

2016 Pilot Project Report – DroughtSpotter Platform

Project Title:	Scaling in soil ecology
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Organisation:	The University of Adelaide, The University of Nottingham

General information about the project design

The project involved growing wheat with a variety of soil nitrogen and soil water treatments. The treatments were: 3 water treatments, 3 nitrogen treatments, 4 harvests, 4 replicates per treatment = 144 plants.

The soil used was a mixture of clay loam, UC mix and cocopeat (1:1:1), due to its well-characterised water and N response curves. The mix was equally divided into three nitrogen treatments: 0 mg/kg (no added) nitrogen (N1), 25 mg/kg of N (N2), 75 mg/kg of N (N3). Nutrients were adequately added (DTPA Cu, Fe, Mn, Zn, Al, Ca, Mg, K, Na, B hot CaCl₂), and soil was potted into 4.5L pots, with a bulk density of approximately 1.2 cm³. After potting, pots were left undisturbed for a week and then transferred to the DroughtSpotter platform at The Plant Accelerator®.

The DroughtSpotter was set up with three different watering treatments: Dry, Adequate and Variable.

The Dry treatment replicated a water stress with soil maintained at 25% of water holding capacity (WHC), with a gravimetric moisture content of 0.130 g water/g of dry soil. The Adequate treatment consisted of soil maintained at 75% of WHC (gravimetric moisture content of 0.235 g water/g dry soil). The Variable treatment mimicked a wet/dry cycle, with water added to 75% of WHC (gravimetric moisture content of 0.23 g water/g dry soil). Soil was subjected to a dry-down until soil reached a soil moisture of 25%, then watered back up to 75%.

At the start of the experiment, all pots were watered to 25% of WHC for one week. After one week, two-thirds of pots were watered to 75% of WHC, and the other third of pots were maintained at 25% of WHC. Seeds from wheat variety 'Gladius' were sown directly into the pots (two seeds per pot then thinned).

Each harvest was dictated by the Variable treatment. Plants subjected to Variable watering were maintained at 75% WHC for one week, then watering was stopped until soil reached 25% of WHC (35-42 days). (Some pots were watered as required to maintain 25% WHC.). On day 42, pots were re-watered to 75% of WHC for one week. On day 49, the first harvest occurred; only 35 or 36 plants were destructively harvested at a time. Successive harvests followed a similar procedure.

Experimental analysis included both non-destructive and destructive sampling. Non-destructive sampling included use of the PlantEye laser scanner to determine plant height, digital biomass and projected leaf area. Zadoks growth scale was also used to assess plant growth stages. Destructive sampling included measuring fresh and dried shoot and root biomass and WinRhizo/RootGraph root scanning. Dried biomass was ground and further analysed for Total Organic Carbon/Total Nitrogen (TOC/TN).

The soil was also harvested, and divided into four subsamples. One sub-sample measured TOC/TN, pH/electrical conductivity and plant-available P. A second sub-sample looked at ammonium (NH₄⁺) and nitrate (NO₃⁻) content (colorimetrically analysed using 2M KCl). A third sub-sample was analysed for Microbial Biomass Carbon (MBC) using a CHCL fumigation method and 0.5M K₂SO₄ extraction. The final sub-sample was frozen at -20°C to use at a later stage for soil microbial DNA sequencing.

Aims of the experiment

Nitrogen is the major limiting nutrient from crop production in most soils. While much is known about soil N dynamics under different moisture regimes, most of this work has been done in the absence of a plant. Equally, much is known about plant N uptake and responses to water stress (drought), but with little consideration of soil N cycling over the growth cycle of the plant. The DroughtSpotter was used to establish and quantify the impact of variable soil moisture regimes on soil N dynamics, and plant (wheat) N uptake and growth (including root development), as the plant develops.

Key results and outputs

Plant growth

There were large differences in root and shoot biomass between nitrogen treatments. The differences between treatments was greatest in the roots and this treatment difference increased over time. The effects of watering treatment were unexpected with limited differences between dry and adequate water treatments and the lowest growth seen in the variable watering treatment.

