Increasing Crop Productivity and Water-Use Efficiency by Utilizing Ethanol CO_2 Emissions

Dave Goorahoo[12*], **Shawn Ashkan**[1], **Florence Cassel S**[1]
Diganta D. Adhikari[1] and **David Zoldoske**[1,2],

[1]Center for Irrigation Technology
[2] Plant Science Department.
California State University, Fresno,
5370 North Chestnut Ave. M/S OF18, Fresno, CA 93740-8021,

Emails : dgooraho@csufresno.edu , sashkan@csufresno.edu , fcasselss@csufresno.edu
diganta@csufresno.edu and dzoldoske@csufresno.edu
(* Presenting author)

Abstract:
Ethanol production is growing in the San Joaquin Valley (SJV), which is one of the most productive agricultural areas of California. About ten new ethanol plants are expected to be built in the near future in the SJV. These production facilities are expected to produce more than one million tons of CO2 annually, which will be vented directly into the atmosphere if not captured and sequestered or used for beneficial purposes. In this presentation we outline the technology used to deliver the CO2 and summarize the research conducted to date. Our findings to date imply utilizing CO2 emissions from ethanol production facilities has good potential to enhance crop yield, water use efficiency, and farm income, while at the same time mitigate global warming by recycling CO2 emissions in agricultural fields.

Attached is the PowerPoint Presentation to be presented at the IA conference.

Increasing Crop Productivity and Water-Use Efficiency by Utilizing Ethanol CO_2 Emissions

By

Dave Goorahoo, Shawn Ashkan, Florence Cassel, Diganta Adhikari and David Zoldoske

Center for Irrigation Technology (CIT)

&

Plant Science Department

California State University- Fresno

Topics

- CO_2 Emissions
- CO_2 and Plants
- Ethanol Production/CO_2 Emissions
- CIT CO_2 Research

CO_2 Emissions

Annual rate of CO_2 emissions increases:

- U.S. = 1.2% per year (1990-2005)
- Global = 2.1% per year

Global CO_2 Emissions:

- Year 2003: ~ 26,000 MMT
- Year 2030: ~ 44,000 MMT--- ~70% rise in less than 30 years

CO_2 and Plants

Available CO_2/Plant Data:

- Thousands of scientific CO_2 studies available from greenhouses and growth chambers over the past 50 years
- Hundreds of experiments available from Free Air CO_2 Enrichment (FACE) projects in open fields over the past 15 years

CO_2 and Plants- Cont'd

Available Data Shows Elevated CO_2:

- Enhanced crop growth and yield
- Increased water use efficiency
- Reduced growth-limiting environmental stress
- Increased soil carbon sequestration

But CO_2 benefits are site specific ---

depend on crop and growth conditions

CO_2 and Plants- Cont'd

Tomatoes Open Field CO_2 Enrichment (CIT)

