A. Cover Page


2. Project Leaders:
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3. Cooperators: None

4. Supporters:

   County of Santa Clara Department of Agriculture and Environmental Management, Agriculture Division; Bay Area Chrysanthemum Growers Association; Kings River Water Quality Coalition

5. CDFA Requested Funding

<table>
<thead>
<tr>
<th>Funding request</th>
<th>2018: $75,000.32</th>
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</tbody>
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6. Agreement Manager

   Suzanne E. Burton,
   Senior Contracts and Grants Analyst
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B. Executive Summary

1. Problem

Asian specialty vegetables are grown intensively in open field and protected agricultural systems. In protected agricultural systems, some of the vegetables are grown 6-7 times per year in continuous rotations with a 15-day gap between each rotation. Grown primarily in Fresno, Monterey, Riverside, San Bernardino, Santa Clara, San Luis Obispo, and Ventura counties on around 7026 acres, Asian vegetables are valued at $79 million per year (California County Crop Reports, 2015).

In Fresno and Santa Clara Counties, these crops are grown primarily by limited-resource, small-scale, socially disadvantaged Chinese, Hmong, and other Asian immigrant farmers. A recent survey of nitrogen (N) fertilizer use for some of the Asian vegetables was found to be as follows: bok choy up to 140 lb/acre, garlic chives up to 500 lb/acre, and edible chrysanthemum up to 220 lb/acre. Information is currently lacking on nitrogen uptake in many of these crops. With proposed regulations under the Irrigated Lands Regulatory Program (ILRP) by the Central Coast Regional Water Quality Control Board (CCWQCB) and the Central Valley Regional Water Quality Control Board (CVRWQCB) to control N application, it is important to understand N uptake and removal in crops that have significant acreage but do not have commodity board support. Asian growers producing specialty vegetables and herbs are required to fill out the nitrogen management plan as part of the ILRP. However, they lack the information to complete this form accurately as there is no information on nitrogen fertilizer recommendations or nitrogen uptake for most of their crops.

The project proposes to provide detailed measurements of total N uptake and N uptake pattern of bok choy, edible chrysanthemum, garlic chives, moringa, and lemongrass. This project will also evaluate current irrigation management practices of these crops and compare them with the crops’ water requirements and identify potential practices that may help reduce nitrate leaching. The proposed project also includes outreach activities, including workshops to train growers in nitrogen management.


The overall goal of this project is to provide detailed measurements of total N removal, N uptake, and the N uptake pattern of bok choy, edible chrysanthemum, garlic chives, moringa, and lemongrass. Total N is crucial for viable crop production, but irrigation efficiency is vital to retaining the applied N within the crop root zone. This project will also evaluate the current irrigation management practices of these crops, compare them with the crops' water requirements and identify potential practices that may help reduce nitrate leaching. Together, the information collected will provide the basic information necessary for growers to better manage N inputs to these crops and protect water quality. Specifically, the following two objectives shall be addressed with the work proposed for this project:

1. Evaluate N uptake, N availability, canopy development and water application of bok choy, edible chrysanthemum, garlic chives, moringa, and lemongrass.
2. Extend the findings of this research to Chinese and Hmong growers in the Central Coast and Central Valley regions to increase their understanding of N uptake, and publish results to provide documentation of the findings.

Evaluations will be conducted in grower fields with typical crop production practices for the region and crop (direct seeded bok choy and edible chrysanthemum, transplanted garlic chive, moringa, and lemongrass); irrigation and fertilizer management practices will also represent the typical practices for the region. These include sprinkler irrigation for the majority of the fields in Santa Clara County, and either flood/furrow irrigation or drip irrigation in Fresno County. The evaluations will be conducted on 12 commercial fields each year.

During the growing seasons 2018 and 2019 above ground biomass, biomass N and soil nitrate evaluations will be determined 3 times for bok choy, 7 times for edible chrysanthemum and moringa, and up to 12 times for garlic chive and lemongrass to generate N uptake curve. At key stages of crop development, diagnostic sampling of leaves will be done for analysis of total N. In addition, flow meters and soil moisture sensors shall be installed and canopy development shall be determined.

The results of this project shall be presented at grower workshops, conferences (e.g., FREP conference) and published in Cooperative Extension newsletters and scientific journals. Outreach material shall be translated into Cantonese and Hmong and presented verbally in Hmong to bridge potential language barriers. The success of the project will be determined by the number of growers attending the training workshops. We expect that a total of at least 70 growers will attend the training sessions each year.

3. Audience

The information developed by this project will be beneficial to small and beginning, minority and disadvantaged Chinese, Hmong, and other Asian immigrant farmers. The information will also benefit all other farmers growing these crops, as well as local water quality coalitions managing grower records for the ILRP.

C. Justification

1. Problem: Asian specialty vegetables are grown intensively in open field and protected agricultural systems. In protected agricultural systems some of the vegetables are grown 6-7 times per year in continuous rotations with 15-day gap between each rotation. Grown primarily in Fresno, Monterey, Riverside, San Bernardino, Santa Clara, San Luis Obispo, and Ventura counties on around 7026 acres Asian vegetables are valued at $79 million per year.

In Fresno and Santa Clara counties these crops are grown primarily by limited resource, small farm, minority and disadvantaged Chinese, Hmong, and other Asian immigrant farmers. A recent survey of nitrogen (N) fertilizer use for some of the Asian vegetables was found to be as follows: bok choy up to 140 lb/acre, garlic chives up to 500 lb/acre, and edible chrysanthemum up to 220 lb/acre (personal communications).
With proposed regulations under the Irrigated Lands Regulatory Program by the Central Coast Regional Water Quality Control Board (CCWQCB) and the Central Valley Regional Water Quality Control Board (CVRWQCB) to control N application, it’s important to understand N uptake in crops that have significant acreage but do not have commodity board support.