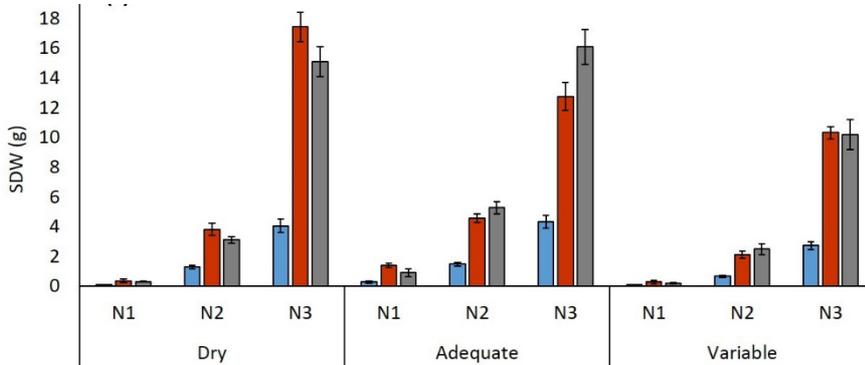


Figure 1. Shoot (+ heads) dry weight (SDW) from Harvest 1 (blue bars), Harvest 2 (red bars) and Harvest 3 (grey bars), over a time period of 14 weeks.

Soil properties and nutrients

Soil nitrate concentrations reflected the nitrogen treatment but were also affected by water treatments with the highest concentrations in the variable water treatment.

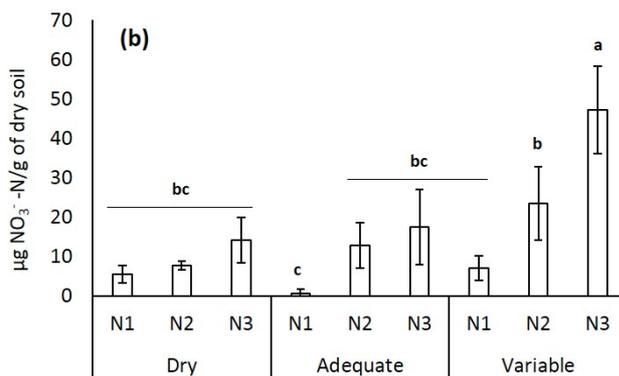


Figure 2. Ammonium (NH₄⁺) and nitrate (NO₃⁻) concentrations in soil at harvest 2

Microbial biomass varied with nitrogen treatment but showed no effect of water treatment.

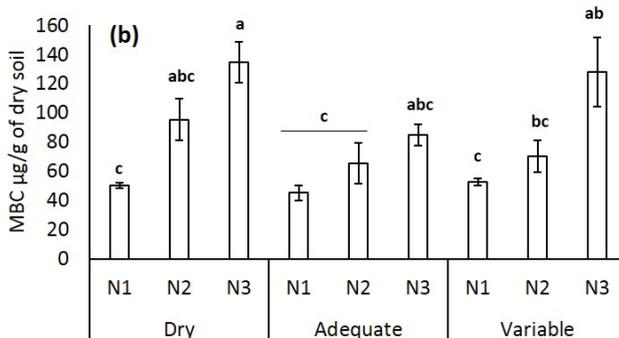


Figure 3. Microbial Biomass Carbon (MBC) from Harvest 1 (a), Harvest 2 (b) and Harvest 3 (c) soils.

Statement on how data obtained from the DroughtSpotter provided new insights into your research

The Droughtspotter allowed us to apply soil water regimes that otherwise would not have been practical. Plants are not as responsive to water as to N (N treatments seemed to have a greater effect on plant growth than water). The changes in the soil N and MBC did not appear to influence plant growth significantly. These results are interesting and will require further investigation. From the results shown, one suggestion is that wheat line Gladius might respond to double stress (of water and nitrogen availability) differently than if it was only subjected to one stress. This is the so-called 'priming effect' which is an implicit memory effect in which exposure to one stimulus/stress influences the response to another stimulus/stress. The variable water treatment is probably reflecting this priming effect. This insight will be useful in determining how to set up my next experiment. The DroughtSpotter pilot study has also taught me how complex plant systems are, and that there are always more interactions occurring than may be seen at first glance. (*Olivia Cousins*)