CO_2 and Plants- Cont'd

CO_2 enriched tomatoes

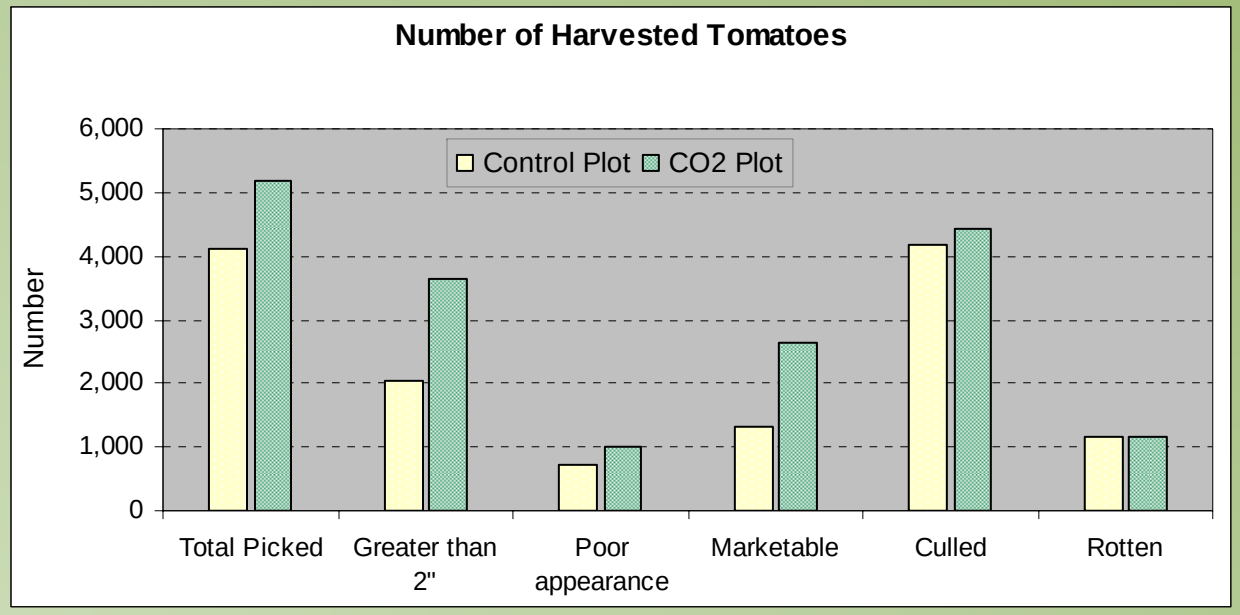
Control (non-CO_2) tomatoes

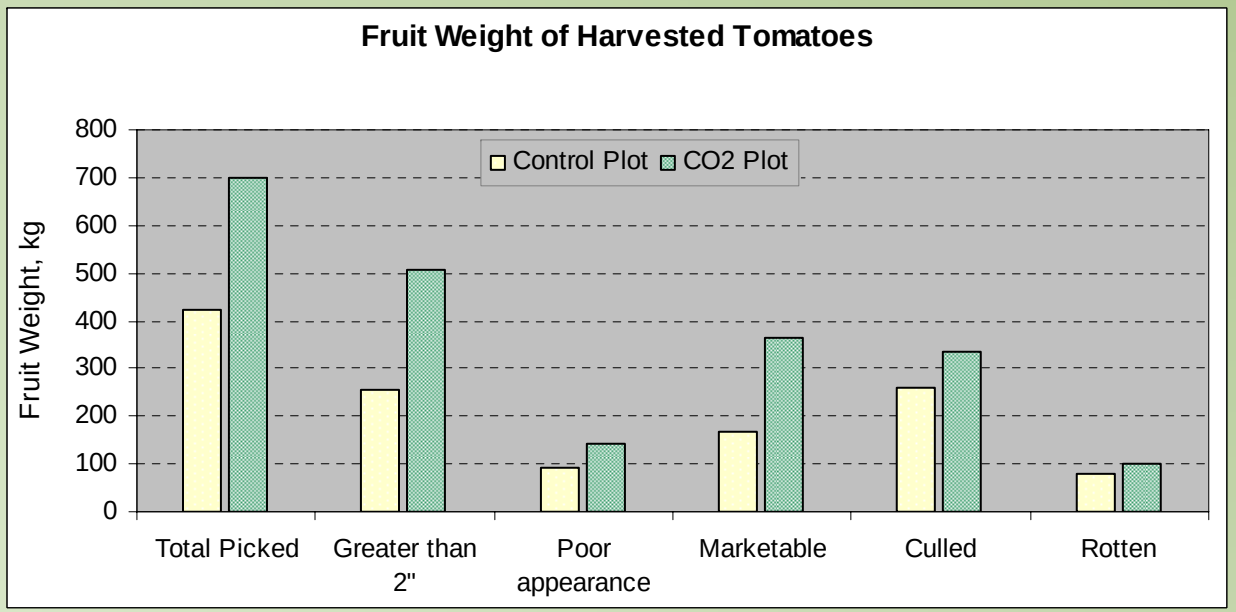
CO_2 and Plants- Cont'd

CO_2 enriched tomatoes

Control (non-CO_2) tomatoes

CO_2 and Plants- Cont'd





Ethanol Production/CO_2 Emission

U.S. Annual Ethanol Production/Projection:

- Now: ~5 billion gallons
- 2012: ≥ 7.5 billion gallons (2005 Energy Bill)
- 2030: Displacing 30% of 2004 gasoline demand with biofuels (DOE goal)- 60 billion gallons/year required to achieve the goal

Now: Ethanol production in U.S. is corn based

Future: Ethanol will be based on cellulose too

- CO_2 is a natural by-product of ethanol --- One-third of a bushel ends up as CO_2

Ethanol Production/CO_2 Emissions

California:

- Is the largest consumer of ethanol in the U.S.
- Currently has a small national production share
- Should produce 20% of its own biofuels by 2010, 40% by 2020, and 75% by 2050 (Executive Order S-06-06)

Businesses to build new plants in California

Most plants will be in the San Joaquin Valley

Opportunity to capture/utilize waste CO_2 from ethanol for agriculture?

