Proposal to CA Department of Food and Agriculture – FREP PROGRAM – Cover Page

Project Title: Pima Cotton Nitrogen Management, Uptake, Removal – Impacts of Varieties, Subsurface Drip and Furrow Irrigation

Project Management:

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Support: (not providing direct project funding):
Salary and support for Principal Investigators is provided by University of California. One trial is to be conducted at Univ.CA West Side Research & Extension Center (WSREC) and others with growers. University of CA subsidizes 50-60% of the full cost of projects at the WSREC: Univ. CA West Side Res. & Extension Center; 17353 W. Oakland Avenue, P.O. Box 158; Five Points, CA 93624-0158; telephone: (559) 884-2411. Grower supporters who provide large field trial sites are not known at the time of preparation of this proposal, since land requirements for the variety trials are large and sites not selected in advance.

Names of supporters providing letters: The following individuals have indicated that they would be willing to supply support letters, and those have been requested: Mr. Roger Isom (CA Cotton Ginners and Growers Association; roger@ccgga.org); Mr. Chris McGoeylin (CA Cotton Ginners and Growers Assc; chris@ccgga.org); Mr. Warren Hutchings (Innovative Ag, LLC, Hanford, CA; wdhutchings@innovativeag.net); Mr. Jim Razor (JG Boswell Corporation, Corcoran, CA; jrazor@jgboswell.com). *letters received provided as attachments

Funding Amount Requested from CDFA-FREP program: Three year project support requested as follows: 1st year: $75,000 2nd year: $75,000 3rd year: $75,000

Other Funding: We plan to send in a proposal to the CA Cotton Industry Research Council (CCIRC) and the California Cotton Growers and Ginners Association (CCGGA) to request approximately $15,000 to $18,000 per year for support of plant and soil analysis costs from this study. Contact information for those groups: Mr. Roger Isom, CEO and Ms. Jodi Raley, VP Regulatory Services, address: 1785 N. Fine Avenue, Fresno, CA 93727; PHONE: (559) 252-0684; FAX: (559) 252-0551; roger@ccgga.org; jodi@ccgga.org. For University of CA West Side REC (indirect support for projects - see Budget details)

Agreement Manager’s Contact Information: UC Regents, Sponsored Programs; Plant Sciences Dept. contact: Ms. Serena Reid, Plant Sciences Dept–MS/2, Univ. CA Davis, 1045 Wickson Hall, One Shields
Project Title: Pima Cotton Nitrogen Management, Uptake, Removal – Impacts of Varieties, Subsurface Drip and Furrow Irrigation

SECTION B: Executive Summary

Problem. Over the past three decades, California cotton production has shifted from nearly all acreage being planted to specialized Upland cotton varieties (the sub-group of high-quality Uplands called “Acala” cotton) to Pima cotton. For the past 10+ years, over 70% of California’s cotton acreage has been planted with Pima cotton varieties, with recent years reaching over 85% of total acreage in Pima (USDA-Economic Research Services). As a premium-quality cotton, Pima commands a significantly higher price than Acala or non-Acala Upland cotton, so Pima is likely the type of cotton most producers will plant in future years. However, it requires a 2-3 week longer growing season than most Acala varieties, and there are known differences in sensitivity to insect pests, impacts of plant water stress on fruiting, and plant responses to management practices such as use of plant growth regulators Kerby et al, 1994; Hutmacher et al, 2004). Silvertooth and Norton (2011), Unruh and Silvertooth (1996) in Arizona and some unpublished CA studies have demonstrated that petiole nitrate guideline recommendations for Pima differ greatly from those developed for Upland cotton. As with Upland cotton, good nitrogen management decisions in Pima are known to impact various aspects of crop management (input costs, vegetative:reproductive growth balance, insect pest pressure, timing of maturity, ease of defoliation). Since cotton produces a high protein content seed, many prior studies in Upland cotton have shown that close to harvest timing, the bolls contain typically 50-60% or more of total above-ground late-season plant N. The seed are the primary sink for N in the boll, with very low concentrations of N in the boll structural tissue or in the lint. Under CA conditions where we leave essentially all leaf and stem materials in the field at harvest, most N removal with harvest should be in the seed.

