Carbon Sequestration Opportunities and Greenhouse Gas Production in Almond Orchards

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Interpretive Summary:

Increases in the greenhouse gases of carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) are increasing the radiative forcing of the Earth's atmosphere. The nature of this project was to gain a perspective upon the carbon sequestration potentials and mitigation practices that the Almond Industry of California can utilize to reduce greenhouse gases (GHG) and store soil carbon. This project is in light of recent policy acts, frameworks and intergovernmental reporting, both globally such as the Kyoto Protocol (1997) and The United Nations Framework Convention on Climate Change (UNFCCC, 1994), Intergovernmental Panel of Climate Change (1990-current) and on a more regional scale, the California Global Warming Solutions Act of 2006 (AB32), set up to tackle the possible problems arising from climate change. As agriculture plays a major role in the global fluxes of these trace gases, the need for the involvement of agricultural industries in GHG mitigation has been widely recognized since the 1990's.

This project will look into the impacts that California agriculture, particularly the Almond Industry has on climate change and subsequent release of three climatically active trace greenhouse gases such as (N_2O, CH_4 and CO_2). The project will also concentrate on looking into the mitigation practices the Almond Industry have already adopted and can adopt to reduce greenhouse gases and their potential to sequester carbon and will look

into the possible economic benefits of each mitigation practice with regards to regional policy acts. Concepts such as carbon sinks, carbon credit systems and emissions trading have attracted special interest from many sources.

Finally, the project with the aid of writing a white paper will recognize the research needs to carry out mitigation including identifying any knowledge gaps associated between scientific needs and policy requirements. The main knowledge gaps lying in the lack of background annual budgets of GHG, previous land and soil management and the effects new climate change legislature will have upon the agricultural and Almond industries.

Objectives:

The objectives of this study are to evaluate the potential almond orchards have to sequester carbon. International concern about greenhouse gases and their impacts on climate change have added to the need to for an understanding of carbon sequestration in agricultural soils. Current knowledge for perennial cropping systems is scant; therefore the quantification of the fluxes from all three radiatively active trace gases in almond groves is also needed.

The overall objective of this project was to develop a scientific understanding of the relationship between soils, climate change, GHG fluxes, carbon sequestration and the Almond Industry of California and to gain knowledge on the impacts and effects of almond production in relation to AB32, through the a literature review and production of a white paper. The paper would hopefully provide the integration dialogue needed between science, farming and policy relative to the agricultural practices of the Almond Industry that may enhance carbon sequestration, improve soil quality and reduce GHG emissions.

Using the white paper to address research needs, another grant was recently accepted by the California Almond Board to actually start and tackle the scientific gaps in knowledge and data. The continuation of this project will concentrate 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 future 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.

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 grassland.

2) Assess the potential of almond orchards under "normal" management regimes to sequester carbon in contrast to the background carbon storage of unmanaged natural grassland in order to subtract natural background emissions and thus reduce the calculated fluxes within almonds.

3) Conduct a survey of almond growers to determine variation in N fertilizer inputs, irrigation, wood chipping or burning practices and potential cover crop usage. Information from this survey will be used to develop more sound policy decisions concerning C sequestration and GHG emissions from one of the most valuable California commodity crops. This in turn will enable us to highlight where almond orchards may already be contributing to GHG mitigation.

Materials and Methods:

For this study an extensive literature search and review of current information on climate change, both globally and regionally was used to assess the impacts to the Almond industry.

Results and Discussion:

Current Legislation:

The total emissions of GHG's in the U.S. have reached over 1562 million metric tons of carbon equivalents a year and are projected to rise by an estimated 14 % in 2012; California is the world's twelfth largest producer of GHG's. Global warming and climate change such as the predicted 2 to 3 degree rise in temperature could seriously impact upon the natural resources, environment and agricultural economy of the State. The California Global Warming Solutions Act of 2006 (AB32) is the first in the nation to impose legislation by using emissions caps on the utilities, refinery and manufacturing plant industries with the goal of cutting GHG emissions by 25 % by 2020. This act requires the adoption and state enforcement of emission limits where these industries are given a carbon dioxide equivalent emissions allowance for all GHG's emitted during a specified year. Failure to comply or violation of the regulations will result in that industry being fined a penalty. Compliance with the act will result in a reduction in the overall emissions of GHG's. One goal of this investigation is to explore ways in which compliance might be imposed upon the California Almond Industry, which is yet to be stated.

