A. Cover Page

1. Project Title
Assessing Drip Irrigation and Nitrogen Management of Fresh Onions Produced in California Low Desert.

2. Project Leaders
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City, State Zip: Davis, CA 95616
(Area Code) Telephone number: (530)-754-9637
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3. Cooperators
N/A

4. Supporters
Imperial Valley Vegetable Growers Association (Kay Pricola, executive director), Coastline Family Farms (Larry Cox, owner), and Imperial Valley College (Michael Kanyi, assistant professor).

5. CDFA Funding Request Amount/Other Funding
$222,451.32 requested from CDFA. Other funding sources: N/A

6. Agreement Manager
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B. Executive Summary

1. Problem

California is the largest onion producer in the nation with a farm gate value of almost $340 million. Imperial County growers harvest 42% of total onion production in CA. In Imperial County, about 500,000 acres are irrigated using saline water from the Colorado River. Recent studies supported by the Bureau of Reclamation concluded that the Colorado River Basin users will likely to experience shortfalls in water allocations in the coming decades. Salinity is the major water quality concern in the Colorado River Basin. To prevent soil salinization and enhance agricultural production, agricultural fields in Imperial County have subsurface drainage systems and excess of irrigation are applied to leach salts from the root zone. Although salt leaching improves soil conditions, drainage water dissolves chemicals and carry them into the drainage system. Irrigation excesses as well as municipal and industrial discharges from Imperial, Coachella and Mexicali valleys end into the largest California’s lake, the Salton Sea. Currently, the Salton Sea has high nutrient, salinity, and toxic concentrations. Adoption of improved irrigation and nutrient management practices by growers is needed in order to reduce water pollution from excess nutrients in California low desert region.

2. Objectives, Approach, and Evaluation

The main goal of this project is to evaluate the effects of irrigation management and nitrogen fertilization rates on yield and quality of fresh onion bulb production in arid regions using saline water. Specific objectives are:

Objective 1. Evaluate the response of onion to drip irrigation and regimes and compare onion production under different N fertilizer application rates.

Objective 2. Communicate findings directly to growers, as well as to crop advisors, academics, regulatory bodies, and agriculture industry.

Objective 3. Provide training opportunities to college students.

Field assessment will be performed at the University of California Desert Research and Extension Center -UCDREC, Holtville, CA. The assessment will be carried out with four replicates in a split-plot design with drip irrigation treatments in the main plot and seven N-fertilization rates at the subplot level. Research plots will be 50 ft long and comprise 4 rows on 40-inch beds. One hundred twelve plots will be established (28 treatments and 4 replicates). Sprinklers will be used for germination and establishment in all treatments. Four irrigation levels will be established: 40, 70, 100, and 130% of crop evapotranspiration (ETc). Irrigation scheduling will be based on weather data from the UCDREC’s CIMIS station and crop coefficients published by UN FAO for 100% crop evapotranspiration. Watermark soil water tension meters will be installed in each of the irrigation treatments at 6-, 12-, and 24-in.

Seven in-season nitrogen treatments will be assessed: pre-plant; pre-plant plus 50 lbs N per acre; pre-plant plus 100 lbs N per acre; pre-plant plus 150 lbs N per acre; pre-plant plus 200 lbs N per acre; pre-plant plus 250 lbs N per acre; and pre-plant plus 300 lbs N per acre. Seven weekly nitrogen applications through drip after bulbning start will be scheduled. Soil samples will be collected (pre-planting, during season, and post-harvesting) at different depths (from 0 to 36 in depth) and analyzed for NH₄ and NO₃. Irrometer soil solution access tubes will be installed at 6-, 12-, and 24-in. Water samples will be analyzed for pH, electrical conductivity and NO₃. Furthermore, bulbs and leaves will be analyzed for their N concentration during growing season to determine N uptake and removal in the different treatments. Water and biomass data will be
collected 5 or 6 times after starting bulb formation until harvesting. Onion quality parameters, including size (minimum and maximum diameters), weight, mold, firmness, color, pungency, and overall quality will be measured, after onion harvest and curing.