With the exception of the Arizona studies mentioned above and a few small nitrogen uptake measurements made as part of irrigation studies conducted by the project team developing this proposal, we are not aware of arid or semi-arid zone research done specifically to identify whether or not N management recommendations and guidelines developed for Upland cotton are applicable to Pima cultivars. Most past research related to nitrogen management and uptake in cotton has focused on Upland cotton varieties, which continue to be the primary type of cotton produced in other parts of the U.S. (Bronson et al, 2017; Bronson et al, 2011; Hutmacher et al, 2004; Fritschi et al, 2004; Bassett and MacKenzie, 1983). With the exception of petiole nitrate guidelines, most growers base N management decisions on their own Pima experiences in combination with available recommendations based on Upland cotton research. More Pima-specific information would assist in efforts to fine-tune nitrogen management practices, avoid negatives associated with inadequate or excess N applications, and provide improved N removal estimates to be used in nitrogen management plans for CA producers.

Objectives, Approach and Evaluation. The objective of this study are: (1) At the West Side REC site, evaluate for high-yield potential Pima cotton impacts of N application amount, variety and irrigation method on total plant N uptake and harvest removal; and (2) Utilize 3 grower farm sites with moderate to high yield potential, using multiple Pima varieties and representing different soil types to determine total above-ground plant N uptake at early open-boll timing, and N removal with harvest (measured as N content of seed, lint, gin trash, measured separately) to better understand Pima N requirements. Two different types of studies to be conducted:
1) **West Side REC site**: Total N Uptake of three Pima varieties versus two Upland varieties will be determined under subsurface drip and furrow irrigation at three N application levels. At the West Side REC small plot site, N uptake, growth and yield responses of 2-3 Pima and 1-2 Upland varieties will be evaluated, with the varieties differing in either growth habit (plant size, maturity) or lint percent (different % of seed versus lint) to four N application levels (50, 75, 100 and 125% of estimated N requirements adjusted for soil residual nitrate N in the upper 2 feet of the soil profile at planting timing. We will plan for 3 Pima and 2 Upland cultivars, but the final number of cultivars to use will be decided based on availability of commercial cultivars differing in the stated characteristics, and availability of $ resources to support the nutrient uptake and removal analyses. Since currently available commercial Pima varieties tend to all have quite large and similar seed sizes, one option we will consider is use of a non-transgenic commercial cultivar with a more determinate growth habit for one of the Pima varieties in the study. Varieties with large differences in seed size are an issue with Upland varieties, so N partitioning to seed will be compared between a large-seeded and a smaller-seeded variety in the Upland variety comparison. In one Pima variety and one Upland variety, a zero applied fertilizer treatment will also be included in the study as a baseline treatment in terms of uptake and yield response.

2) **Grower site, large plot evaluations**: In Pima variety trials conducted in grower fields at three locations (Merced County, Kern County and Fresno or Kings County), yields will be determined, and total above ground plant N uptake and harvest time N removal with seed and gin trash will be sampled and analyzed for total N. We will work with growers at each site and collect soil samples to determine planting-time residual soil nitrate-N levels, and recommend and monitor application of what we estimate to be optimal fertilizer N applications. At each site, plant sampling will include three commercial Pima varieties differing in seed size/lint percent (proportion of yield in lint versus seed) and/or maturity class (duration of growth).

At all sites, seed and lint yields and gin trash will be separated during ginning so we can relate total N uptake and removal to specific yield levels. One reason for multiple-site, multi-year research is to increase opportunities for data sets to represent a range of yield levels, with emphasis on multiple sites achieving high enough yields to represent some grower yield goal “targets”. We desire the yields in the test sites to represent ranges of yield levels that would support sustained economic cotton production in our CA environment. Plant petiole nitrate or leaf N percent (to be decided based on other studies) will be monitored only at specific stages (first bloom, peak bloom, near cutout) in one Upland and one Pima variety at West Side REC study and one Pima variety at other sites to assess relative adequacy of plant N status at each site. Plant mapping will be conducted at 6-week intervals in one variety per site so we can describe growth patterns and potential yield-limiting conditions at each site.