The project proposes to provide detailed measurements of total N uptake and N uptake pattern of bok choy, edible chrysanthemum, garlic chives, moringa, and lemongrass. Bok choy a 45-day duration crop, is widely grown by Chinese, Hmong, and other Asian farmers. Also, bok choy serves as a model crop as the same production practices are also followed by growers for other crops such as gai choy, Shanghai bok choy, gailan, A choy, and yu choy. Edible chrysanthemum is medium duration crop that has multiple harvests during the 4-6 months crop cycle. Edible chrysanthemum serves as a model crop for other medium duration crops as the same production practices are also followed for crops such as water spinach. Garlic chives and lemongrass are longer duration crops and are harvested multiple times in a typical 2-year crop cycle. This project will also evaluate current irrigation management practices of these crops and compare it with their water requirements and identify potential practices that may help reduce nitrate leaching.

2. **FREP Mission and Research Priorities:** This proposal addresses FREP goals by providing reliable information on total N uptake and the pattern of N uptake by bok choy, edible chrysanthemum, garlic chive, moringa, and lemongrass grown in California. This proposal addresses FREP research priority area “Improving Input Management”. By providing information on the uptake pattern of N by these crops, it will provide information to help better time fertilizer applications. These aspects of N management are linked to irrigation management and will provide a better understanding of the need for careful water management to improve applied N use efficiency.

3. **Impact:** The proposed project will generate data which will be valuable for limited resource, small farm, minority and disadvantaged Chinese, Hmong, and other Asian immigrant farmers. The collected data will allow creating N fertilization guidelines for major Asian vegetables for the dominant production systems in Santa Clara and Fresno counties. In addition, the interactions between fertilization and crop N requirements, as well as between irrigation and N losses can be highlighted at outreach events based on the collected data. While the focus of this project is on some major Asian vegetables, the general knowledge about irrigation and N management will be valuable for other crops grown by these growers.

Ultimately, this project shall lead to a better understanding of N fertilization and irrigation management among disadvantaged Chinese, Hmong, and other Asian immigrant farmers and improve water and N use efficiency of their vegetable production. This will have economic benefits for the farmers and reduce leaching of nitrate to the groundwater.

4. **Long-Term Solutions:** This project will provide key information that will allow growers to continue to make progress towards applying N more efficiently while reducing nitrate loading to ground and surface waters.

5. **Related Research:** Daniel Geisseler is currently working on a FREP funded project which aims to develop a CropManage version for processing tomatoes (project number 15-0410-SA). Field
work and lab analyses are very similar for this and the proposed project. The gained experience will be highly beneficial for the proposed project. Furthermore, the results shall be incorporated into the N calculator, an online tool his team is currently developing with FREP support (project number 16-0610-SA-0).

6. **Contribution to Knowledge Base:** The proposed project will generate a large dataset of N uptake and N removal by major Asian vegetables. These values will be important for the growers to plan their fertilization management. The data collected will allow creating N uptake curves and calculating total N uptake values. This information is needed to optimize timing and rate of N fertilizer applications. In addition, N removal data will be valuable for the Irrigated Lands Regulatory Program. A major metric for the Program is the ratio between N applied and N removed, with the amount of N removed being calculated based on yield reported by the grower and average values for the N content of the harvested portion of the crop. This project will provide these values for major Asian vegetables.

7. **Grower Use:** The collected data from this proposed project will allow creating N fertilization guidelines for major Asian vegetables for the dominant production systems in Santa Clara and Fresno counties. The outreach events and the material developed with the proposed project will directly benefit disadvantaged Chinese, Hmong, and other Asian immigrant farmers.

D. **Objectives:** The overall goal of this project is to provide detailed measurements of N removal, total N uptake and the N uptake pattern of bok choy, edible chrysanthemum, garlic chives, moringa, and lemongrass. Total N is crucial for viable crop production, but irrigation efficiency is vital to retaining the applied N within the crop root zone. This project will also evaluate the current irrigation management practices of these crops, compare it with their water requirements and identify potential practices that may help reduce nitrate leaching. Together, the information collected will provide the basic information necessary for growers to better manage N inputs to these crops and protect water quality. Specifically, the following two objectives shall be addressed with the work proposed for this project:

1. Evaluate N uptake, N availability, canopy development and water application of bok choy, edible chrysanthemum, garlic chives, moringa, and lemongrass.

2. Extend the findings of this research to Chinese and Hmong growers in the Central Coast and Central Valley regions to increase their understanding of N uptake, and publish results to provide documentation of the findings.

E. **Workplan and Methods**

1. **Workplan**

   Evaluations will be conducted in grower fields with typical crop production practices for the region and crop (direct seeded bok choy and edible chrysanthemum, transplanted garlic chive, moringa, and lemongrass); irrigation and fertilizer management practices will also represent the typical practices for the region. These include sprinkler irrigation for the majority of the fields in Santa Clara County, and either flood/furrow irrigation or drip irrigation in Fresno County. The
evaluations will be conducted on 12 commercial fields four fields for bok choy – two locations, two farms per location; edible chrysanthemum, garlic chives, moringa, and lemongrass – one location and two farms per location; for a total of 24 fields in 2018 and 2019 growing seasons.