We will present and discuss results in local and state growers, FREP, and UC Cooperative Extension meetings. Summary results will be made available at the end of each harvest season and journal articles will be prepared after the completion of the third field season. We will use field experiments and laboratory analysis to train future practitioners in the irrigation and nutrient management methods most likely to be used in the coming years.

Analysis of variance will be performed with SAS. Duncan test at 5% level will be used to find any significant difference between treatment means. Soil, water, and biomass data will be analyzed using appropriate correlation and assessment procedures. To assess grower potential adoption, participant surveys will be conducted at field days. Student intern performance will be assessed regularly and informally throughout each season. A more formal evaluation process will occur at the end of each crop season. At that time, the student prepares a written self-evaluation of his/her work. The student will also prepare a short document (5-7 pages) and presentation about his/her internship experience.

3. Audience
The target audience for this project is onion growers and crop consultants in the California low desert region. This study will also provide training opportunities in English and Spanish to college students majoring in agricultural fields from minority and undeserved communities.

C. Justification
1. Problem
California has diverse agroecosystems throughout the state including low desert irrigated areas in Imperial County. California is the largest onion producer in the nation with a farm gate value of almost $340 million. Imperial County growers harvest 42% of total onion production in CA. For over 100 years, the Colorado River has been the sole water source of a highly productive agricultural sector in Imperial County, one of the top ten agricultural counties in the nation. Agriculture is the largest water user in the Imperial County. Although the Imperial Irrigation District (IID) has very senior rights on Colorado River water, shortfalls at Lake Mead could increase political pressure for California and IID to take cuts to allocations. Recent studies supported by the Bureau of Reclamation concluded that the Colorado River Basin users will likely to experience shortfalls in water allocations in the coming decades. Salinity is the major water quality concern in the Colorado River Basin. To prevent soil salinization, agricultural fields in Imperial County have subsurface drainages and excess of irrigation are applied to leach salts from the root zone. Although salt leaching will improve soil conditions, drainage water dissolves chemicals and carry them into the underground water supply. Irrigation excesses as well as municipal and industrial discharges from Imperial, Coachella and Mexicali valleys end into the Salton Sea. Currently, the Salton Sea has high nutrient, salinity, and toxic concentrations.

Growers in the Imperial Valley are adopting more efficient irrigation systems (sprinkler and drip) and science-based irrigation scheduling methods (soil moisture, weather-based techniques) motivated by themselves and through the IID On-Farm Efficiency Conservation Program. The current water transfer agreement between IID and the San Diego County Water Authority
(SDCWA) calls for transfer of up to 303,000 acre-feet annually of Imperial Valley-Colorado River water to San Diego. From 2018 to 2026, most of the water available for transfer will have to come from on-farm water conservation programs. The purpose of this project is to enhance sustainability through evaluation of irrigation and nutrient management strategies that conserve water and minimize nutrient export. The use of irrigation technology based on plant needs along with soil moisture indicators can help create a healthy environment for crops and minimize the risk of nitrate losses to the groundwater.

2. **FREP Mission and Research Priorities**
   This project addresses the FREP priority area "Improving Input Management" and the sub-area "Improving and Promoting Adoption of Management Practices that Optimize Nutrient and Irrigation Water Use".

3. **Impact**
   One of the key components for economic success in the crop industry is addressing water and nutrient management. By incorporating current technologies into agricultural production, water and nutrients can be managed to maximize yields, reduce costs, and protect natural resources. Improving irrigation management in vegetable crop production reduces production costs, saves water, and reduces the risk of nutrient export. Agriculture is the largest global consumer of water (around 70 to 90 percent), but there is a lack of scientific data about agricultural water management including scheduling, as well as social, environmental, and economic impacts of irrigation in arid agro-ecosystems, such as Imperial County, CA. Studies show that most farmers do not use scientific methods for scheduling irrigation and nutrient management. Qualitative assessments are used for most farmers to decide when to irrigate and apply fertilizers. The use of technology based on plant needs along with soil moisture indicators can help create a healthy environment for crops. This project will provide critical baseline information of water and nitrogen use in onion production in arid regions using saline irrigation water. Onion growers and crop consultants in the California low desert region will increase their understanding of water conservation and nutrient management and its economic and environmental benefits. Growers and users of irrigation systems will be more aware of new technology (soil, water, and plant diagnostic tools) available for water and fertilizer management.