**Audience.** The information developed will benefit CA cotton growers, largely in the San Joaquin Valley, by providing them with updated descriptions of N uptake and removal specific to Pima cotton under current production conditions and moderate to higher prevailing yield levels typical of modern on-farm production needed for economical, viable operations. This research should directly benefit producers, crop advisors and consultants by providing them with improved estimates of expected N uptake and removal and how they might relate to yields and yield goals in making N management decisions. This project addresses the Fertilizer Research and Education Program’s goals to better “Understand Soil-Plant Processes”, more specifically “filling a knowledge gap for nitrogen management” in Pima cotton.
SECTION C: Justification

There are economic incentives for growers to adopt and test improved practices that can result from this study. Cotton production is only economically viable if growers maintain high yields with care in keeping input costs under control. By the end of the project, researchers will identify some economically favorable applications, which can then be integrated into the practices of California’s cotton industry. The information provided by this project should improve the knowledge base for California cotton producers and regulatory agencies, better defining N applications needed to produce the most profitable crop (in terms of yield and quality). This project has potential to improve information available to growers and consultants on Pima cotton nitrogen management, and can provide a better base of information to meet the Fertilizer Research and Education Program’s goals of:
(a) Increasing the availability of information about improving efficient use of fertilizers
(b) Better managing agricultural nitrogen fertilizers to minimize nitrate movement below the root zone and improve crop N use efficiency
(c) Develop educational materials or improved guidelines to improve grower and consultant abilities to better match fertilization practices with crop N needed for profitable yields with reduced N losses.

Problem. Cotton growers in the San Joaquin Valley increasingly seem to be aiming for relatively high yields in order to be able to cover production costs and pay for increasing costs of inputs such as irrigation water, fertilizer and crop protection chemicals in the CA production environment. This high yield goal can serve as a significant incentive for growers to apply high rates of fertilizer N in order to increase their chances of achieving desired yields and profit potential. However, in recent years, applications of nitrogen (N) to cropland in the form of fertilizers or manure have received increased attention due to groundwater nitrate studies by the United States Geologic Survey and UC Davis researchers (Harter et al 2012). These studies report that agricultural applications of N (from both organic and inorganic sources) are largely responsible for the high nitrate levels observed in groundwater in the study areas (Tulare Basin and Salinas Valley), with the implication that N fertilization practices might impact groundwater nitrate in other crops and production regions throughout California. Regulatory decisions made since that time by the State Water Board and other state agencies raise the likelihood of a range of efforts to require more tightly-managed use of fertilizer and manure-based N sources in the future. These nitrogen management programs that are in various stages of development and implementation across the state also serve to point out some of the knowledge gaps we have regarding crop N responses, and uptake and removal under a range of production conditions. Pima cotton is one of the relatively large acreage crops for which there is quite limited data on crop N responses, uptake and removal with harvest.

Over the past three decades, California cotton production has shifted from nearly all acreage being planted to specialized Upland cotton varieties (the sub-group of high-quality Uplands called “Acala” cotton) to Pima cotton. For the past 10+ years, over 70% of California’s cotton acreage has been planted with Pima cotton varieties, with recent years reaching over 85% of total acreage in Pima (USDA-Economic Research Services). As a premium-quality cotton, Pima commands a significantly higher price than Acala or non-Acala Upland cotton, so Pima is likely the type of cotton most producers will plant in future years. However, it requires a 2-3 week longer growing season than most Acala varieties, and there are known differences in sensitivity to insect pests, impacts of plant water stress on fruiting, and plant responses to management practices such as use of plant growth regulators Kerby et al, 1994; Hutmacher et al, 2004). Silvertooth and Norton (2011), Unruh and Silvertooth (1996) in Arizona and
some unpublished CA studies have demonstrated that petiole nitrate guideline recommendations for Pima differ greatly from those developed for Upland cotton. Due to the facts of these known differences in multiple plant characteristics between prevailing Upland versus Pima varieties, we believe separate studies are warranted to answer these basic nitrogen uptake and removal questions for Pima.

**FREP Mission and Research Priorities and Impacts, Long-Term Solutions.**

This research should provide information that can be utilized by cotton industry personnel, including growers, crop advisors and consultants. It should be of assistance in providing them with improved estimates of expected N uptake and removal under irrigated, San Joaquin Valley Pima production conditions and how they might relate to yields and yield goals as part of the N management decision process. This project addresses the Fertilizer Research and Education Program’s goals to better “Understand Soil-Plant Processes”, more specifically “filling a knowledge gap for nitrogen management” in Pima cotton.

