Greenhouse Gas Emissions of Biofuel Cropping Systems: Separating Root-Derived Respiration from Soil CO_2 Efflux Using Shading

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INTRODUCTION

In order to estimate the net CO_2 emissions associated with biofuel cropping systems we must distinguish between the soil- and live root-derived components of soil respiration. Photosynthate disruption should affect only the living roots. By exploiting the different response of the soil- and live-root portions to shading, we estimated their relative contributions to the total soil respiration.

OBJECTIVE

- Estimate the percentage of the total soil carbon dioxide emissions which originate from live-root sources for 3 different biofuel cropping systems.

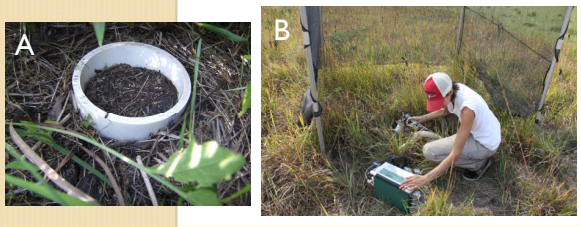

Fig. 1. A: Close-up of 9-cm collar used for measuring soil CO_2. B: Measuring soil respiration through the open north face of a 50% shaded prairie plot.

MATERIALS AND METHODS

A field experiment was conducted at Iowa State University as part of the Comparison of Biofuel Systems (COBS) project. 3 levels of shading were applied to 3 potential biofuel cropping systems (Fig. 3). Soil respiration was measured under each light regime using a portable infra-red gas analyzer (LICOR 6400-09, Fig. 1). Soil temperature (5 cm depth) and soil moisture (7.5 cm depth) were also measured. Measurements were performed bi-weekly.

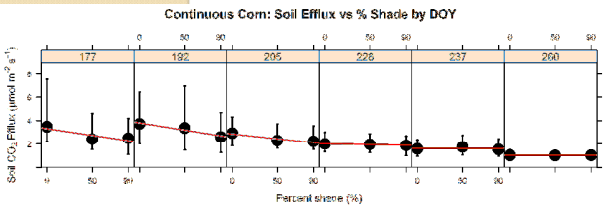

Fig. 2 The effect of shading on soil CO_2 efflux changes through the season. Bars represent upper (0.975) and lower (0.025) quantiles.

Fig. 3: Shade treatments of a 1m x1m area receiving 0, 50, and 90% of ambient solar radiation, respectively. CO_2 measurements were made after 2 full days of shade treatment. 3 potential biofuel cropping systems were investigated: N-fertilized diverse prairie (pictured), un-fertilized prairie, and continuous corn.

We fit a simple linear regression to the CO_2 efflux vs the percent reduction in solar radiation (Fig 2). From this regression line we predicted CO_2 efflux at 100% shading, which we interpreted as the soil-derived efflux (Fig. 4). The difference between the efflux under 0% shade and the predicted efflux at 100% shade is the calculated live root-derived efflux.

$$\frac{\textit{live root-derived efflux}}{\textit{efflux at 0\% shade}} \quad x\ 100 = \%\ \textit{root-derived, Fig. 5}$$

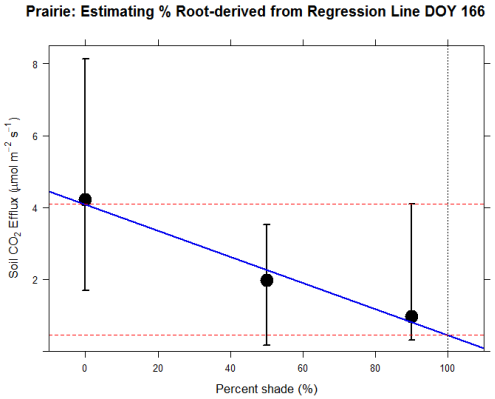

Fig. 4: On this day, shading reduced soil CO_2 efflux in the prairie. The difference between the two red lines is the calculated root respiration.

RESULTS

Shading reduced soil respiration in the corn to the greatest degree immediately after N side-dress. The effect of shading on soil respiration decreased as the season progressed.

Shading reduced soil respiration in the prairie systems until ca. end of July. After this period higher % shading corresponded with higher soil CO_2 efflux.

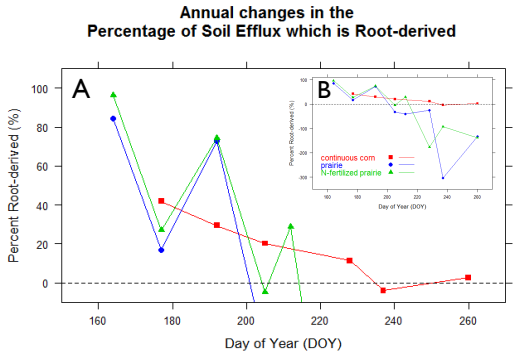

Fig. 5A : Cropped results of regression method to show seasonal trends. B: Negative values indicate an increase in soil efflux under increased shading.

CONCLUSIONS

- For corn, root respiration is highest during rapid growth early in the season and decreases as the plant matures.
- Before Aug 1, both prairies averaged a higher % root contribution than the corn. This is consistent with the fact that the prairies have a higher root biomass than corn.
- Shading is a promising method for non-destructively partitioning soil respiration.

I am very thankful to the many people who helped me; I would like to specifically thank Russell Willett, as he worked through a very hot, dry summer without complaining.

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