A recent USDA report on employment projections indicates about 55,000 scientist and professionals will be required annually to fill positions in food, agriculture, and natural resources systems (FANRS), while at the same time FANRS colleges are graduating about 35,000 annually. Specifically, in the agricultural plant sciences approximately 30 to 40 % of scientists and professionals will be eligible for retirement in the next 10 years across all employment sectors (academic, government, industry, and private practice). This is particularly true in the highly academic and research fields. There is a decline in the number of students interested in the agricultural plant sciences which puts at risk the available pool of qualified candidates needed to fill future job vacancies. The natural resources area is lacking trained professionals, specifically trained minority professionals, in addressing this critical need. The propose project directly addresses these educational needs by offering training opportunities to local and regional college students in the use of state-of-the-art technology and methods to better manage water and fertilizers in vegetable production. The overall impact is to increase the pool of qualified students from under-represented groups to meet the annual demand in the agricultural job market.
4. **Long-Term Solutions**

Sustainable production systems can be attractive when economically efficient strategies are incorporated into the system. This project will demonstrate the differences among irrigation and fertilizer amounts to facilitate informed decisions as to adapt onion production systems in arid regions using saline water. Then, the project will generate information about irrigation scheduling and amount of water to apply based on soil and agro-climatic parameters. The project will also generate nutrient management plans that maintain or improve yields while reducing leaching.

To facilitate adoption, however, growers need to experience a successful irrigation and nutrient management system. Better field environmental information for irrigation and nutrient management will increase our understanding of sustainable farming systems in arid environments using saline water. Better trained farmers in sustainable irrigation and nitrogen management will produce higher crop yields, reduce the risk of pollution (soil erosion, nutrient export, etc), and protect water for future generations. The testing, application, and transfer of advanced irrigation and nitrogen management technologies will provide farmers with tools that maximize their investments.

5. **Related Research**

Although Imperial County growers harvest about 42% of total onions produced in California, there are no comprehensive and long-term studies looking at irrigation and nutrient management practices in onion production. To start building knowledge in this area, the project team performed a preliminary study during the 2016-2017 growing season. This project was conducted in silty clay soils at UC ANR Desert Research and Extension Center - DREC in Holtville, CA. The trial was carried out with three replicates in a split plot design with irrigation treatments in the main plots and 3 fertilization rates at the subplot level. Sprinklers were used for germination and establishment in all treatments. Three irrigation levels were established in drip treatments: 70, 100, and 130% of crop evapotranspiration. In furrow irrigation treatments only one irrigation level was tested: 100% of crop evapotranspiration. Three fertilizer treatments were assessed: pre-plant plus 150 lbs N per acre; pre-plant plus 200 lbs N per acre; and pre-plant plus 250 lbs per acre. Seven weekly nitrogen applications after bulbing start were scheduled. Onion quality parameters, including bulb % brix, size (minimum and maximum diameters), weight, mold, moisture, and firmness were measured after onion harvest and curing.

Effects on yield were not statistically different among drip irrigation and fertilizer treatments (Table 1 and 2). Overall, the furrow irrigation treatment with 200 lbs N per acre, three surges and zero tail runoff produced the highest yield in the first year of the study (1,583 50-Lb Sacks/acre).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (50-Lb Sacks/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1-150</td>
<td>1,284</td>
</tr>
<tr>
<td>N2-200</td>
<td>1,277</td>
</tr>
<tr>
<td>N3-250</td>
<td>1,304</td>
</tr>
</tbody>
</table>
Water use efficiency - WUE was affected by irrigation treatment (Table 2). The highest and lowest WUE (0.57 lb/ft³ vs 0.45 lb/ft³) were achieved for drip irrigation treatments at 70%- and 130%-ETc, respectively. The furrow irrigation treatment yielded a high WUE (0.55 lb/ft³).