**Related Research.** The section on cotton provided as part of the report “Nitrogen Concentrations in Harvested Plants – A Literature Review” submitted by the Nitrogen Management Plan Technical Advisory Work Group (TAWG). As part of our University of CA Cooperative Extension field research efforts in several irrigation projects, we have been collecting some limited information as a side project on above-ground plant nutrient uptake measurements in both Upland and Pima types of cotton. All of this work has been done over a number of years at the University of CA West Side Research and Extension Center (WSREC). The nitrogen component of these studies was only a minor subset of the work on the overall projects, so much of this work was done with limited replications and only at one site, and has not been published to date. A primary reason to mention these limited field studies, however, is to point out that we have some data on N uptake and removal for both Pima and Upland / Acala types of cotton, and some values in those data sets differ from values shown in the cotton section of the above mentioned TAWG group report, particularly those for Pima types of cotton.

The values used in the TAWG report show an average N removal with harvest of 43.7 lbs N per ton of lint and seed harvested in studies that include older Upland varieties. There is some limited work on Pima cotton referenced in that report. However, the values shown in those limited studies (7 observations total) for Pima types of cotton (Fritschi, et al, 2004) indicated an average value of N removal of 33.1 lbs N/ton of lint plus seed, suggesting that removal in Pima is much lower than the average value of 43.7 lbs N/ton of lint plus seed, an average which mostly represents Acala and non-Acala Upland types of cotton. The Pima studies referred to, which were also conducted at the West Side REC, were relatively limited in number, and represented lower yield situations than those now achieved by commercial Pima growers in California.

The limited uptake data from small plot irrigation studies (unpublished to date) conducted at the UC West Side REC over the past 8 years is shown in the table below, noting the averages and relatively large standard deviations for:

(a) harvest-time total plant N uptake (lbs N in above ground plant parts/acre) and
(b) N removal in lint plus seed with harvest (in lbs N/ton of lint plus seed)

The values shown in the table were determined using small area harvests in field research plots, with plants partitioned in different components, weighed, and then subsampled to determine N content.
<table>
<thead>
<tr>
<th>Type of cotton</th>
<th>Total Plant N Uptake in these studies (above-ground)</th>
<th>Total Plant N Uptake in these studies (above-ground)</th>
<th>N Removal with harvest (in lint plus seed) (lbs N/ton of lint plus seed)</th>
<th>N Removal with harvest (in lint plus seed) (lbs N/ton of lint plus seed)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean and std deviation</strong></td>
<td><strong>Range of values</strong></td>
<td><strong>Mean and std deviation</strong></td>
<td><strong>Range of values</strong></td>
<td></td>
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<tr>
<td>Pima cotton</td>
<td>216.4 +/- 28.9</td>
<td>161 to 265</td>
<td>43.9 +/- 3.1</td>
<td>36 to 48</td>
</tr>
<tr>
<td>Acala types of Upland cotton</td>
<td>204.5 +/- 31.3</td>
<td>163 to 258</td>
<td>41.9 +/- 2.3</td>
<td>38 to 44</td>
</tr>
<tr>
<td>Non-Acala Upland types</td>
<td>205.8 +/- 29.8</td>
<td>172 to 239</td>
<td>41.5 +/- 3.2</td>
<td>38 to 45</td>
</tr>
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* generally there were three samples replicates per site for these evaluations.

As can be observed in the table of information provided above, the average values that we have for N removal with harvest for Pima types of cotton are actually quite similar to those in some more limited studies we have done using Acala and Upland varieties, and have not shown lower values for Pima cotton.

**Contribution to Knowledge Base, Long-term Solutions, Grower Use of Information.** Improved information on Pima cotton N responses and uptake should be helpful for many years in providing estimates of Pima cotton N responses and needs for multi-year management. Crops and variety choices, however, are often a “moving target”, so there is no guarantee in the long-term that additional questions will not develop regarding N management options for cotton in CA. The changes from Upland/Acala varieties of cotton to more Pima acreage began with introductions made in the late 1980’s and early 1990’s, with more than 50% of acreage in Pima not occurring until the early 2000’s. There used to be little use of subsurface or surface drip in cotton, with most production occurring under furrow or flood irrigation, but there has been a significant shift toward more subsurface drip in recent years, reaching over 20% of cotton acreage by some estimates in recent drought years. Our best current estimates are that Pima cotton will predominate and represent most CA cotton if cotton can remain profitable in coming years, and higher costs and competition for water supplies will drive further shifts toward drip irrigation or perhaps overhead sprinklers, where fertigation will be more broadly used.

