RESEARCH PROJECT PROPOSAL

Title of Proposed Research Project: Side-By-Side Field Comparison Of Fumigant Emission-Reduction Methodology

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Project Leader: Scott Yates, Research Leader, USDA-ARS, U.S. Salinity Laboratory, 450 W. Big Springs Rd., Riverside, (951) 369-4803 syates@ussl.ars.usda.gov

and

Prof. Res. Sci., Environmental Sciences, University of California, Riverside, CA 92521

Project Cooperators: Proposed Initiation Date: 7/1/2007 Proposed Completion Date: 8/1/2007

Abstract: Provide an abstract of 250 words or less for use in the Center Annual Report and web site describing the project and the issues being addressed. Ozone, a principal component of smog, can lead to reduced lung function, respiratory inflammation in humans and, thus, creates a significant health hazard. Ozone is formed from the photochemical oxidation of nitrogen oxides and VOCs, such as fumigant chemicals. Research is needed to accurately determine the true level of VOC emissions from fumigation and to develop methods to reduce emissions to low levels. Failure to do this may cause agricultural producers to face potentially restrictive control strategies, which may cause a reduction in profit or force farmers to cease food production.

The proposed research project will measure the cumulative and period-averaged (e.g., hourly) emission rates for standard broadcast-shank fumigation and compare the emission measurements to a reduced-emission strategy. The test chemical will be Telone II (1,3-dichloropropene, 1,3-D).

A variety of useful information will be obtained from this project and includes: 1,3-D concentration in the air surrounding treated fields during the experiment, measurements of the emission rate vs. time, emission ratios, micrometeorological measurements, and a variety of measurements of the soil physical and environmental conditions.

The duration of this research project is 3-4 weeks and will provide information that can be used to determine if proposed low-cost methods to control VOC emissions are adequate to achieve required reductions. This information may also be useful as a starting point in the development new cost-effective methods to further reduce emissions.

Justification and Problem Statement: Include a statement of the problem and its importance to the region or state and to agriculture or natural resource industries. Include issues of biological, economic and environmental importance. State how the research will address the problem and the potential beneficial impacts of a successful project. State the urgency of the project and why it needs to be conducted on this Center. Ground level ozone is a public and environmental health hazard. Exposure to ozone, a component of smog, for several hours can reduce lung function and produce respiratory inflammation in humans. Soil fumigants participate in the production of ozone, which is leading to increased regulation of agricultural VOC sources.
Data has shown that pesticides contribute significantly to the total VOC loading in the San Joaquin and Sacramento Valleys. As a result, the California Department of Pesticide Regulation is requiring reductions in pesticide-related VOC emissions from 12% to 20% from 1990 levels in the agricultural regions of the State, and anticipates additional future VOC reductions to meet 1-hour and 8-hour State Implementation Plan requirements as required by EPA’s Ambient Air Quality Standards.

Research is needed to accurately determine the true level of VOC emissions from fumigation and to develop methods to reduce emissions. Failure to do this may cause agricultural producers to face potentially restrictive control strategies, and may cause a reduction in profit or force farmers to cease food production. There are both environmental and economic incentives to use less chemicals/crop protection products and a research effort is needed to determine the effectiveness of emission reduction methodology.

3. Previous Work and Present Outlook: Provide a brief summary of research conducted on this problem and the status of current research efforts. Is this project likely to expand over the next three years or there after?

The principal investigators have been conducting research on the environmental fate and transport of fumigants for over 15 years. During this time, a large number of laboratory and field research projects have been conducted providing a wealth of information on methods to reduce fumigant emissions. Still lacking, however, are large-scale field demonstration projects that include a side-by-side comparison to traditional fumigant application methods.

Some of the methods developed and studied include: (a) impermeable surface barriers (i.e., films/tarps), (b) application depth, (c) the injection method, (d) soil amendments, (e) surface compaction, and (f) surface irrigation. From this research several promising methodologies have emerged, including: the use of impermeable film where emissions can be reduced by as much as 95% compared to standard practices in small research plots; use of a soil amendments (i.e. a fertilizer) where emissions of halogenated fumigants have been lowered by 60-90% when applied as a thin layer at the soil surface; and the use of sprinkler irrigation to create a diffusion barrier at the soil surface where emissions can be reduced 10-40%.