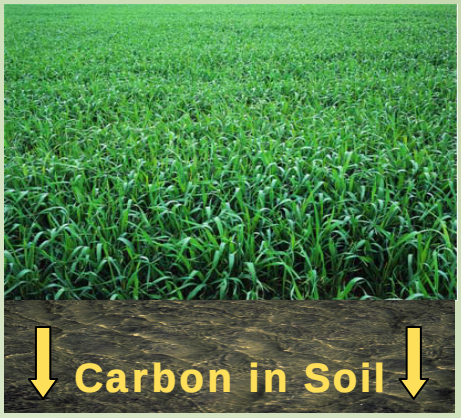
CO_2 Cycle in Ethanol Fuel Production *Without* Capture

CO_2 in the Atmosphere from All Sources

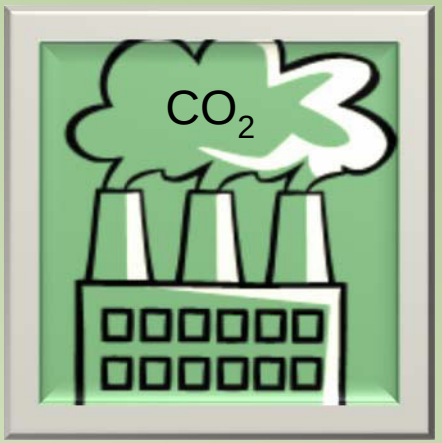
CO_2 Uptake through Photosynthesis

CO_2 Emissions from Biomass Fermentation

CO_2 Emissions from Ethanol Combustion



Carbon in Biomass



Carbon in Ethanol

Ethanol Fuel

Biomass Production

Ethanol Production

Industry Consumption

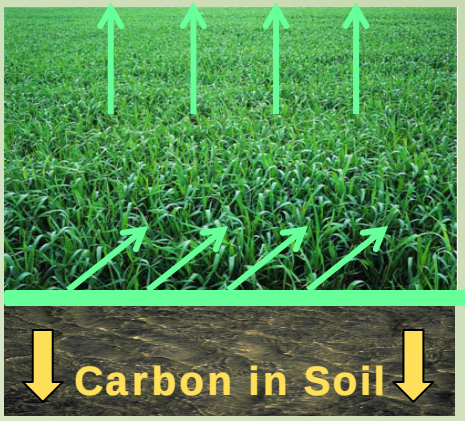
CO_2 Cycle in Ethanol Fuel Production *With* Capture

CO_2 in the Atmosphere from All Sources

CO_2 Uptake through Photosynthesis

CO_2 Emissions from Biomass Fermentation "Captured and Applied in Agricultural Fields"

CO_2 Emissions from Ethanol Combustion



Carbon in Biomass

Carbon in Ethanol

Ethanol Fuel

Biomass Production

Ethanol Production

Industry Consumption

CIT CO_2 Research

Objectives:

Utilizing CO_2 wastes from ethanol production facilities in agriculture to:

- Increase crop yield per unit land
- Increase crop yield per unit water
- Recycle/sequester carbon in plant/soil

CIT CO_2 Research- Cont'd

Objectives address three important agricultural/environmental/political issues:

- Increasing food demands
- Increasing freshwater shortages
- Increasing CO_2 emissions

CIT CO_2 Research- Cont'd

CIT research is focused to:

- Evaluate technical and economic feasibility of utilizing ethanol CO_2 wastes in agriculture
- Evaluate potential environmental benefits as related to climate change

CIT CO_2 Research- Cont'd

Many (technical/economic/environmental) testing/measuring/monitoring/verification to do:

Technical Issues:

- Proof of concept of new technology
- Development of new technology

  "e.g., methods to transport, deliver, control and apply CO_2 to commercial farms efficiently and cost-effectively"

CIT CO_2 Research- Cont'd

Economic Issues:

- Does CO_2 enrichment offer a profitable business for commercial growers?
- Does investment in a CO_2 recovery system provide an attractive return for ethanol industry?

Environmental Issues:

- Total greenhouse gas emissions from agricultural operations without and with CO_2 capture?

  "e.g., energy and fertilizer use efficiencies, land and water use efficiencies"

CIT CO_2 Research- Cont'd

CIT Work Plan:

- Research will be conducted over at least three growing seasons in the San Joaquin Valley
- Major crops will be selected for field testing
- All necessary field equipment will be installed/software and hardware developed
- Necessary soil, plant, air, and engineering measurements will be taken
- Technical, economic, and environmental studies will be conducted