**SECTION D: Objectives**

The objectives of this study are:
(1) At the West Side REC site, evaluate for high-yield potential Pima cotton impacts of N application amount, variety and irrigation method on total plant N uptake and harvest removal; and
(2) Utilize 3 grower farm sites with moderate to high yield potential, using multiple Pima varieties and representing different soil types to determine total above-ground plant N uptake at early open-boll timing, and N removal with harvest (measured as N content of seed, lint, gin trash, measured separately) to better understand Pima N requirements.
(3) As information is developed in the study, present information to appropriate grower groups, consultants and industry to give opportunities for feedback and to refine concepts of workable changes in N management approaches.

SECTION E: Work Plans and Methods
Work plan and Methods

Experimental Sites: Two types of field studies would be included: (1) University of CA West Side REC - small plot studies will focus on N uptake as a function of N application amount and variety under subsurface and drip irrigation; and (2) Grower field site studies in three San Joaquin Valley counties (Merced, Kern and Fresno or Kings) will focus on determining total plant N uptake and N removal with seed and gin trash as affected by Pima varieties differing in growth habit and lint percent. The West Side REC site is in a high water holding capacity, clay loam soil. Most grower sites are likely to be in soils described as clay loams or loams in terms of texture, since few sandy loam grower sites are still in cotton production. At farm locations, efforts will be made to include one subsurface drip and two furrow irrigated sites if possible, and there will be some variation site to site in soil characteristics, which we will describe in our reports. If not possible, all three locations could be furrow (most likely) or level-basin irrigation at one site. Costs for travel to and access to harvest equipment and personnel at the grower sites utilized will be partly covered by other industry project funds, since we will plan to use research sites already established for Pima variety trials, where yield and subsampling for ginning to separate seed from trash and lint are already a part of the protocol.

Varieties Included in Testing:
West Side REC site: Total N Uptake of three Pima varieties versus two Upland varieties will be determined under subsurface drip and furrow irrigation at three N application levels. At this small plot site, N uptake, growth and yield responses of 2-3 Pima and 1-2 Upland varieties will be evaluated, with the varieties differing in either growth habit (plant size, maturity) or lint percent (different % of seed versus lint). We will plan for 3 Pima and 2 Upland cultivars, but the final number of cultivars to use will be decided based on availability of commercial cultivars differing in the stated characteristics, and availability of $ resources to support the nutrient uptake and removal analyses. Since currently available commercial Pima varieties tend to all have quite large and similar seed sizes, one option we will consider is use of a non-transgenic commercial cultivar with a more determinate growth habit for one of the Pima varieties in the study. Varieties with large differences in seed size are an issue with Upland varieties, so N partitioning to seed will be compared between a large-seeded and a smaller-seeded variety in the Upland variety comparison. In one Pima variety and one Upland variety, a zero applied fertilizer treatment will also be included in the study as a baseline treatment in terms of uptake and yield response.

2) Large-Plot Grower Sites: We will be utilizing existing, planned sites for our UC Cooperative Extension Pima variety trials for these trials, and typically those trials have 6 to 8 or more different commercial variety entries. Based on the seed size, growth habit or other variety characteristics mentioned in the previous paragraph, we will identify 3 different Pima varieties to use for the N uptake and removal studies, and those same 3 varieties will be used for evaluations at all three grower test sites.

Applied Fertilizer Nitrogen Treatments / Irrigation and other Management Practices:
There will be two types of experiments conducted within this overall cotton nitrogen uptake and removal study:
**West Side REC site.** We will plant 2-3 Pima varieties and 1-2 Upland varieties at this site, and establish plantings under both subsurface drip irrigation (3 field replications) and furrow irrigation (3 field replications). Irrigation amounts will be determined using past local research information on crop coefficients combined with the on-site CIMIS Weather Station ET data to determine irrigation timing and target amounts. Water application amounts and timing will be scheduled to be optimal for this site and essentially not growth-limiting. Applied amounts will be recorded for furrow and drip plots, and limited infrared thermometry readings will be made mid-afternoon at intervals to verify acceptable crop water status levels.