Numerous laboratory and field plot experiments have been conducted and demonstrate the effectiveness of these methods to reduce fumigant emissions. The current research project has been initiated to “take the next step” and demonstrate these methods in large fields prepared and managed following industry standards. Further, state regulatory agencies require this type of information prior to allowing new fumigation practices to be used.

4. Objectives: Describe the specific objectives of the project.

The California Air Resources Board (Project title: Reducing Emissions of Volatile Organic Compounds (VOCs) From Agricultural Soil Fumigation), the California Strawberry Commission (Project title: Development and Testing of Simplified and Cost-Effective Methodology to Evaluate Emission Reduction from Fumigation During Strawberry Production), and USDA-ARS (CRIS project: Minimizing Air and Water Contamination from Agricultural Pesticides) are funding the proposed research with the goal that soil fumigation will continue in California and be conducted in an environmentally benign manner.

The proposed research is relatively short in duration and involves simultaneously fumigating two approximately 1.5-acre fields and measuring fumigant emission using standard technologies. The fields would be needed for a 30-day period between July 15 and September 30.

The proposed project has the following objectives:

a) Determine cumulative and period (e.g., hourly) emission rates for Telone II (1,3-dichloropropene) after broadcast-shank fumigation and compare the traditional application methodology with the addition of an impermeable film. To accomplish this, two experimental fields will be needed, one using a traditional fumigation practice as a benchmark for comparison.
(b) Obtain accurate emission rates from large fields to allow testing of the hypothesis that cumulative emission rates obtained from laboratory experiments using the same soil, temperature conditions, and fumigation practice will provide equivalent results.
(c) Determine if VOC emissions and bystander exposure is significantly reduced when the emission-reduction strategy is employed.
(d) Obtain sufficient soil and environmental measurements to allow numerical simulation of the fate and transport of 1,3-dichloropropene in soil and volatilization into the atmosphere. The data collected by this project will allow the testing of new soils-based volatilization models that couple soil and atmospheric conditions.
processes (Yates et al., 2002). An accurate model may help to reduce the need for expensive field experimentation to test future emission reduction strategies.

5. **Procedure:** Include experimental design, data to be collected, and methods of data analysis. Relate evaluation methods used to the objectives stated above. Please detail specific land areas and services needed from the Center so that the staff hours required may be estimated. Include experimental design including size and number of experimental units [size of plot areas, number of treatments, number of replications, etc.]

The experiment will be conducted during the summer of 2007. Two rectangular fields approximately 1.5-acre in size (280 ft by 250 ft) will be needed to conduct the experiment. The fields should be located at opposite ends of the Research Station (i.e., must be separated by at least 1000' to ensure that emissions from one field do not affect the other field). From an experimental viewpoint, the ideal situation would have one field located in the southwestern and the other field in the northeastern corners of the research station. These fields would not align in the direction of typical wind patterns (based on long-term hourly averaged wind direction data obtain from CMIS Station #2 data).

SOPs have been developed that provide a detailed description of the study plan and procedures for collecting and analyzing data. A brief synopsis is provided here.

The fumigant mixture will be applied by a professional applicator, using a shank injector and according to the industry standard and label for Telone II. The total amount of Telone will be accurately measured before and after application so that the total amount applied will be known. A scale of sufficient accuracy will be used so that the total mass applied to the field will be known with an uncertainty less than 0.5%. A sample will be collected from each Telone II cylinder used in the study prior to the initial weighing of the cylinder. These samples will provide information on the purity of the Telone II applied to the field.

Telone II will be applied at 12 gal/acre and at a depth of 18 inches. This will provide the source of 1,3-D for the study. Following application of the fumigant, the soil will be sealed with a single pass of a disk and a ring roller in the direction of the shanks. This field will serve as a control plot and will not have any other agronomic operation performed that will affect emissions.

The second field will be prepared in an identical manner. The fumigant will be applied at the same rate, depth and using the same type of equipment. During the application, the soil will be sealed with a continuous low-permeability tarpaulin that will serve as an emission barrier.

Meteorological and air sampling equipment will be located adjacent to each test plot. This equipment will be placed to gather the necessary information for flux calculations and for ancillary information. Meteorological measurements include: (a) wind direction, (b) wind speed, (c) solar radiation, (d) ambient air temperature and relative humidity, and (e) barometric pressure. These measurements will be recorded at 2-5 minute intervals. In addition, other soil and chemical property information will be obtained including: (a) soil moisture, (b) soil temperature, (c) soil bulk density, (d) particle size distribution, (e) organic matter content, and (f) pH.