Work Plan Year 1

Task 1: Conduct N, irrigation and root evaluations of 12 bok choy, edible chrysanthemum, chive, moringa, and lemongrass fields in 2018

Sub-task 1.1 Conduct N uptake pattern and total N uptake evaluations
  1. Select 4 high yielding fields of bok choy and 2 high yielding fields each of edible chrysanthemum, garlic chive, moringa, and lemongrass from Fresno and Santa Clara counties.
  2. During the growing season, conduct above ground biomass, biomass N and soil nitrate evaluations 3 times for bok choy, 7 times for edible chrysanthemum and moringa, and 12 times for garlic chive and lemongrass to generate N uptake curve. Each field will be divided into three blocks (replicates). Separate samples will be taken from each block. When the crops are harvested, the harvested portion of the crops and the residues left in the field will be sampled separately.
  3. At key stages of crop development, diagnostic sampling of leaves will be done for analysis of total N.

Sub-task 1.2 Conduct crop canopy evaluations and irrigation application evaluations
  1. Install flow meters in the above mentioned fields
  2. Using an infra-red camera, take canopy photos of crop every two weeks and up to three harvests for multiple harvest crops.
  3. Install and maintain soil moisture monitoring sensors

Sub-task 1.3 Analyze all data and prepare mid-term report to FREP

Sub-task 1.4 Reports and extension
  1. Provide mid-term report to FREP
  2. Report preliminary results to Chinese and Hmong growers at workshops and UCCE newsletters

Work Plan Year 2

Task 2: Conduct N, irrigation and root evaluations of 12 bok choy, edible chrysanthemum, chive, moringa, and lemongrass fields in 2019

Sub-task 2.1 Conduct N uptake pattern and total N uptake evaluations
  1. Select 4 high yielding fields of bok choy and 2 high yielding fields each of edible chrysanthemum, garlic chive, moringa, and lemongrass from Fresno and Santa Clara counties.
  2. During the growing season, conduct biomass, biomass N and soil nitrate evaluations 3 times for bok choy, 7 times for edible chrysanthemum and moringa, and 12 times for
garlic chive and lemongrass to generate N uptake curve. Each field will be divided into three blocks (replicates). Separate samples will be taken from each block. When the crops are harvested, the harvested portion of the crops and the residues left in the field will be sampled separately.

3. At key stages of crop development, diagnostic sampling of leaves will be done for analysis of total N.

Sub-task 2.2 Conduct crop canopy evaluations and irrigation application evaluations
   1. Install flow meters in the above mentioned fields
   2. Using an infra-red camera, take canopy photos of crop every two weeks and up to three harvests for multiple harvest crops.
   3. Install and maintain soil moisture monitoring sensors

Sub-task 2.4 Analyze all data and prepare final-term report to FREP

Sub-task 2.5 Reports and extension
   1. Final report to FREP
   2. Provide report of final results to Chinese and Hmong growers at workshops and annual FREP Conference
   3. Publish results in UCCE newsletters, and prepare peer reviewed manuscript for submission to a scientific journal. Develop educational brochures in Cantonese and Hmong for the growers.

2. Methods

Crop biomass, biomass N and soil nitrate-N will be measured 3 times for bok choy, 7 times for edible chrysanthemum and moringa, and up to 12 times for garlic chives and lemongrass. At harvest, total biomass and commercially harvested biomass, and biomass N will be measured. Fertilizer application rates and timing in each field will also be documented.

Flow meters will be installed at each monitored field to quantify the volume of water applied from crop establishment to harvest. The flow meters will be connected to data loggers to record the length and frequency of irrigations. Using an infra-red camera, crop canopy photos will be taken every two weeks and up to three harvests for multiple harvest crops to develop crop coefficients for estimating crop ET. Soil moisture sensors will also be installed to monitor changes in soil moisture storage. Using these data, we will be able to estimate the volume of drainage below the root zone. Plant tissue samples will be oven-dried at 65 °C and ground for analysis. Total N will be determined by dry combustion (Nelson and Sommers, 1996, Bremner, 1996).

As per Smith et al., (2016) crop evapotranspiration (ETc) will be calculated for each monitored field by multiplying daily reference evapotranspiration (ETo) data collected from the nearest California Irrigation Management Information System (CIMIS) weather station by daily crop coefficients (Kc). Daily Kc will be estimated as described in Johnson et al. (2016): Kc = max[Ke,T] where Ke is a soil evaporation coefficient based on the method of Gallardo et al. (1996) and T is a transpirational coefficient derived from crop canopy cover. Infrared images
taken by a digital camera will be used to estimate $T$. Canopy cover data will be fit into an equation modified from Gallardo et. al. (1996): 

$$\text{Canopy cover (\%) } = \frac{G_{\text{max}}}{1 + \exp[A + B \times \text{day}/(\text{Maxday} \times F_{\text{max}})]}$$

where $G_{\text{max}}$ is the maximum canopy cover, $A$ and $B$ are fitted parameters, day is the number of days after planting or transplanting, Maxday is the total days between planting and harvest, and $F_{\text{max}}$ is the fraction of the crop cycle when the maximum canopy size is achieved. Parameters for this model will be determined separately for bok choy, edible chrysanthemum, garlic chives, moringa, and lemongrass. These models will be used to calculate the daily $T$ value using the equation: 

$$T = \frac{(0.63 + 1.71 C - 0.0061C^2)}{100},$$

where $C$ is percent canopy cover determined in the above modified equation.

Pre-plant and post-harvest soil samples will be taken to a depth of 2 feet in 1-foot increments and analyzed for soil moisture, ammonium and nitrate. The pre-plant samples will also be used to characterize the soil at each site (analyses will include soil texture, pH, EC, total C and N, bicarbonate extractable P and ammonium-acetate extractable K). Each sample will be a composite sample from at least 5 locations in the same field.

