

Deep root growth in response to nutrients and water in *Poa annua*

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Introduction:

Climate change is causing longer and more intense droughts globally, with devastating impacts on agricultural production. Surface soil drought is especially common – where the top layers of the soil dry out due to evaporation, and there is a need for plants which are better able to use water resources from deeper soil layers. While plants are known to increase root growth in nutrient-rich soil patches, their root allocation strategies under varying local soil water concentrations remain understudied. This study aims to investigate the effects of surface drought and deep-soil water availability on plant root distribution in *Poa annua* plants, under high and low nutrient conditions.

Materials and Methods:

Poa annua plants were established for two weeks in 24cm long plastic tubes with holes drilled into the sides for watering. After establishment, two types of water treatments – Surface and Deep – where the plants were irrigated at the soil surface and at a deep soil layer respectively, were imposed (Figure 1a) under both high and low nutrient conditions. Plants were harvested after seven weeks of treatment. Roots were collected in four soil sections, separated vertically, as shown in Figure 1b.

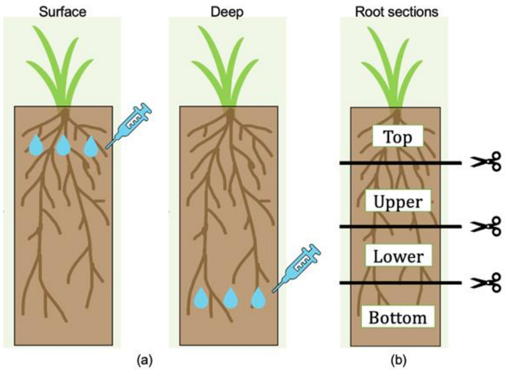

Figure 1 (a) Experimental setup of 'Surface' and 'Deep' water treatments. (b) Soil sections for root harvest.

Results:

Under high nutrient conditions, although the total root masses of Surface and Deep plants did not differ significantly, the root allocation significantly differed in all four soil sections. In the top two sections, Surface plants had a greater root mass. Conversely, in the bottom two sections, Deep plants had a greater root mass. The difference was more pronounced in the lower sections with Deep plants allocating nearly twice the amount of roots in the Lower and Bottom sections (18.1% and 16.7% of the total root mass) when compared to the Surface plants (9.3% and 7.5%). However, no significant differences in root distribution were observed between Surface and Deep plants under low nutrient conditions.

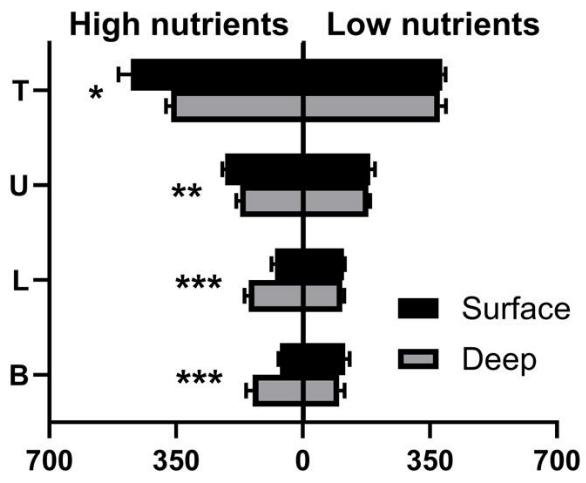

Figure 2 Dry weight of roots in Top (T), Upper (U), Lower (L), and Bottom (B) soil layers under high and low nutrient conditions. Error bars indicate standard error values (SEM).

Under high nutrient conditions, the shoot masses of Surface plants were, on average, 8.7% greater than the Deep plants. No differences in shoot mass were observed under low nutrient conditions.

Discussion:

Our results indicate that nutrient-replete plants under surface drought conditions allocate a larger portion of their roots to deeper soil sections compared to plants that only have access to water at surface layers. The increased root mass in the lower layers may be a result of either an increase in root growth or a decrease in root death, presumably due to increased carbon allocation. Given the significance of deep rooting strategies for drought survival, further research is required to understand the mechanisms behind plant root distribution in response to soil water availability.

However, it is important to note that this phenomenon was only observed under high nutrient conditions, suggesting that there is a nutritive effect on the ability of plants to allocate resources to increase deep root growth. Under nutrient limited conditions, the root distribution is comparatively more evenly distributed through the four soil layers. The reason for this difference is not clear and requires further study.