Telone II vapor will be collected on activated charcoal adsorption tubes. Air will be drawn through the charcoal sampling tubes using battery-operated vacuum pumps at airflow rates between 1 and 2 liters of air per minute. A minimum of 8 locations surrounding each field will be sampled at 1.5 m height throughout the experiment. The airflow rates will be checked and recorded before and after each sample with a flow meter to ensure consistent operation.

Pre-application samples (3 samples, 6 hr collection period) will be taken at the center of each test plot at the 1.5 m height on the day prior to the start of application and will serve as a background air concentration samples. Three soil-gas samples will be collected in each field at a 6-inch depth and will serve as initial soil gas concentrations.

Air samples will be collected for up to 21 days, with 3 hour sampling intervals to begin during application. Samples will be continuously collected each day at 0600, 0900, 1200, 1500, 1800, 2100 hours. A few days after fumigation, as determined by laboratory analysis, the sampling interval will be increased 4-hour intervals. After about a 7-10 days, the sampling interval will be increased to 6 or 8 hours and continue until the end of the experiment. Sampling may terminate prior to 21 days if laboratory results indicate that negligible amounts of Telone II is being emitted from the respective plots.

Several measures of quality control will be used for this study including pre- and post-calibration of flow meters, wind speed sensors, and temperature probes; and the use of travel and field-exposed spiked samples. Further, additional spot sampling will be conducted to determine if any nearby sources of Telone II...
are present. Air sample tubes will be placed in freezer storage as soon as possible after being removed from the field. Samples will be shipped with dry ice directly to the U.S. Salinity Laboratory by automobile several times during the study.

The soil gas phase will be sampled at least once per day during the first 3 days of the study, and periodically thereafter, using stainless steel soil vapor samplers and gas tight air syringes. Soil gas measurements will be taken using dedicated soil gas probes at 2 locations within the plots at depths of approximately 15, 30, 45, 60, 75 and 100 cm below the soil surface and in the air space below the tarp.

A validation of laboratory sample recovery will be completed using the analytical method prior to the analysis of any field samples. The validation will consist of (a) 1 reagent blank, (b) 4 controls, (c) 8 samples at the LOQ, (d) 3 samples at the 10 times the LOQ, and (e) 3 samples at a concentration between the LOQ and 10 times the LOQ. The principal analyst and/or study director will review the results to determine if acceptable recovery rates have been obtained.

DATA ANALYSIS: All the data collected during each study will be imported into Microsoft Excel® spreadsheets. The first database will consist of raw meteorological data, laboratory data and information concerning the study. The raw data will be plotted as a function of time to determine if any unexpected behaviors occurred, and if observed, corrected where possible. Any modification will be noted in a comment field permanently attached to the spreadsheet.

Using the period averaged meteorological and air concentration data, the emission rate and cumulative emissions will be determined. For all methods, the cumulative emissions (kg) will be obtained by integrating the volatilization rate over area and time.

ISCST3 will be executed using the period values for meteorological inputs. At each receptor location the predicted air concentration will be obtained and imported into a worksheet. Linear regression will be used to obtain the slope along with various statistics. The slope and the nominal flux rate gives the period flux rate.

For each field site a variety of graphs will be produced: (a) period emission rate vs. time, (b) cumulative emission vs. time, (c) wind speed and direction vs. time, (d) wind rose diagram for the study, (e) ambient air temperature, relative humidity, barometric pressure vs. time, (f) incoming and net solar radiation vs. time, (g) temperature gradient vs. time, (h) air concentration at the receptor points vs. time, (i) soil temperature and heat flux vs. time, (j) contours of soil gas concentration, (k) soil moisture vs. time and depth, and (l) bulk density vs. depth.

SAFETY ASSURANCE: Field personnel will be trained and use proper and approved protective equipment to prevent exposure to Telone II vapor or spray mist. According to the product label, proper protective equipment for applicators making direct contact or for applicators outside an enclosed cab includes coveralls, waterproof gloves, chemical resistant footwear plus socks, face sealing goggles, chemical resistant headgear (for overhead exposure) and apron, and a respirator with an organic-vapor removing cartridge. After application, occasional access to the field may be required and field personnel will be required to wear coveralls, waterproof gloves, chemical resistant footwear plus socks, and a respirator with an organic-vapor removing cartridge during the “no-entry” period. After the “no-entry” period, this personal protection equipment will remain available to all field personnel for the remainder of the study.

