MEASURING AND PARTITIONING SOIL RESPIRATION IN SHARKEY SHRINK-SWELL CLAYS UNDER PLANTATION GROWN SHORT-ROTATION WOODY CROPS

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The Lower Mississippi Alluvial Valley (LMAV) offers an ecological niche for short-rotation woody crop (SRWC) production by mating marginal agricultural land with optimal growing conditions. Approximately 1.7 million ha within the LMAV consist of Sharkey shrink-swell clays. They are considered marginal in terms of traditional agricultural productivity due to their hydric characteristics (Vepraskas and Richardson 1997). However, these soils are ideal for SRWC production using native, well-adapted species.

Total soil carbon dioxide (CO_2) efflux (F_S) is a composite measure of many processes. One major component is rhizosphere respiration (R_{Rhizo}), where CO_2 is derived through both growth and maintenance of plant roots and rhizosphere microorganisms. The second major component is heterotrophic respiration (R_H), which is CO_2 derived from soil macro- and microorganisms. Soil temperature and moisture are among the strongest environmental factors exhibiting control over F_S, (Bond-Lamberty and Thomson 2010, Boone and others 1998, Carlyle and Than 1988, Janssens and Pilegaard 2003, Raich and others 2002). To gain a better understanding of F_S, a separation of its components is essential since both R_{Rhizo} and R_H respond differently to temperature and moisture, and their relative contribution to F_S will be variable throughout the year (Boone and others 1998). The objectives of this work are to determine: (1) the suitability of the PVC root-exclusion method for measuring and partitioning F_S into its primary components, R_H and R_{Rhizo}, throughout the year of establishment; and (2) if F_S and its primary components are influenced by species and management intensity.

The work was conducted on an Army Corps of Engineers tract, which is 36.42 ha in size and located near Hollandale, MS (33˚ 09' 03.51" N, 90˚ 54' 17.65" W). This region has a mean annual temperature of 23.4 ˚C and receives on average 123.3 cm of precipitation annually (NOAA 2012). The soil is classified as Sharkey series (very-fine, smetitic, thermic, Chromic, Epiaquerts). At the end February 2012, the site was established using cuttings of native *Salix nigra* Marsh. and clonal *Populus deltoids* Bartram ex Marsh. This study is a randomized complete block (RCB) design replicated three times. Treatments were arranged as a 2 by 3 full factorial, where tree species was randomly assigned across three planting intensities (326; 1,006; and 1,659 trees ha^{-1}).

Soil gas exchange measurements were taken four times during the 2012 growing season, and one dormant season measurement was taken in February 2013. Gas exchange was measured *in-situ* using a LiCor 8100A infra-red gas analyzer (IRGA) with a 10-cm-diameter survey chamber (LiCor Biosciences Inc., Lincoln, NE). Volumetric soil moisture (SM; average across 0 to 6 cm depth) and soil temperature (TC; 5 cm depth) were measured concurrently with gas exchange measurements using a Theta Probe ML2x (LiCor 8100-204; Delta-T Devices Ltd., Cambridge, England) and an Omega soil temperature probe (LiCor 8100-201), respectively. Soil efflux collars were manufactured to LiCor specification using 10-cm polyvinyl chloride pipe (PVC, schedule SDR 35) cut to 5 cm in length with a 45º bevel on one end. Collars were installed the evening prior to taking measurements (LI-COR 2010) to a depth of approximately 3 cm. F_S was separated into its autotrophic and heterotrophic respiratory components using the root-exclusion method (Bond-Lamberty and others 2011). Briefly, root-exclusion collars were manufactured from 25.4-

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cm-diameter PVC pipe (schedule 40) cut to 50-cm lengths. Root-exclusion collars were manually driven to a depth of 50 cm, where the top edge of the exclusion was flush with the surrounding soil to prevent altering the soil-water status within the root-exclusion zone. The distance between paired measurement collars for F_S and R_H did not exceed 30 cm. One measurement was taken inside the root-exclusion zone, and one measure was taken outside of the root-exclusion zone. Heterotrophic respiration (R_H) was estimated from the measurement taken within root-exclusion zone. All measurements were averaged across subsamples for each experimental unit (plot). Treatment effects were tested by analysis of variance (ANOVA) with repeated measures using the MIXED procedure in SAS 9.3.1.

The first field campaign took place 14 days following the complete installation of root-exclusion zones. We compare inside the root exclusion (R_H) to outside the root exclusion (F_S) to test for the presence of any pulse respiration that might have resulted from the potentially traumatic nature of installing the root-exclusion zones and found no difference ($p > 0.05$; n = 96). We repeated this test 54 days after root-exclusion installation (98 days after planting); the resulting data suggest a clear difference ($p < 0.05$; n = 91) between inside and outside the root-exclusion zone, indicating that the difference at 54 days following installation is driven by an emerging autotrophic efflux component. Not only have we established that our root-exclusion zones are not influenced by pulse respiration and are effectively excluding autotrophic sources, but we also demonstrated their viability throughout the first growing season (fig. 1). One can see that the root-exclusion zones not only maintain effectiveness throughout the growing season but also yield a seasonal trend where the relative contributions of R_{Rhizo} and R_H to F_S are consistent with those report in the literature (Bond-Lamberty and others 2004).

Installing a large segment of PVC in the soil to exclude roots spawned concern over whether or not soil temperature and moisture within the exclusion would be representative of the surrounding soil. The influence of abiotic properties were assessed utilizing paired measurements. A comparison of soil temperature yields a significant ($p < 0.01$) time by exclusion interaction; however, this interaction is largely driven by a large sample size. Repeating this assessment for soil moisture revealed no interaction ($p = 0.99$) for time by exclusion. Soil moisture within a campaign does exhibit limited variability during some campaigns, and these minor differences are likely due to a buffering effect of the PVC when going into, and emerging from, a drydown event. Implications of this work will provide future investigators with some insight into the suitability of root exclusion and the response of F_S and its components in shrink-swell clay soil.

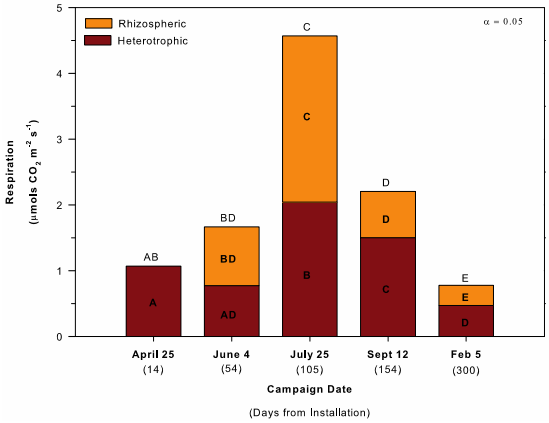

Figure 1—The relative contributions of R_{Rhizo} and R_{Hetero} to F_S. Letters within a color show significant differences, while letters atop bars indicate significant differences among F_S.

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