### Table 2. Water use efficiency - WUE by irrigation treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Water Applied (ft)</th>
<th>Yield (50-Lb Sacks/acre)</th>
<th>Water Use Efficiency - WUE (lb/ft³)</th>
<th>Relative Yield (%)</th>
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<td>2.4</td>
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<tr>
<td>D100</td>
<td>2.9</td>
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<td>0.45</td>
<td>97</td>
</tr>
<tr>
<td>F100</td>
<td>3.3</td>
<td>1,583</td>
<td>0.55</td>
<td>116</td>
</tr>
</tbody>
</table>

Onion size distributions (prepack, medium, jumbo, and colossal) were not statistically different (P < 0.05) among drip and fertilizer treatments. Jumbo and colossal onion size distributions were higher in the surge irrigation trial than the other treatments. Measured onion quality parameters were not statistically different between drip and fertilizer treatments. Although applied irrigation volumes were different among treatments (from 2.4 ft to 3.4 ft), average soil moisture and soil water tension values measured in the field showed that soil water availability was suitable during the entire season at 6- and 12-in depths. Irrigation treatments at 130% ETc showed soil moisture values closed to field capacity during the entire study. Onion yields were in the range of commercial ones and no water stress was noticed. Adequate soil water availability occurred as a result of soils with large water holding capacity (silty clay) and frequent irrigations on a weekly basis. Results from this trial were presented at growers meetings in Imperial County, CA, field days at DREC, and numerous meetings in California, Washington, and Mexico.

The proposed project will build on this preliminary study. Based on the results and our experience gained, the proposed study will include a 40% ETc treatment to study irrigation effects on productivity and quality of onions, as well as nitrogen treatments with in-season application rates below 150 lbs/acre and above 250 lbs/acre. These additional irrigation and nitrogen treatments will allow identifying the optimal irrigation and nitrogen application rates for yield and quality.

Research in onions performed in Fresno County, CA showed the benefits of using drip irrigation in conserving water, applying fertilizers, and increasing yields. Previous work on onions under full and deficit irrigation has been performed in other arid regions (Tunisia, Ethiopia). These studies found that onion yields and quality were influenced by different irrigation and N management strategies. Further scientific information about nutrient and irrigation management methods is needed in the California low desert area to help growers target the right amount and time of nitrogen and irrigation applications.

**6. Contribution to Knowledge Base**

The results from this study will advance the state of knowledge regarding onion water and fertilizer use in arid regions irrigated with salty water. Proper selection of irrigation scheduling and nutrient management procedures will optimize crop production in terms of crop yield, quality, health benefits, water and nutrient input costs, and costs to the environment.
This project will fill knowledge gaps in the process components of actual evapotranspiration, soil moisture, crop yield, efficiency of water conservation practices, nitrogen management, and nitrogen transport in irrigated fields using saline water.

7. **Grower Use**
The proposed project will provide onion growers in the low desert area with science-based information on efficient water and N fertilizer use. The information will allow them to manage irrigation and N fertilizer in an economically and environmentally sustainable way that ensures high yields and onion quality while saving water and reducing the risk of N leaching losses below the root zone. Outreach activities directed towards growers and crop advisers will ensure that the results of this project will be available to growers and their consultants.

**D. Objectives**
The main goal of this project is to evaluate the effects of irrigation management and nitrogen fertilization rates on yield and quality of fresh onion bulb production in arid regions using saline water. Specific objectives are:

Objective 1. Evaluate the response of onion to drip irrigation and regimes and compare onion production under different N fertilizer application rates.

Objective 2. Communicate findings directly to growers, as well as to crop advisors, academics, regulatory bodies, and agriculture industry.

Objective 3. Provide training opportunities to college students.