6. Extension of Results: Explain plans for the sharing of research results including publications, field days, seminars, etc. The investigators have active extension and outreach programs to disseminate research results to the public, university extension personnel, pest-control advisors, fumigators, members of the agro-industry, commodity boards, and state and federal regulators. We will arrange to participate in field days to provide a forum to discuss the research effort and demonstrate our management strategies. Similar outreach programs will be conducted in connection with the California Strawberry Commission, the Carrot Advisory Board, California Air Resources Board and the California Department of Pesticide Regulation to discuss how to reduce the fumigant emissions while maintaining pest control. At the national level, scientific talks will be presented at the International Research Conference on Methyl Bromide Alternative and Emission Reduction Research, the American Chemical Society, and the American Society of Agronomy. Results of the experiments will be published in a final report as well as newsletters, appropriate trade journals (i.e., California Agriculture), and become part of other technical publications.

7. Submit a completed Annual Request for Land, Labor and Facilities Form for appropriate Center.
NOTE: Your electronic submission will be considered as to represent your signature.
SHAFTER RESEARCH & EXTENSION CENTER
ANNUAL REQUEST FOR LAND, LABOR AND FACILITIES

Center Project No.: 89
Project Title: Side-By-Side Field Comparison Of Fumigant Emission-Reduction Methodology
CEFS No./AES No. and Title: ____________________________
Project Leader: Dr. Jay Gan, Professor Univ. Calif-Riverside (CE Specialist) Phone: 951-827-2712
Project Cooperator(s): Dr. Scott Yates, USDA-ARS and Univ of Calif-Riverside Phone: 951-369-4803
This request is for: 7/2007 to 8/2007 Project Termination Date: 8/31/2007

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<tbody>
<tr>
<td>1. Land:   Acres 1.6</td>
<td>Plot Size  250 ft. x 300 ft.†</td>
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<tr>
<td>2. Crop:   none</td>
<td>Variety:</td>
</tr>
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<td>3. Row Spacing:  none inches</td>
<td>No. of Rows:</td>
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<td>4. Irrigation:   Furrow   none</td>
<td>Flood   none</td>
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<tr>
<td>5. Irrigation Water:   Canal   none</td>
<td>¹Well   none</td>
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<tr>
<td>6. Fertilizer:   Normal   none</td>
<td>¹Special (describe)   none</td>
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<tr>
<td>7. Weed Control:   Normal   none</td>
<td>¹Special (describe)   none</td>
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<td>8. Insect Control:   Normal   none</td>
<td>¹Special (describe)   none</td>
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<tr>
<td>9. Disease Control:   Normal   none</td>
<td>¹Special (describe)   none</td>
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<tr>
<td>10. ¹Other Special Requirements (use additional sheets if needed):  soil preparation for fumigation (i.e., tillage, possible ripping, irrigation)</td>
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<tr>
<td>11. Greenhouse:   Crop  none   # of benches   none   Months Needed   none</td>
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<tr>
<td>12. Lath house:   Crop  none   # of benches   none   Months Needed   none</td>
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<td>13. Off-Center Use of Equipment ²:  Planter   none   Picker   none   Other   none</td>
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<td>14. Laboratory, storage or other facilities:  List specifics in proposal.</td>
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<td>15. Do you plan to use unregistered compounds, experimental compounds, and/or Danger pesticides?  Yes  No</td>
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<td>16. Does the project require a permit(s) from any regulatory agency?  Yes  No  If yes, attach a copy of permit(s).</td>
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<tr>
<td>17. Does the project involve any carcinogenic compounds, radioactive materials or unregistered re-combinant DNA?  Yes  No  If yes, attach documentation of campus approval, and containment plans.</td>
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<td>18. Crop Destruct:  Yes  No</td>
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†Fields are approximately 280 feet of working length.
²Any special needs should be included in the project proposal and may be subject to recharge.

While working at the Shafter Research & Extension Center, I agree that my employees and I will abide by safe work practices as outlined in the Shafter Research & Extension Center, Environmental Health and Safety Guidelines.

NOTE: Your electronic submission will be considered as to represent your signature.