California Wheat Commission
1240 Commerce Ave., Suite A, Woodland, CA 95776
**Research Committee Meeting Thursday, February 21, 2019 (2:00pm)**

# Conference Call Attendance

Access Number Participant: = +1 408-638-0968 (US Toll) or +1 646-558-8656 (US Toll)

Participant Passcode/Meeting ID: 466 870 1284

Join by Link: https://zoom.us/j/4668701284

| | Call In | Attending |
|---|---|---|
| Ron Rubin | X | |
| Jim Parsons | X | |
| Lee Jackson | | X |
| Larry Hunn | | X |
| Kirk Elholm | X | |

# Research Committee Meeting Notice

Sent and posted February 8, 2019

**Via Teleconference Call**

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|---|---|
| **DATE:** | **Thursday, February 21, 2019** |
| **TIME:** | **02:00 P.M.** |
| **ACCESS NUMBER:** | +1 408 638 0968 (US Toll) or +1 646 558 8656 (US Toll) |
| **PASSCODE/ Meeting ID:** | 466 870 1284 |
| **Or Join with the link:** | https://zoom.us/j/4668701284 |
| **LOCATION:** | 1240 Commerce Ave. Suite A<br>Woodland, CA 95776 |

*Board Members wishing to participate in the meeting VIA TELECONFERENCE CALL must notify Isabel Rivera via email to (irivera@californiawheat.org) or by Fax to (530) 661-1332 at least 24 hours prior to the listed meeting.* ***Failure to do so will disqualify you from participation.***

## AGENDA

**I. Call to order — Chairman Ron Rubin**

**II. Roll call**

**III. Approve agenda**

**IV. Research Project Report - Breeding and Testing Programs**

**V. Financial Resources**

**VI. Research Priorities - Call for Proposals**

**VII. Funding Recommendation**

**VIII. Adjourn**

*All agenda items are subject to discussion and possible action.* All interested parties are invited to attend the meeting. Time will be allowed for members of the public to make comments on each agenda item (up to 2 minutes). To make a request for more information, or to make a request regarding a disability-related modification or accommodations for the meeting, please contact Crystal Sandoval at 530-661-1292, or 1240 Commerce Ave., Ste. A Woodland, CA 95776, or via email at csandoval@californiawheat.org Requests for disability-related modification or accommodation for the meeting should be made at least 48 hours prior to the meeting time. This notice and agenda are available on the Internet at *www.californiawheat.org*

# CALIFORNIA WHEAT COMMISION

## COMPREHENSIVE ANNUAL RESEARCH REPORT
## January 1, 2018 to December 31, 2018

**PROJECT TITLE:** Development of wheat varieties for California

**PRINCIPAL INVESTIGATOR:** Jorge Dubcovsky
OTHER INVESTIGATORS: Oswaldo Chicaiza, Mark Lundy, Francisco Maciel, Marcelo Soria

## CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS

**Variety releases**: New HRS variety UC-Central Red and Desert Durum UC-Desert Gold were submitted for PVP. Foundation seed was produced for both varieties (>11,000 lb each) and 50-100 acres of certified seed are currently being grown by Penny Newman and Baglietto Seeds. Foundation seed was produced for the resistant starch varieties UC-Lassik-RS (6,450 lb), UC-Patwin-RS (8,297 lb), and UC-Desert King-RS (9,617 lb) and UC-Desert Gold (14,725 lb) and ~50 acres of certified seed for each variety are been grown by LimaGrain. Breeder seed of UC1107$_{5+10\ 515\ 2NS\ Lr19}$/yellow pigment was produce in 2018. The seed was plant in November to produce foundation seed in 2019.

**Regional trials**

**Common wheat:** Five new hard red spring wheat lines UC1879, UC1880, UC1882, UC1884 and UC1885; and two hard white spring wheat lines UC1881 and UC1883, were included in the 2018 regional trial based of their high yield performance and good bread making quality.

**Durum wheat:** Four durum wheat lines UC1870, UC1871, UC1872 and UC1873 were included in the 2018 regional trial. All these lines showed good yield performance and good pasta quality in the elites yield trials from the previous year.

**Quality Collaborators Program**: Three hard red spring wheat lines UC1817 'Central Red', UC1879 Yecora Rojo-515 and UC1881, and hard white spring line UC1815 were included in the 2018 collaborative testing program. All four lines received excellent scores for bread-making quality. UC-Central Red was also one of the best lines for tortillas. Both UC-Central Red and Patwin-515HP are currently within the list of preferred varieties based on their excellent breadmaking quality.