**E. Work Plans and Methods**

1. **Work Plan**

   *Objective 1. Evaluate the response of onion to drip irrigation and regimes and compare onion production under different N fertilizer application rates.*

   *Task 1.1:* Conduct field experiments at the University of California – Desert Research and Extension Center for three seasons to quantify the impacts of water and nitrogen management in fresh onion production. Field trials will be conducted every year from October to May. (Three growing seasons: 2019, 2020, and 2021)

   *Task 1.2:* Data analysis. Compile results and perform statistical analysis to quantify differences among treatments, leading to at least one peer review paper. (Fall 2022)

   *Task 1.3:* Develop a report for FREP. Distribute reports through Project Leaders and Supporters’ respective networks. (Fall 2022)

   *Objective 2. Communicate findings directly to growers, as well as to crop advisors, academics, regulatory bodies, and agriculture industry.*

   *Task 2.1:* Organize and conduct extension activities, including workshops to present research findings of improved irrigation and nitrogen management practices and assist in adapting management practices. In Imperial County, workshops will be hosted in collaboration with Imperial Valley Vegetable Growers Association during monthly meetings and UC Cooperative Extension during field days and meetings. In addition, project leaders will disseminate project findings during field days through California’s onion main production areas (Fresno, Siskiyou, San Joaquin, and Kern Counties). (2019, 2020, and 2021)
Objective 3. Provide training opportunities to college students.

Task 3.1: Recruit students from the Imperial Community College - IVC and Universidad Autonoma de Baja California - UABC, Mexico. We will train at least four college students per year majoring in agricultural fields using field experiments at DREC. In addition, we will host classes from IVC, UABC to expose them to research methods and technology used in this study. We will provide training to future practitioners in the irrigation and nutrient management methods most likely to be used in the coming years. (2019, 2020, 2021).

2. Methods

Field Experiments and Laboratory Analysis: Irrigation scheduling will be based on weather data from the UCDREC's CIMIS station and crop coefficients published by UN FAO for 100% crop evapotranspiration. Watermark soil water tension meters will be installed in each of the irrigation treatments at 6-, 12-, and 24-in. Soil samples will be collected (pre-planting, mid-season, and post-harvesting) at different depths (from 0 to 36 in depth) in the 0-, 150-, and 300-lbs N/acre treatments and analyzed for NH₄ and NO₃. Irrrometer soil solution access tubes will be installed at 6-, 12-, and 24-in in every main irrigation treatment in 0-, 150-, and 300-lbs N/acre plots. Water samples will be analyzed for pH, electrical conductivity and NO₃. Furthermore, bulbs and leaves will be analyzed for their N concentration during growing season to determine N uptake and removal in the different treatments. Water and biomass data will be collected 5 or 6 times after starting in-season nitrogen management until harvesting. Onion quality parameters, including size (minimum and maximum diameters), weight, mold, firmness, color, pungency, and overall quality will be measured, after onion harvest and curing.

Data Analysis: Analysis of variance will be performed with SAS. Duncan test at 5% level will be used to find any significant difference between treatment means.

Extension on Results: We will present and discuss results in local and state growers, FREP, and UC Cooperative Extension meetings. Summary results will be made available at the end of each harvest season and journal articles will be prepared after the completion of the third field season. The results of this project will also be incorporated into the California Fertilization Guidelines for onions (https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Onion.html).

Student Training: We will use field experiments and laboratory analysis to train future practitioners in the irrigation and nutrient management methods most likely to be used in the coming years.

3. Experimental Site

Field assessment will be performed at DREC facilities in Holtville, CA. The assessment will be carried out with four replicates in a split-plot design with four irrigation treatments in the main plot and seven N-fertilization rates at the subplot level. Research plots will be 50 ft long and comprise 4 rows on 40-inch beds. One hundred twelve plots will be established (28 treatments and 4 replicates). Sprinklers will be used for germination and establishment in all treatments. Four irrigation levels will be established: 40, 70, 100, and 130% of crop evapotranspiration (ETc). Seven in-season nitrogen treatments will be assessed: pre-plant; pre-plant plus 50 lbs N per acre; pre-plant plus 100 lbs N per acre; pre-plant plus 150 lbs N per acre; pre-plant plus 200 lbs N per acre; pre-plant plus 250 lbs N per acre; and pre-plant plus 300 lbs N per acre.
F. Project Management, Evaluation, and Outreach

1. Management

Project leader Jairo Diaz, will have overall operational and management responsibilities in completing the project scope of work and will also serve as its primary spokesperson. Dr. Diaz will be responsible for the experimental design and conducting field experiments. He will oversee the limited term staff at Desert Research and Extension Center who will be supporting field and laboratory analysis. Dr. Diaz will be responsible for coordinating with the supporters, conducting outreach events on schedule and with appropriate stakeholder audience groups, data collection and analysis and report writing.