During the growing season, soil samples from the top foot of the profile will be taken regularly (depending on harvest and irrigation schedule) and analyzed for soil moisture, ammonium and nitrate. Soil samples will be taken with a soil probe, sieved (2 mm) and kept cool until analysis.

Samples for ammonium and nitrate analyses will be extracted with 2 M KCl solution and the nitrate and ammonium concentrations will be determined colorimetrically (Verdouw et al., 1978; Forster, 1995, Doane and Horwath, 2003). Soil organic carbon and total N will be analyzed by dry combustion (Nelson and Sommers, 1996, Bremner, 1996). Soil texture will be analyzed using the pipet method (Gee and Bauder, 1986), EC in a saturated paste and pH will be determined in a 1/2.5 soil:water suspension (Thomas, 1996). Soil moisture will be determined by drying samples for 24 h at 105 °C. Available P will be extracted with sodium bicarbonate (Olsen-Method; Olsen et al., 1954) and analyzed colorimetrically (Murphy and Riley, 1962; Watanabe and Olsen, 1965), available K will be extracted with ammonium acetate and analyzed by ICP (Helmke and Sparks, 1996).

Together with general information about irrigation scheduling and N management, the data collected in commercial fields will be used for a wide range of outreach activities. These outreach activities will include local grower meetings, handouts, newsletters, and online resources (e.g. UCCE Small Farm website, California Fertilization Guidelines).

3. Experimental Site

The project will consist of a survey of well-managed, high-yielding bok choy, edible chrysanthemum, garlic chive, moringa, and lemongrass grower fields in Santa Clara and Fresno Counties.

F. Project Management, Evaluation, and Outreach

1. Management
The project leaders will meet at least once a year to coordinate activities, discuss the progress of the research, and make adjustments to the work plan when necessary. Aparna Gazula and Ruth Dahlquist-Willard will be responsible for conducting the field evaluations of N uptake, crop water use, and data management. Daniel Geisseler will provide technical input to these evaluations and will also be responsible for the analysis of soil and tissue samples and data management. The project leaders will collaborate on outreach activities.

2. Evaluation

The success of the project will be determined by the number of growers attending the training workshops. We expect that a total of at least 70 growers will attend the training sessions each year.

3. Outreach

The results of the evaluations will be reported to the Chinese and Hmong growers annually in 2019 and 2020. Based on experience working with the Chinese and Hmong growers, to ensure active participation in the workshops the following steps will be taken:

i. The information presented at the grower workshops will be translated into Cantonese and Hmong.
ii. Each year the information for nutrient management and irrigation management will be presented at two discrete workshops and the workshops will incorporate visual information about nitrogen fertilization and irrigation management practices.
iii. All outreach materials such as handouts, power point presentations, and brochures will also be translated into Chinese and Hmong.
iv. The information will also be broadcasted over the Hmong radio channel, an important source of information for the Hmong growers.

Outreach efforts will be measured and evaluated as follows: As a result of the information developed by the proposed project, the number of Chinese and Hmong growers completing nitrogen use reports and nitrogen management plans for bok choy, edible chrysanthemum, garlic chives, moringa, and lemongrass will increase by 20%.

The results will also be published in Monterey County Crop Notes in 2020 and a scientific journal to provide peer reviewed reference of findings at the conclusion of the project.

4. References


G. Budget Narrative

The budget for Daniel Geisseler will be sub-contracted as follows:

a. Personnel Expenses

Salary
- Soil and plant samples will be processed and analyzed by a Junior Specialist (step II) who will work 1.5 days per week on this project for 8 months in year 1 and for 2.5 days per week for 8 months in year 2. On an annual basis, this corresponds to 0.2 and 0.33 FTE, respectively. In year 1, the junior specialist will analyze the soil samples for ammonium and nitrate and dry the plant and soil samples. The other soil analyses and all plant N analyses will be done in year 2 of the project. The junior specialist will also enter the data into a database and do preliminary data analyses. The annual full-time salary for a junior specialist is expected to be $40,048 in 2018 and is expected to increase by 3% for 2019. Therefore, we request $8,374 and $14,231 for 2018 and 2019, respectively for the junior specialist's salary.

Benefits
- It is anticipated that composite benefit rates for the junior specialist will be 38.9% in fiscal year 2017/18 and increase to 40.1% and 41.3% in fiscal year 2018/19 and 2019/20, respectively. Thus, the total benefits for the junior specialist will be $3,308 and $5,792, respectively.

b. Operating Expenses

Supplies
- Supplies for laboratory analyses include reagents and disposable material for soil and plant analyses (e.g. cuvets, pipet tips, tin capsules, reagents and gas for ICP). We expect that more than 700 soil samples will be analyzed for ammonium and nitrate over the course of the project. The number of soil samples analyzed for texture, pH, EC, total C and N, bicarbonate extractable P and ammonium-acetate extractable K is expected to be about 30. These analyses will be done during the second years for the samples collected in both years. The total number of plant tissue samples that need to be analyzed for total N will be approximately 800. Plant samples will be dried immediately and stored in paper bags. Most of them, however, will be ground and analyzed for total N during the second year of the project. We request a total of $2,516 and $6,362 for laboratory analyses for years 1 and 2, respectively.

Equipment
- None

Travel
- Daniel Geisseler: we request travel support for two trips to Santa Clara and two trips to Fresno per year for field visits and outreach activities. We estimated a distance from Davis to Santa Clara and to Fresno of 240 and 400 miles per trip, respectively. A sedan from UC Davis fleet service ($56 per day, $0.078 per mile) will be used. Total travel costs for field
visits and local outreach activities will be $324 per year. We also request funding to attend
the FREP conference in 2019. We estimate the total distance to be 380 miles and the costs for
one night in a hotel to be $100. Using the rates for a sedan from fleet service, the total costs
to attend the FREP conference will be $242 in 2019.