Potential Mitigation Strategies:

Efforts to mitigate the atmospheric increase in temperature require that we know the quantity produced and global warming potential (GWP) of all GHG's under a variety of management strategies. The main conservational practices which reduce carbon emissions and maintain soil quality are;

- Increasing vegetation cover by planting trees, wind breaks and vegetation buffers including hedgerows
- Using conservation and no-till cultivation techniques
- Effectively utilizing fertilizer and reducing N inputs if crops allow

- Effectively utilizing irrigation and water supply to crops
- Using cover crops to increase soil biomass

Mitigation strategies that might be applied to almond orchards may involve reduction and improved efficiency of N fertilizer use and to make effective use of irrigation systems. This crop also produces masses of shell and wood stock prunnings that are usually burned and release vast quantities of CO_2 to the atmosphere, chipping has become an alternative to burning. By chipping the wood stocks it reduces air pollution and research has shown that they can return organic matter to the soil if put back into the ground without depleting the essential nutrients in the soil itself.

One of the main mitigation strategies is to obviously sequester carbon in soils and reduce CO_2 concentrations in the atmosphere. Figure one demonstrates some basic strategies that may be applied to the industry to sequester carbon; however, further research is very much needed in this area and will hopefully be addressed with the continuation of this project.

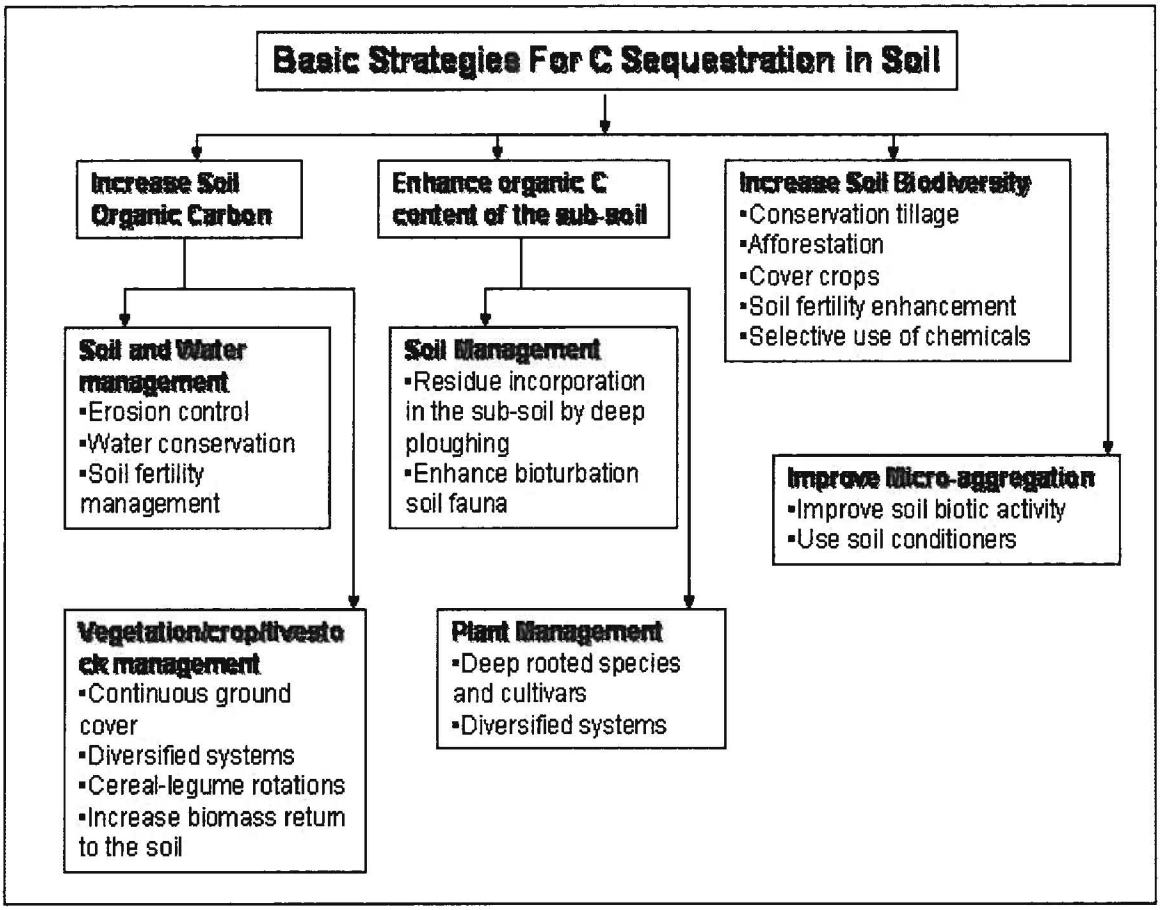

Figure 1: Flowchart of strategies for carbon sequestration in soil (Soil Management and Greenhouse Effect (Lal *et al.*, 1995)

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.*