Five N application levels will be established, representing 0, 50, 75, 100 and 125% of estimated N requirements, adjusted for soil residual nitrate N in the upper 2 feet of the soil profile at planting timing. Estimated N fertilizer needs will be adjusted for early season residual soil nitrate, with the target amount based on a realistic yield goal for the site (which should be about 1700-1800 lbs lint/acre). The timing of N applications for the subsurface drip treatments will start at the 7-8 leaf growth stage, with proportional application rates stepped up as plants grow (based on prior West Side REC studies with drip), with the goal of completing N applications (applied as water-injected liquid urea) by approximately peak bloom growth stage (late July or early August). Furrow irrigated plots will receive N applications in two injections of knifed-in liquid UAN about 8-10 inches away from the seed row and about 4 to 6 inches deep, with the injections split between one made about 3 weeks post-planting and another at lay-by.

**Large-Scale Grower Field Sites.** We will consult with growers at each large field site to provide information on pre-plant soil nitrate test results, and recommend N fertilization amounts that should be non-limiting but not wasteful for the yield targets developed at each site. Actual amounts applied will be recorded, as will irrigation dates and amounts. Goals will be to identify high yield potential sites for these studies, and provide information to growers to encourage non-growth limiting irrigation schedules to the degree possible, and split N fertilizer applications with near-planting timing and layby splits. Applied fertilizer amounts and timing will be recorded. Choice of fertilizer materials and application methods will be grower choice at these sites. If possible, we will try to select one variety trial location that is being drip irrigated, but the others will be irrigated using furrow or level basin methods.

**Plot Size, Layout, Harvest and Irrigation Operations:**

**West Side REC site.** All treatments utilized (variety by nitrogen treatment combinations) will be replicated three times at each site (four if space available and cooperators agree). Each plot will be approximately 4 rows (40 inch row spacing) by approximately 50-60 feet in length, arranged in a randomized complete block design. Seedcotton yield will be determined using a modified machine spindle picker for research plots, with the center 1/2 of the plot area harvested after border areas are removed. Ginning will be done using small machine ginners (without commercial cleaners or dryers) to separate out seed, cotton lint and trash in the subsamples for additional analyses. An analysis of variance will be performed on all data.

**Deep Soil Sampling for Nitrates – Preplant Soil Samping (all sites) and post-harvest (only at West Side REC site):** At initiation of the projects at West Side REC and grower sites, we will use a Giddings soil sampler to collect samples to a depth of eight feet below grade to identify initial residual soil nitrate. These data will be used to develop a crop nitrogen fertilization estimate (applied N plus estimate of residual soil nitrate-N use). Unless other resources become available beyond funding from FREP and the CA Cotton industry, due to costs for analyses of these soil samples, the end-of-season (harvest timing) evaluations of soil nitrate levels to eight feet depth will only be done at the West Side REC site in all
nitrogen treatments, but only for one Pima variety in the test under both irrigation regimes (furrow and subsurface drip).

**Plant Tissue Sampling:** This will be the most extensive sampling for the study, and will include: **Petiole Sampling.** Twenty-five random petiole samples will be collected from one variety at grower field sites at two timings (first bloom, 4 weeks later) to assess relative crop nitrogen status during these growth stages critical to fruit set. At the West Side REC location, all N application treatments will be sampled at these same growth stages in both irrigation treatments. **Plant Sampling for Peak Above-Ground N Uptake.** This sampling will be done approximately at 20-30% open boll stage, which is prior to defoliant applications but after essentially all new N uptake has occurred according to prior cotton studies. Biomass sample estimates will be made at the same time in all plots as an area harvest (about 5 feet of row length), with 5 plants selected from these areas for separation into stems, leaf/petiole and burs/seed components and then analyzed to determine tissue N concentrations for uptake estimates. Bolts will have to be dried and ginned to separate out seed.

**Final Harvest Sampling.** Seeds are the primary location for most N in cotton bolls, and this has been found in CA and AZ location studies in both Upland and Pima (Bronson, 2008; Fritschi et al, 2004; Unruh and Silvertooth, 1996). These studies as well as those conducted in cotton in southern and southeastern states have consistently shown that under a wide range of irrigated and rainfed production conditions, and with a wide range of cultivars, boll carpel walls have very low N concentrations at harvest timing, and N removal with lint (fibers) is extremely low (generally less than 5 lbs N removal per acre in lint).