Other Expenses
• Indirect Costs: Indirect costs are being applied at 15% MTDC based on UCOP’s
  communication with Secretary Karen Ross on February 13, 2017. Indirect costs are
  $2,178.30 and $4,042.50 in year 1 and 2, respectively.

The budget for Aparna Gazula and Ruth Dahlquist-Willard is as follows:

c. Personnel Expenses

Salary
• Trial setup, field work and data collection for bok choy, edible chrysanthemum, and garlic
  chives in Santa Clara county will be done by an Agricultural Technician who will work 0.27
  full time equivalent (FTE) on an annual basis in year 1 and 2. In year 1 and 2 the agricultural
  technician will install the moisture sensors, flow meters, and data loggers in the trial fields.
  The technician will also collect and weigh soil samples and biomass samples, collect crop
  infra-red images, data from flow meters and soil moisture sensors. The hourly salary for the
  agricultural technician is expected to be $16.35 in 2018 and is expected to increase by 3% for
  2019. Therefore, we request $9,430.68 and $9,713.60 for 2018 and 2019, respectively for
  the agricultural technician’s salary.
• Trial setup, field work and data collection for bok choy, moringa, and lemongrass in Fresno
  county will be done by the Small Farms Assistant (Community Education Specialist 1)
  who will work for 66 days in year 1 and 72 days in year 2. In year 1 and 2 the Small Farms
  Assistant will install the moisture sensors, flow meters, and data loggers in the trial fields.
  This assistant will also collect and weigh soil samples and biomass samples, collect crop
  infra-red images, data from flow meters and soil moisture sensors. The hourly salary for the
  Small Farm Assistant is expected to be $16.50 in 2018 and 2019. Therefore, we request $8,
  712.00 and $9,504.00 for 2018 and 2019, respectively for the agricultural technician’s
  salary.

Benefits
• It is anticipated that composite benefit rates for the junior specialist will be 6.28% and 6.47%
  in fiscal year 2018 and 2019, respectively. Thus, the total benefits for the Agricultural
  Technician will be $575.27 and $592.53, respectively.
• It is anticipated that composite benefit rates for the Small Farms Assistant will be 56% in
  fiscal year 2018 and 2019. Thus, the total benefits for the Small Farms Assistant will be
  $4,878.72 and $5,322.24, respectively.

d. Operating Expenses

Supplies
In year 1 in Santa Clara county supplies for field trials include sampling bags ($105) and pruners (2 pruners at $20 each), shutter release and pole for one infrared camera $2000. For each of the six intensively monitored fields one data logger and four soil moisture sensors and software $7380 ($615/data logger and 4 sensors) $390 for software. For each of the three intensively monitored fields one flow meter ($200), one datalogger (CR200, Campbell Science, $ 1,000) with enclosure, solar panel and battery will be required per field in year 1. 4 of the units will be purchased with grant funds and two with PI funds. In year 2 supplies for field trials include sampling bags ($105) and pruners (2 pruners at $20 each).

In Fresno County supplies for field trials include one infrared camera (Canon T4i 650D 18.1Megapixel Vegetation Stress Camera) including lens, shutter release, pole and bag: $4000. The camera is needed for canopy cover measurement and will be purchased in year 1. Also in year 1, for each of the six intensively monitored fields one data logger and four soil moisture sensors will be purchased for $3690 ($615/data logger and 4 sensors) with accompanying software for $195. Flow meters will be purchased at $200 per flow meter for 4 of the fields, and the PI will provide the other two flow meters needed. Additional parts are needed including extension cables for the soil moisture sensors (3 cables at $25 each) and materials to connect flow meters to the existing irrigation systems ($50). Two soil probes at $125 each are required for soil sampling.

**Equipment**

- None

**Travel**

- Agricultural Technician: In Santa Clara county, we request $945 (70 trips at 25 miles per round trip and mileage rate of $0.54 per mile) for years 1 and 2 to travel to the grower fields for data collection.

- Aparna Gazula: In year 1 and 2 we request $500 (fuel expenses for 70 trips at 50 miles per round trip in a truck with 21 miles/gallon and a gas price $3 per gallon). In year 2 we also request $318 for conference registration and hotel expenses to attend the FREP conference.

- Ruth Dahlquist-Willard: For year 2, we request $500 for travel by rental car, conference registration, parking, and hotel expenses to attend the FREP conference.

**Other Expenses**

- Sample Shipping Fee: For both Fresno and Santa Clara Counties, twenty-two shipments of samples per county via overnight Fedex shipping ($40 per shipment) $880 per county per year for both years 1 and 2.

- Outreach: For Santa Clara County, translation of outreach materials into Cantonese and Hmong and printing costs are $4000 in year 2. For Fresno County, we request $300 for radio outreach (4 radio shows at $75 per show), $250 for a meeting room fee, and $413.19 for printing flyers and handouts.