Project leader Roberto Soto will be in charge of conducting biomass sampling and corresponding N-content analysis. He will provide assistance in conducting N-canopy measurements using optical sensors. Dr. Soto will lead postharvest analysis in collaboration with UABC faculty and students. He will help recruit students at UABC and provide training opportunities. He will be conducting overall statistical data analysis and provide support in developing publications and educational activities.

Project leader Daniel Geisseler will contribute to the trial design and soils sampling protocol. His team will analyze soil samples for ammonium and nitrate concentrations. Daniel Geisseler will also contribute to data analysis, publications and outreach activities. In particular, he will incorporate the findings of the project into the online Fertilizer Guidelines for onions (https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Onion.html)

Kay Pricola from the Imperial Valley Vegetable Growers Association will support the project by connecting the researchers with onion growers and advertising extension events.

Larry Cox, local onion grower, will provide continuous exchange of information about onion management and production.

Michael Kanyai, assistant professor at Imperial Valley College, will lead student recruitment and coordinate student visits to UC DREC experimental sites.

Evaluation

Analysis of variance will be performed with SAS. Duncan test at 5% level will be used to find any significant difference between treatment means. Soil, water, and biomass data will be analyzed using appropriate correlation and assessment procedures. To assess grower potential adoption, participant surveys will be conducted at field days. Attendees will be asked to share their current irrigation and nitrogen methods, reaction to in the information presented at the field days, what other field days they have attended, and how both their practices and intended practices have or have not been changed by the project presentations and activities. All of this data will be analyzed statistically to better quantify changes and rates of adoption among contacts of the project. The diverse group of project supporters will facilitate broad engagement and effective outreach of our findings.

Student intern performance will be assessed regularly and informally throughout each season. A more formal evaluation process will occur at the end of each crop season. At that time, the student prepares a written self-evaluation of his/her work. The student will also prepare a short document (5-7 pages) and deliver a presentation about his/her work to IVC or UABC classmates.
Adoption of improved water and nutrient management practices (drip irrigation systems, irrigation scheduling methods, and optimization of nitrogen management) by growers would be driven by economic incentives towards cost-sharing of practice implementation. Agricultural stakeholders are cognizant of landscape stewardship and practices that promote environmental sustainability such as drip irrigation systems, soil moisture sensors, and fertigation will be looked on favorably. Research behind these technology and systems that highlights the effectiveness in water conservation and nutrient reductions will move these practices towards the environmental quality incentives program (EQIP), and thus provide significant incentives for adoption. Further research to improvements of the agricultural landscape as a result of irrigation water and nitrogen management practices demonstrating better cost-benefit results will remove all economic and behavioral barriers to adoption.

Our field work will be focused on fresh market onions on silty clay soils in conventional systems with 40-in beds, which is the most common system used by growers in Imperial County. Onion production in Imperial County is very diverse including processing and dehydrated onions, larger beds (60- and 80-in), furrow and sprinkler irrigation, and conventional and organic production management. The selection of treatments is intended to bridge the span of systems likely to be used, adopted and applicable in our conditions.

2. Outreach

Results of this project will be communicated to growers, crop consultants, resource agency managers and stakeholders through:

- Field workshops, submission of conference and peer-reviewed journal papers about the impact of best irrigation and nitrogen management practices. Eight field days (Imperial, Kern, Siskiyou, and San Joaquin Counties), eight presentations in agricultural meetings (FREP, Imperial County), three extension bulletins in the UCCE Imperial County Ag Briefs (2019, 2020, 2021), and two peer-reviews papers (2022) are planned;
- highlighting the importance of drip irrigation systems, irrigation scheduling methods, and fertigation and contribute to improved knowledge of best irrigation and nutrient management practices in arid regions using saline water;
- the development of methods to serve as a template for other growers in California arid regions.
- incorporation of the results into the online California Fertilizer Guidelines for onions (https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Onion.html).