With this in mind, since all plots at grower sites and West Side REC site will be harvested using a spindle type commercial picker, we will use large samples (approximately 3 to 6 lbs each) that will be collected at intervals from the same field plots where seedcotton weights will be measured to determine yields. The full plot lengths will be used to determine yields, so we will have large area harvests to improve accuracy of yield levels for varieties in the grower sites and across all N treatment by variety combinations at the West Side REC site. These samples will be ginned, and seed and gin trash samples collected for nitrogen concentration determinations. Yield, gin percentage, percent trash and concentrations in these tissues will be used to estimate N removal.

**Task 1. Selection of Research Sites, Finalization of Sampling Schemes, Decide on Sample-handling Protocols (January, 2019 or earlier)**
Meetings will be held to develop protocols for field site selection, sampling, and discussion of data collection needs for WSREC and grower sites. For initial sampling, sample collection materials will be purchased and sample handling methods and grower cooperator/site needs will be reviewed.

**Task 2. Establishment of Variety Trial sites and Research Center site for N Management Studies**
**Subtask a. Collect preliminary soil samples and data for field sites. (Late winter through Spring, 2018-2019, 2020, 2021)**
Subtask a. Select research sites, choose varieties to use
Subtask b. Pre-plant soil sample collection and analysis
Subtask c. Planting and establishment of baseline fertilization needs (P, K) and residual nitrate

**Task 3. Plant tissue sampling, subsamples and preparation for analyses**
Subtask a. Collect plant tissue samples (petiole during season, near first open boll for uptake, at harvest for removal studies)
Subtask b. Grind tissue samples
Subtasks c. Tissue samples submitted for analyses
Subtask d. Harvest for yields in fall (October, November in SJV collected at research sites across treatments - break down samples into total uptake versus removal samples)

Subtask e. Ginning of seedcotton samples from trials, separate into seed, lint and gin trash for analyses


Subtask a. Samples will be collected all N management trts for two varieties at West Side REC test site.

Subtask b. Grind samples, prepare and submit for analyses

Task 5. Laboratory Analysis. (fall and winter, 2019, 2020, 2021)

Subtask a. Nutrient analysis (Nitrate-N for soils, plus P and exch-K to represent the site conditions) using widely accepted protocols for each parameter

Subtask b. Nitrate-P-K analysis for petiole samples

Subtask c. Total N analysis for plant samples for uptake and removal studies.

Task 6. Data Analysis and Interpretation (each year, various times of year)

Subtask a. Data entry, quality control of raw data

Subtask b. Statistical analysis, regression analysis, correlations

Subtask c. data summary presentations, interpretation, analysis


As project results are developed and properly reported, yearly updates of information and summary materials on the projects will be made available through reports, popular press articles where appropriate, through on-line resources available to the California Cotton Growers and Ginners Association, Fertilizer Research and Education Program and University of CA Cooperative Extension newsletters where appropriate. In addition, our analyzed and summarized results will be presented in field day meetings as well as industry meetings such as cotton workgroup meetings, Agronomy program team meetings, and the CA Plant and Soil Conferences.

SECTION F: Project Management, Evaluation, Outreach

The project leader and cooperators are experienced in conducting separate as well as cooperative field research projects. Throughout this research project, meetings and teleconferences will be utilized to develop data collection plans and to ensure coordination of project activities. The site at the Univ. CA West Side REC site will be managed by Robert Hutmacher, the site in Kern County by Brian Marsh, the site in Merced County by Lynn Sosnoskie; and the site in Fresno County by Dan Munk. All investigators and some staff at their locations will be involved in soil and plant sampling, harvest operations, and in the analyses of data.

As an indication of how recommendations derived from N management research projects can be utilized for adjusting N fertilizer management practices, we will consider some of the approaches we used based on a prior research project that involved two of the Project Investigators for this proposed trial, a project entitled Field Evaluations and Refinement of New Nitrogen Guidelines for California Cotton. That project was conducted between 1996 and 2003 by UC Cooperative Extension personnel using commodity group and FREP funding. The results of that cotton research, which concerned yield and N uptake responses, soil nitrate uptake and accumulation patterns with different N management practices have since been integrated into decision practices for many California cotton growers using a variety of outreach approaches (Hutmacher et al. 2000; Roberts et al 2001; Hutmacher et al. 2002). Similar research approaches applied to Pima cotton could provide similar information to improve nitrogen management, including evaluations that will help identify if good N management decisions for Pima cotton differ markedly from recommendations for Upland/Acala types of cotton.
SECTION G: Budget Narrative

Personnel Expenses. Personnel expenses for each Project Investigator are expected to cover a small portion of the salary and benefits of staff that will be partially supported also through other funding sources.