- Grower Reimbursement: In Santa Clara County, reimbursement to limited-resource growers for destructive sampling of 6 boxes of bok choy ($20/box), 14 boxes of edible chrysanthemum ($25/box), and 24 boxes of garlic chives ($60/box) for a total of $1910 per year and in both years 1 and 2. In Fresno County, reimbursement to limited-resource growers for destructive sampling of 6 boxes of bok choy ($20/box), 14 boxes of moringa ($25/box), and 24 boxes of lemongrass ($60/box) for a total of $1910 per year and in both years 1 and 2.
- Indirect Costs: Indirect costs are being applied at 15% MTDC based on UCOP's communication with Secretary Karen Ross on February 13, 2017. Indirect costs are $7,604.35 and $5,740.02 in year 1 and 2, respectively.

e. Other Funding Sources

Two flow meters and dataloggers will be purchased with funding from the PI’s startup package.
H. Budget Template

I. Appendices

1. Project Leaders

   Resumes
   a. Aparna Gazula
   b. Ruth Dahlquist-Willard
   c. Daniel Geisseler

   Current and Pending
   a. Aparna Gazula
   b. Ruth Dahlquist-Willard
   c. Daniel Geisseler

   Outreach Activities
   a. Aparna Gazula
   b. Ruth Dahlquist-Willard
   c. Daniel Geisseler

2. Cooperators - none

3. Supporters
   a. County of Santa Clara Department of Agriculture and Environmental Management, Agriculture Division
   b. Bay Area Chrysanthemum Growers Association
   c. Kings River Water Quality Coalition
a. Aparna Gazula
University of California Cooperative Extension Santa Clara County
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Phone: 408-282-3127
E-mail: agazula@ucanr.edu

Biography:
Dr. Aparna Gazula has been an extension advisor for the past eight years. She has offered close to 300 extension education events that were attended by more than 10,000 farmers. She has been recognized at the national, regional, and state levels for her extension education programs and publications. She has worked with both small and large vegetable farmers, and has also conducted on-farm trials. In her position as the University of California Cooperative Extension Small Farm Advisor for Santa Clara, San Benito, and Santa Cruz counties, she works with the small farmers in the area.

Education:

<table>
<thead>
<tr>
<th>Institution</th>
<th>Field of Study</th>
<th>Degree</th>
<th>Year</th>
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<tbody>
<tr>
<td>University of Florida</td>
<td>Horticultural Sciences</td>
<td>PhD</td>
<td>2009</td>
</tr>
<tr>
<td>The Ohio State University</td>
<td>Horticulture and Crop Science</td>
<td>MS</td>
<td>2004</td>
</tr>
<tr>
<td>Acharya N.G. Ranga Agricultural University</td>
<td>Agricultural Sciences</td>
<td>BS</td>
<td>2000</td>
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Employment:

<table>
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<tr>
<th>Institution</th>
<th>Position</th>
<th>Year</th>
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<tbody>
<tr>
<td>University of California</td>
<td>Assistant Extension Advisor</td>
<td>2016-Present</td>
</tr>
<tr>
<td>University of Florida</td>
<td>Extension Agent III</td>
<td>07/15-12/15</td>
</tr>
<tr>
<td>University of Florida</td>
<td>Extension Agent II</td>
<td>07/09-07/15</td>
</tr>
<tr>
<td>University of Florida</td>
<td>Extension Agent I</td>
<td>01/09-07/09</td>
</tr>
<tr>
<td>University of Florida</td>
<td>Graduate Research Assistant</td>
<td>2005-2008</td>
</tr>
<tr>
<td>The Ohio State University</td>
<td>Research Associate</td>
<td>2004-2005</td>
</tr>
<tr>
<td>The Ohio State University</td>
<td>Graduate Research Assistant</td>
<td>2001-2004</td>
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</table>

Publications:


**Honors:**

*National Association of County Agricultural Agents:*


**Professional Organizations**

American Society for Horticultural Science
California Chapter of the American Society of Agronomy
b. **Ruth Dahlquist-Willard**  
University of California Cooperative Extension, Fresno County  
550 E. Shaw Ave., Suite 210-B  
Fresno, CA 93710  
Phone: 559-241-7513  
E-mail: rdahlquistwillard@ucanr.edu

**Education:**

**Ph.D. in Entomology, 2008**  
University of Idaho, Moscow, ID and the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba, Costa Rica  
NSF-IGERT Fellow, University of Idaho-CATIE interdisciplinary joint doctoral program

**Postbaccalaureate coursework, 2000 – 2001**  
California State Polytechnic University, Pomona, CA  
Additional coursework in entomology, crop science, and integrated pest management

**B.S. in Biology, 1998**  
University of California, Los Angeles, Los Angeles, CA  
Emphasis in ecology, animal behavior, and evolution

**Employment:**

Small Farms and Specialty Crops Farm Advisor, University of California Cooperative Extension, Fresno and Tulare Counties, CA, 2014-present  
- Conduct extension and research programs that address challenges to viability for small-scale agriculture in Fresno and Tulare Counties.  
- Provide expertise in integrated pest management, crop nutrition, and other fields related to small-scale production such as direct marketing and regulatory compliance.  
- Collaborate with other farm advisors, community crops, and statewide and federal organizations to address issues faced by small-scale producers.

Assistant Professor of Biology, Fresno Pacific University, Fresno, CA, 2008-2014  
- Taught undergraduate courses in the Biology, Environmental Science and Pre-Health programs.  
- Conducted research with undergraduate students on soil solarization and biological control.  
- Advised and mentored undergraduate pre-health majors.