The information generated will be useful to other researchers interested in refining methods of evaluation of irrigation systems, scheduling methods and fertigation. Our methods will be continuously evaluated and reported. We intend to build this research and extension over time. This grant will represent a step forward in the refining of sustainable irrigation and nitrogen application methods from an UC ANR and UABC multidisciplinary group with support from local farmers, stakeholders, and colleges.
G. Budget Narrative

a. Personnel Expenses.

Salary for Research Associate - RA (TBD) - Budget is requested for 230 hours/year x $24/hour over a 3-year period ($5,520 + $5,686 + $5,856 = $17,062), and a 3% budgeted annual increase for years 2 and 3. The RA will provide support for field experiments, data collection, laboratory analysis, and student training at UC DREC. Dr. Diaz will supervise the RA.

We budgeted 100 hours/year at $14/hour for undergraduate students from Imperial Valley College for three years ($4,200). Students will be trained in irrigation and nutrient management. They will directly exposed to research methods, equipment, and outreach activities developed in this project.

Fringe Benefits:
Fringe benefits for the Research Associate (limited term) and students is established at 6.3% of the salary in Y1, 6.5% in Y2, and 6.7% in Y3.

b. Operating Expenses.

- Supplies: Funds are requested for materials and suppliers to be used in field trials at UC DREC (drip tape, lay flat, flow meters, soil moisture sensors and dataloggers, soil solution access tubes, etc); laboratory supplies for water, biomass and nitrogen content, and postharvest analysis; and field laptop to retrieve data from dataloggers and data collection = $39,790.
- Equipment: N/A
- Travel: See below table with details of travel per year.

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<th>Destination</th>
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<th>Lodging ($)</th>
<th>Meals ($)</th>
<th>Registration ($)</th>
<th>Others ($)</th>
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- Professional/Consultant Services: Phosphorus and potassium soil analysis in a local laboratory = $2,648. Soils laboratory rate is $35 per sample. We are scheduling 24 soil samples for laboratory analysis every year. A 5% laboratory rate increase was scheduled in Y2 and Y3. We are budgeting two calibration services of HACH 3900 used for water analysis at UC DREC = $3,000. Daniel Geisseler’s laboratory recharge for nitrogen soil analysis = $24,192. His laboratory will analyze 336 soil samples per year at $24/sample.
• **Other Expenses**: Shipping costs of soil samples to Daniel Geisseler’s laboratory in UC Davis = $2,400. UC DREC recharge rate for 3.0 acres and 865 direct research hours for field experiments for three years = $113,752.32. UC DREC approved rates for the period: July 1, 2018 to June 31, 2019:
  - Per acre Research rate $2,092.72
  - Per Acre Ground Prep research rate $1,646.43
  - Direct Field Research rate $44.30 per hour
  - Pressurized Irrigation rate $320 per acre

DREC will provide funding to fund rates at 55% for July 1, 2018- June 31, 2019. If this proposal is granted, our first trial will start in the Fall 2019. Estimated DREC funding to fund rates for 2019-2020, 2020-2021, and 2021-2022 seasons will be 40%, 25%, and 10%, respectively. Below is a table of the estimated costs per year:

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<th>Rate</th>
<th>2019-2020 ($)</th>
<th>2020-2021 ($)</th>
<th>2021-2022 ($)</th>
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<td>Direct Field Research per hour</td>
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<td>Pressurized Irrigation per acre</td>
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<td><strong>30,333.95</strong></td>
<td><strong>37,917.44</strong></td>
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c. **Other Funding Sources**: N/A
d. **PRIOR YEAR PROJECTS**: N/A

**H. Budget Template.** See attached Excel spreadsheet

**I. Appendices**

1. **Project Leaders. Word or PDF format**
   See attached Jairo Diaz, Roberto Soto and Daniel Geisseler resumes.

2. **Cooperators**
   N/A

3. **Supporters**
   See attached letter of support from: Imperial Valley Vegetable Growers Association (Kay Pricola, executive director), Coastline Family Farms (Larry Cox, owner), and Imperial Valley College (Michael Kanyi, assistant professor).