Hutmacher program: Staff Research Associate II, Ag Tech, Field Asst. support for assistance with field work, data collection, data analysis = $ FY19 - $25,603; FY 19-20 - $26,596; FY20-21- $27,726.
Munk program: support for assistance with field work, data collection= $ FY19 - $3,141; FY 19-20 - $3,319; FY20-21- $3,480
Sosnoskie program: support for assistance with field work, data collection= $ FY19 - $3,141; FY 19-20 - $3,319; FY20-21- $3,480
Marsh program: support for assistance with field work, data collection= $ FY19 - $3,141; FY 19-20 - $3,319; FY20-21- $3,480

Operating Expenses. The expected total funding from this CDFA-FREP grant to be distributed to each of the UC Farm Advisor cooperators in this study is planned to total approximately $7,000 per year to each cooperators ($21,000 total each year). So in addition to the amounts shown above to support field assistants, funds for travel expenses to field sites or meetings, and/or expenses for supplies or minor equipment will also be provided out of those funds each year.

Supplies and Equipment: Soil and plant sampling require supplies for collecting, storing and preparing samples for later analyses, and will include boxes, sealable containers, plant grinding equipment, some soil grinding equipment and repair supplies. We already own a Wiley mill, large chipper and cyclone mill that can be used for the project, but some repair parts (blades, etc.) may need to be replaced during the project. Replacement parts for grinders, chippers typically include replacement blades, Kelly bars, augers or cores, engine repairs and hydraulic lines. It is expected that these supplies and minor equipment will constitute most of these expenses.

Travel: Private vehicle or University vehicle travel to research sites and to coordination meetings or outreach events are the travel expenses expected for each investigator. The levels of funding requested will only cover part of these travel expenses, but other funding sources will be used to assist with costs.

Services, Other Expenses: The majority of the funds shown as “testing lab charges” will be for soil and plant samples for mostly nitrate analyses that will be submitted to the UC Davis analytical laboratory. We feel strongly that for consistency across locations and years that there is an advantage to utilizing the same laboratory for most analyses during the duration of the test. A limited number of soil and plant tissue samples may be submitted to private analytical labs if data is needed in a short time frame to allow determination of nutrient levels for application decisions, such as for preplant fertilizer application decisions each year. Supplemental funds from other sources such as the CA Cotton Industry Research Council are going to be needed and will be requested as a partial match to also cover some of the large analytical costs for soil and plant samples. University of CA Research Center recharge costs at West Side REC will also be one of the service expenses for this project. Supplemental funding from these other sources will likely be necessary to meet all of the project sampling objectives.

Other Funding Sources. Costs for travel to and access to harvest equipment and personnel at the grower sites utilized will be partly covered by other industry project funds, since we will plan to use research sites already established for Pima variety trials. At those site, yield and subsampling for ginning
to separate seed from trash and lint are already a part of the protocol and funding for variety trials will help get those tasks completed.

University of CA Research and Extension Center Support for the research site proposed for the University of CA West Side REC would be in-kind support and subsidy provided outside of recharge expenses. Depending upon labor hours and land support provided to these projects, support would be expected to be in the range of $13,000 to over $16,500 per year, and could be several $1000 more if substantial center staff labor hours are required to conduct the trials. Recharge amounts due to the Center would be expected to be similar to the amount that the University is subsidizing for projects conducted on-site, although according to current UC-ANR plans, the recharge costs are planned to increase and the subsidies decrease significantly during this time period.

Costs for any supporting work such as ginning and plant and soil grinding for sample prep projects conducted at the Shafter Research Station site are not in any way subsidized at this privately-run facility, and would be charged to us at full-cost. Contact information: (a) Univ. CA West Side Res. & Extension Ctr, P.O. Box 158, Five Points, CA 93624-0158, phone: (559) 884-2411; (b) Shafter Research Station (privately-operated facility), 17053 N. Shafter Avenue, Shafter, CA.

References


SECTION H: Budget Template (provided separately - as attachment)

SECTION I: Appendix (provided separately - as attachments):
   (a) Project Leader C.V. and brief publication list
   (b) Cooperators – letter of agreement
   (c) Supporter letters