03	0.60	0.57	0.50	-0.17
TRL	0.59	1.00	0.97	0.97	0.87	-0.69	0.97	0.98	0.96	-0.18
TSA	0.71	0.97	1.00	1.00	0.96	-0.51	0.98	0.97	0.93	-0.27
TPA	0.71	0.97	1.00	1.00	0.96	-0.51	0.98	0.97	0.93	-0.27
TV	0.80	0.87	0.96	0.96	1.00	-0.25	0.92	0.88	0.82	-0.35
AD	0.03	-0.69	-0.51	-0.51	-0.25	1.00	-0.59	-0.63	-0.65	-0.21
NoT	0.60	0.97	0.98	0.98	0.92	-0.59	1.00	0.95	0.90	-0.19
NoF	0.57	0.98	0.97	0.97	0.88	-0.63	0.95	1.00	0.95	-0.36
NoC	0.50	0.96	0.93	0.93	0.82	-0.65	0.90	0.99	1.00	-0.39
MHM	-0.17	-0.18	-0.27	-0.27	-0.35	-0.21	-0.19	-0.36	-0.39	1.00

Figure 11: Correlation among root morphological traits and lettuce MHM

Remarks

- Minimal aeration (~0.331 CFM plant⁻¹) improved overall plant performance and addressed root zone hypoxia
- Root traits increased under aeration
- Maximum yield: (~147% increase)

Conclusion

- Aerated ProMix BX gave the highest yield (MHM)
- Aeration improved root traits except root diameter
- Single peat showed a limited response to aeration
- Substrate type controls aeration effectiveness

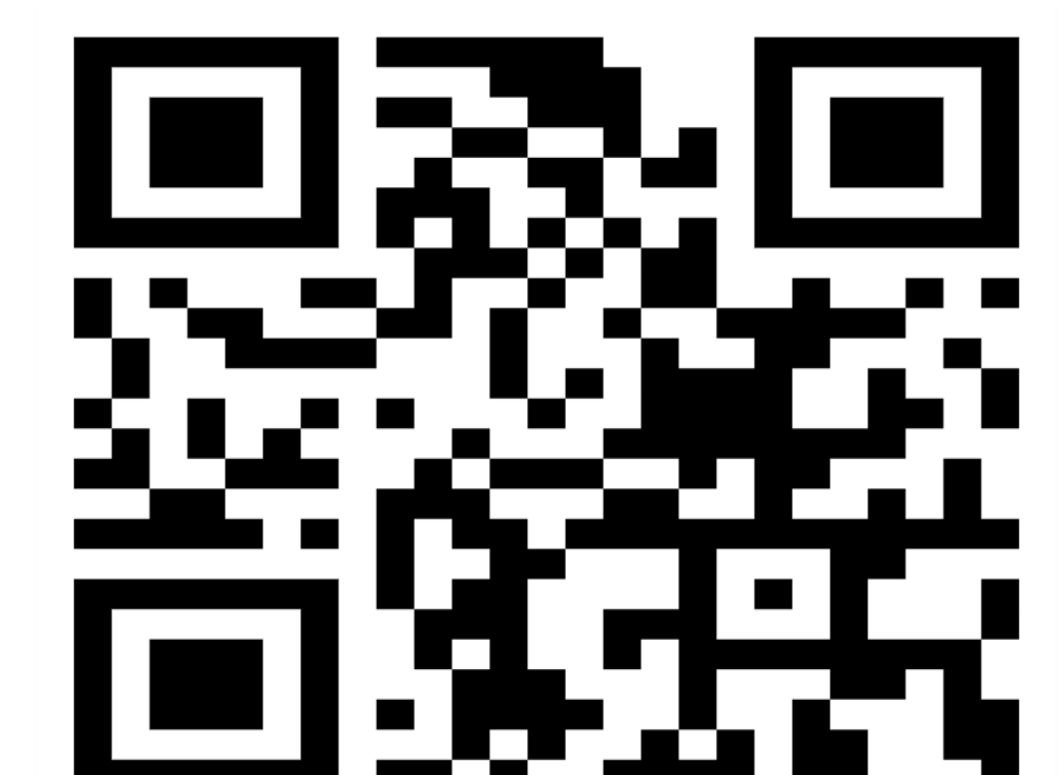
Practical insight

- Reduce the crop losses
- Improves nutrient use efficiency
- Supports substrate reuse
- High-density lettuce production for higher returns

Acknowledgement

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References



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