**Publications:**

http://dx.doi.org/10.1016/j.jclepro.2016.09.051


c. **Daniel Geisseler**  
Assistant Cooperative Extension Specialist in Nutrient Management  
Department of Land, Air and Water Resources  
University of California  
1 Shields Ave.  
Davis, CA, 95616  
Phone: 530-754 9637  
E-mail: djgeisseler@ucdavis.edu

**ACADEMIC EDUCATION**  
PhD in Soil Science; University of California, Davis  
September 2009  
MSc in Soil Science; University of California, Davis  
December 2005  
Undergraduate degree in International Agriculture; Swiss College of Agriculture, Zollikofen  
April 1998

**PROFESSIONAL EXPERIENCE**

<table>
<thead>
<tr>
<th>Role</th>
<th>Institution</th>
<th>Dates</th>
<th>Responsibilities</th>
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<tr>
<td><strong>Assistant UCCE Specialist</strong></td>
<td>UC Davis, Department of Land, Air and Water Resources</td>
<td>Since November 2014</td>
<td>Research and outreach activities in nutrient management</td>
</tr>
</tbody>
</table>
| **Postdoctoral employee**     | UC Davis, Department of Land, Air and Water Resources                       | May 2012 - October 2014| Development of Database of FREP funded research projects ([http://www.cdfa.ca.gov/is/frep/](http://www.cdfa.ca.gov/is/frep/))  
                                  |                              |                        | Create web-based fertilization guidelines of major crops grown in California ([http://apps.cdfa.ca.gov/frep/docs/Guidelines.html](http://apps.cdfa.ca.gov/frep/docs/Guidelines.html))  |
| **Scientific employee**       | University of Kassel, Witzenhausen, Department of Environmental Chemistry    | August 2009 - March 2012| Teaching: Carbon and nutrient cycling in soils in different classes at the MSc and BSc level  
                                  |                              |                        | Supervision of PhD students who study the effect of crop management on soil carbon, nitrogen and phosphorus  
                                  |                              |                        | Own research focusing on nitrogen utilization by soil microorganisms |
| **Research assistant**        | UC Davis, Department of Land, Air and Water Resources                       | October 2003 - June 2009|                                                                                                  |
| **Teaching assistant**        | UC Davis, Department of Land, Air and Water Resources                       | Spring 2005            |                                                                                                  |
| **Farm advisor and teacher**  | Agricultural Education and Consultancy Center Liebegg, Gränichen, Switzerland | April 1998 - August 2003|                                                                                                  |
SELECT PUBLICATIONS (in peer-reviewed journals; total number of publications: 32)

### Current and Pending

#### a. Aparna Gazula

<table>
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<tr>
<th>Status</th>
<th>Support Source</th>
<th>Total $ Amount</th>
<th>Effective and Expiration Dates</th>
<th>% of Time Committed</th>
<th>Title of Project</th>
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<tr>
<td>Current</td>
<td>USDA-NIFA, UC Berkeley</td>
<td>$15,000</td>
<td>10/01/2014-12/31/2017</td>
<td>5</td>
<td>Growing Roots: Deepening Support for Diverse New Farmers and Ranchers in California</td>
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<tr>
<td>Current</td>
<td>California Pepper Commissio n (CPC)</td>
<td>$10,000</td>
<td>03/01/2017</td>
<td>2</td>
<td>Incidence of Pepper Weevil in Santa Clara and San Benito Pepper Fields</td>
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<td>Pending</td>
<td>DPR</td>
<td>$50,000</td>
<td>10/1/2017-2/28/2019</td>
<td>5</td>
<td>Working in Harmony – Agriculture with Urban Edge</td>
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<tr>
<td>Pending</td>
<td>Santa Clara Valley Open Space Authority (SCVOSA)</td>
<td>$167,411</td>
<td>05/01/2017-5/30/2020</td>
<td>10</td>
<td>Development of a Small and Urban Beginning Farmer Learning Hub at Martial Cottle Park in Santa Clara County.</td>
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<tr>
<td>Pending</td>
<td>Rathmann Family Foundation</td>
<td></td>
<td>03/01/2018-12/31/2021</td>
<td>2</td>
<td>Improving Compost Utilization through Extension Research and Outreach in California’s Intensively Managed, Row-crop Agro-Ecosystems</td>
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<tr>
<td>Pending</td>
<td>CDFA-FREP</td>
<td>This proposal</td>
<td>1/2018-12/2019</td>
<td>5</td>
<td>This proposal</td>
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</table>
### b. Ruth Dahlquist-Willard

<table>
<thead>
<tr>
<th>Status</th>
<th>Support Source</th>
<th>Project Title or Creative Activity/Duration</th>
<th>Role (PI, Co-PI, etc.)</th>
<th>Collaborators (with affiliation)</th>
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<tbody>
<tr>
<td>Current</td>
<td>CDFA Specialty Crop Block Grant</td>
<td>Improving Competitiveness of Small and Large California Blueberry Farms through Grafting 10/1/15 – 6/30/18</td>
<td>Co-PI</td>
<td>Matthew Gilbert and Isabel Hernandez, UC Davis Department of Plant Science</td>
</tr>
<tr>
<td>Current</td>
<td>CDFA Specialty Crop Block Grant</td>
<td>Developing a More Sustainable Pest Management Program for Southeast Asian Farmers 10/1/15 – 6/30/18</td>
<td>PI</td>
<td>Kent Daane, UC Berkeley</td>
</tr>
<tr>
<td>Current</td>
<td>CDFA Specialty Crop Block Grant (subaward)</td>
<td>Increasing Access to Specialty Crops in Fresno 10/1/15 – 10/1/17</td>
<td>Collaborator</td>
<td>Chukou Thao, National Hmong American Farmers</td>
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<tr>
<td>Current</td>
<td>CDFA Specialty Crop Block Grant</td>
<td>Identifying Value-Added Practices and Market Potential for Moringa, an Emerging Specialty Crop for California Growers 10/1/16 – 9/30/18</td>
<td>Co-PI</td>
<td>Gail Feenstra and Gwenael Engelskirchen, UC SAREP</td>
</tr>
<tr>
<td>Pending</td>
<td>USDA-NIFA</td>
<td>Building interdisciplinary multi-state research and extension to develop the emerging jujube industry in the United States</td>
<td>Co-PI</td>
<td>Shengrui Yao, New Mexico State University, Louise Ferguson, UC Davis, Efren Delgado, NMSU, Chadelle Robinson, NMSU</td>
</tr>
<tr>
<td>Pending</td>
<td>CDFA Specialty Crop Block Grant</td>
<td>Establishing best practices for sustainable tea production in California through the use of metabolic markers</td>
<td>Collaborator</td>
<td>Jacquelyn Gervay-Hague, UC Davis, Jeff Dahlberg, UC Cooperative Extension, Mark Gaskell, UC Cooperative Extension</td>
</tr>
</tbody>
</table>
c. Daniel Geisseler

