Carbon Sequestration and Greenhouse Gas Exchange in Almond Orchards

Project No.: **07-ENVIR5-Smart**

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Objectives:

1. Create a greenhouse gas inventory by quantifying the extent of annual CO_2, N_2O and CH_4 fluxes from almond orchards in comparison to background fluxes from natural irrigated grassland.
2. Assess the potential of almond orchards under "normal" management regimes to sequester carbon in contrast to the background carbon storage of unmanaged irrigated natural grassland in order to subtract natural background emissions and thus reduce the calculated fluxes within almonds.

Interpretive Summary:

Global warming and climate change could seriously impact upon the natural resources, environment and agricultural economy of the state of California. Changes in temperature and seasonal precipitation will influence production of California's specialty

crops, and are predicted to result in diminished yields, diminished quality, and shifts in suitable growing regions. The mounting concern regarding increases in greenhouse gases (GHGs) with the potential to modify regional climate patterns has prompted California to reduce its GHG emissions with the introduction of **The California Global Warming Solutions Act of 2006 (bill AB32)**. This project is in the early stages of addressing and concentrating on the issues of uncertainty in the emissions of GHGs seasonally and annually from almond orchards, and will characterize spatial and temporal variation of CO_2, N_2O and CH_4 fluxes within the soil zone where nitrogen fertilizers and water are applied. The main objectives below will enable a successful assessment into the ability of almond orchards to store carbon and investigate the potential mitigation and management strategies to enhance carbon sequestration and reduce GHG emissions.

Materials and Methods:

Objective 1: *Annual trace gas budgets*

In order to acquire comprehensive background emissions for GHGs, we are currently measuring the soil CO_2, N_2O and CH_4 emissions from an almond orchard with three different irrigation regimes (double subterreanean drip, micro-sprinkle and drip) at the Nickels Soil Laboratory, Arbuckle. A control site consting of mowed and irrigated grassland is also measured for these gases in order to compare with the orchard and obtain a baseline budget.

Soil GHG flux measurements are taken on a bi-weekly basis starting in October 2007 and diurnal measurements will be taken during periods of increased management activity (irrigation and nitrogen fertlilizer applications). Eighteen permanent diameter 10" PVC collars have been inserted two cm into soil a week prior to the first measurements, and all new growth vegetation within the collars was removed, this will give six repilitions for each of the three irrigation systems we are investigating. Eighteen smaller (8") PVC collars for CO_2 were also installed within the orchard. All soil collars have been placed within the tree rows and within the drip-zone of the irrigation system.

To measure soil CO_2 efflux *in situ* we use a non-dispersive infrared gas analyzer (model LI-6400/6400-09, LICOR, Lincoln NE) where the soil respiration measurements are made between approximately 11 am and 3 pm as measurements of diurnal CO_2 emissions have indicated a 40% to 60% decline at dusk and into early morning during the active growing season, with rates reaching a plateau between approximately 11a.m. and 3 pm.

Cylindrical chambers with a height of 25 cm and a diameter of 30 cm are used for soil N_2O and CH_4 flux measurements. During the time of gas flux measurements the chambers are to be sealed for 3 hours over which time three gas samples are taken using 10 cc evacuated gas vials, samples are obtained between 11am and 3 pm to capture peak mid-day fluxes. The concentrations of N_2O and CH_4 in the samples will be determined in the laboratory with a gas chromatographic system. All efflux measurements are corrected for vapor pressure, soil temperature, and chamber temperature. The cumulative gas fluxes will be calculated for each time interval, totaled up for the entire growing season and then annually. Modeling exercises will then allow us to assemble annual budgets on soil CO_2 and N_2O emissions and CH_4 consumption, the annual emissions for each gas will then be converted to CO_2 equivalents using appropriate global warming potentials in order to determine the global warming effect and climatic impact trace gas emissions from almond orchards.

Objective 2: *Carbon sequestration in almond orchards*

Soils are one of the major sources of atmospheric CO_2 however it also serves as an important carbon sink. In order to asses the potential for almond orchards to sequester carbon and in turn reduce CO_2 emissions the bulk characteristics and soil organic carbon content of each site needs to be measured. Approximately 5 representative and composite soil samples from the top 0 to 15 cm layer will be collected near the gas flux chamber collars for each sampling site, bimonthly. These samples will be sieved and weighed before bulk chemical analysis for total carbon and nitrogen using a total carbon analyzer (HTOC). Samples will also be measured for soil organic matter content (SOM) by a loss-on-ignition technique, which involves the soil sample being oxidized at a moderate to high temperature whereby the weight loss after ignition is determined, and in turn is proportional to the amount of soil organic carbon (SOC) in the sample. Percent gravimetric soil moisture content at 0-20 cm will be determined following each efflux measurement and deep (1 m) soil cores will be taken to determine bulk densities and particle size analyses every month at each site. On a seasonal basis (approximately every four months) using a 1 m x 1 m quadrat, representative samples for above ground biomass (including leaf litter, plant and woody materials) will be collected, these samples will be dried and weighed and biomass calculated on a dry weight per hectare basis. Below ground biomass will be determined by excavating soil cores from four different depths where roots will be removed, sorted and weighed for each core to give total root weight.

By quantifying the SOC and biomass levels of the almond orchards the total carbon sequestered can be calculated by the difference in SOM from season to season, using the oak site as a benchmark to identify any potential carbon losses or gains within the almond orchards. Along with this data we will possibly utilize the T. Dejong “peach tree computer model” which simulates the seasonal and tree carbon partitioning. The model may then be adapted to assess and model the carbon budgets and carbon allocation for almond trees as well as assess implications for carbon sequestration.

Results and Discussion:

Results from bi-weekly greenhouse gas measurements and a 36 hour diurnal experiment will be presented at the CAB annual conference.

Recent Publications:

Suddick, E.C., Smart, D.R., (2007) An Assessment of the Carbon Sequestration Opportunities and Greenhouse Gas Production in Almond Orchards in California – A White Paper. *In Prep.*