PROJECTS (recent, current, in preparation)
07/2015-06/2017: Online fertilizer guidelines for agricultural crops in California, CDFA-FREP
07/2015-12/2018: Developing a decision support tool for processing tomato irrigation and fertilization in the Central Valley based on CropManage, CDFA-FREP
07/2015-12/2018: Developing a decision support tool for processing tomato irrigation and fertilization in the Central Valley based on CropManage, CDFA-FREP
01/2016-12/2018: Evaluation and demonstration of nitrogen and phosphorus management in organic leafy green vegetables production on the Central Coast, CDFA-FREP
03/2016-02/2018: Development of a field-based approach to estimate soil N mineralization for field-specific fertilizer N adjustments, UC California Institute for Water Resources
07/2016-12/2016: Development of yield to N removed conversions for Central Valley Irrigated Lands Regulatory Program, Southern San Joaquin Valley MPEP Committee
10/2016-03/2019: Nitrogen Requirements and Release Rates of Organic Amendments in Organic Fresh Market Tomato Production, CDFA Specialty Crop Block Grant Program
01/2017-06/2018: Expanding the California Fertilization guidelines to support nutrient management decisions for minor annual crops, CDFA-FREP
In preparation: Coupling soil-microbial-hydrologic processes to design new nutrient management guidelines for micro-irrigated agricultural systems, CDFA-FREP
In preparation: Assessment of harvested and sequestered nitrogen content to improve nitrogen management in perennial crops, CDFA-FREP
In preparation: Reducing nitrate leaching to the groundwater by accounting for the soils’ capacity to supply N through mineralization, UC ANR
Outreach Activities

a. Aparna Gazula

Sowerwine ($15,000) USDA-NIFA. Growing Roots: Deepening Support for Diverse New Farmers and Ranchers in California. Project develops networking and support for beginning farmers and ranchers in California. The outreach component of this project is to work with beginning farmers and provide research based educational information on sustainable farming practices.

Gazula ($10,000) CPC. Incidence of Pepper Weevil in Santa Clara and San Benito Pepper Fields. Project studies the incidence of pepper weevil in Santa Clara and San Benito counties, a region heretofore lacking pepper weevil infestation. The outreach component of this project involves sharing study findings with growers, certified crop advisors, and other pepper industry professionals.

Gazula ($50,000) DPR. Working in Harmony – Agriculture with Urban Edge. This project provides on-farm demonstration of effective integrated pest management practices for agricultural farms near schools. The outreach component of this project involves field days and workshops on integrated pest management practices.

Gazula ($167,411) SCVOSA. Development of a Small and Urban Beginning Farmer Learning Hub at Martial Cottle Park in Santa Clara County. Project involves the development of a land based learning hub in Santa Clara County. The outreach component of this project involves field days and workshops for beginning farmers.

Gazula Rathmann Family Foundation. Improving Compost Utilization through Extension Research and Outreach in California’s Intensively Managed, Row-crop Agro-Ecosystems. This project looks at various commercially available composts and their applicability to commercial row-crop agricultural production systems. The outreach component of this project involves field days and workshops to pepper growers in Santa Clara county.

Gazula project time commitment.
My current appointment on an annual basis is 100% extension. My present commitment on above projects is 24% of my time. The proposed project would add 5% time commitment.

b. Ruth Dahlquist-Willard

Ongoing outreach activities include radio outreach to Southeast Asian farmers through a weekly Hmong-language radio show, office and farm visits, regular extension meetings, and community partnerships. Outreach efforts on specific projects are outlined below:

Improving Competitiveness of Small and Large California Blueberry Farms through Grafting, CDFA Specialty Crop Block Grant. Outreach activities include radio outreach in Hmong and field days for growers at the Kearney Agricultural Research and Education Center to demonstrate use of grafted blueberry plants without the need for soil acidification.

Developing a More Sustainable Pest Management Program for Southeast Asian Farmers. CDFA Specialty Crop Block Grant. Outreach activities include extension meetings on topics in pest management, farm visits, production of educational videos, and radio outreach in Hmong.
Increasing Access to Specialty Crops in Fresno. CDFA Specialty Crop Block Grant. Outreach efforts include radio outreach in Hmong and workshops on food safety.

Identifying Value-Added Practices and Market Potential for Moringa, an Emerging Specialty Crop for California Growers. CDFA Specialty Crop Block Grant. Outreach efforts include radio outreach in Hmong, grower meetings, farm visits, and workshops.

c. Daniel Geisseler

CURRENT AND PLANNED RESEARCH AND OUTREACH ACTIVITIES
A major focus of my research is nitrogen mineralization from organic sources. To achieve high nitrogen use efficiency in crop production, growers need better ways to predict the amount and timing of N mineralization from organic sources, such as soil organic matter, crop residues and manure. My research shall contribute to better estimates of nitrogen availability from organic sources.
A second focus of my research and outreach activities is to provide growers with user-friendly decision support tools for nutrient management, based on the most recent scientific findings. One example are the fertilization guidelines for major crops in California. The guidelines are available on an interactive and user-friendly website (https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Guidelines.html).