**Yield trials:** 450 lines of common wheat and 192 lines of durum wheat were evaluated in elite, advanced, and preliminary yield trials in 2018. Grain samples from the best 57 lines of common wheat and 43 lines of durum wheat were sent to the CWC Quality Laboratory for complete quality analyses. The best six lines of common wheat were included in the 2019 regional trial, 22 lines were included in the elite yield trial and 90 in the advance yield trial. The best four durum lines were included in the 2019 regional trial and 21 lines were included in elite yield trial.

**Observation plots:** 520 lines of common wheat and 255 lines of durum wheat were evaluated in observation plots in 2018. After selection for agronomic characteristics, yield performance and protein content of the grain; 253 lines of common wheat and 231 lines of durum wheat were selected and are now being evaluated in the 2019 preliminary yield trials.

**Addition of new hybrids and segregating populations:** 100 crosses were make among common wheat and 52 crosses were make among durum wheat in the winter of 2018. The $F_1$s were planted at Tulelake during the summer 2018. The $F_2$ to $F_6$ segregating lines included 359 populations of common wheat and 257 populations of durum wheat that were planted and evaluated in the field in 2018. After selection for agronomic characteristics, disease resistance, and grain appearance, 384 segregating populations of common wheat and 272 segregating populations of durum wheat were selected for evaluation in 2019.

**Organic Wheat Testing Program**

Nineteen advanced breeding lines, four common wheat varieties (Lassik, Yurok, Patwin-515HP and UC-Central Red), and two durum wheat varieties (Desert King and UC-Desert Gold) were tested with the help of Allison Krill-Brown under organic practices. Four lines of common wheat were dropped based on low weed tolerance score. The remaining 14 advanced breeding lines and 6 varieties will be retested in 2019. The advanced breeding line 17014/15 'UC1107$_{5+10\ 515\ 2NS\ Lr19/yellow\ pigment}$' was select and was included in the 2019 regional trial as UC1909. Breeder seed of this line was produce in 2018 and foundation seed will be produce in 2019.

**Marker assisted selection summary**

***Markers for yield***: During the last two years, we made significant progress in our understanding of the genes controlling grain number and grain weight in wheat. We performed the first yield trials for the *gw-A2* and *gw-B2* mutations that were previously shown to increase grain weight. A large field trial under both drought and normal conditions showed significant differences in grain weight for both genes with an 8.5% increase for the double mutant relative to the control. The double mutant also showed a significant increase in grain protein content (absolute increase of 0.5%). Under normal irrigation, we also detected a 6% increase in grain weight and grain in the double mutant and a 0.4% absolute increase in grain protein content.

We combined the *gw-A2* mutation for increased grain number with the *Elf3A$^m$1* gene transferred from diploid wheat *Triticum monococcum* accession DV92 for increased grain number. The lines carrying the *Elf3A$^m$1* allele from diploid wheat showed an 8.6% higher yield than the lines carrying the wild type allele. The lines carrying the g*w-A2* mutation showed a 7% increase in kernel weight. The line combining the *Elf3A$^m$1* allele and the *gw-A2* mutation showed the highest yield, which was significantly higher than the other three lines combined.

We also evaluated a line including mutations for the *ful-A2* and *ful-B2* genes (henceforth, *ful2*-null) which was associated with increased number of spikelet per spike and florets per spikelet. Relative to the control, the *ful2*-null mutant produced 20% more spikelets per spike ($P$ = 0.0002) and 9% more grains per spikelet ($P$= 0.05), which resulted in a 31% increase in the number of grains per spike ($P$ = 0.0002). In this experiment, part of the positive effect on grain yield was offset by a 19% reduction in average kernel weight ($P$ = 0.0012). In spite of these opposite trends, we observed a net increase of 6% in total grain weight per spike. In separate field studies, we found that the negative correlation between grain number and grain weight depends on the particular genotype and environment combination.

Finally, we discovered a new gene that increases the number of spikelets per spike and the number of grains and designated it *WAPO1*. We characterized the natural variation in this gene and initiated the introgression of new alleles to test their effect on grain yield. An interesting result was the absence of the H2 allele for highest yield in cultivated durum lines, in spite of his

high frequency in common wheat (>80%). We are currently introgressing the WAPO-H2 allele into our top durum wheat varieties to test its potential to increase grain yield in durum wheat. Results from an experiment performed in Davis and Imperial under full irrigation and terminal drought demonstrated that the translation of the increases in grain number into increase in total grain yield depend on the genotype and environment. Some genotypes (source-limited) showed a negative correlation between the increase in the number of grain and the grain weight, but others were able to translate the increase in grain number into a 444.2 kg/ha increase (9.7%) in total grain yield. Under terminal drought, the plants did not have sufficient resources and the increases in total grain yield were only 3.6%. These results suggest that the benefits of increasing grain number in our spring wheat varieties will be maximized in varieties with a strong "source" (e.g. higher biomass) and in environments with optimum irrigation and fertilization resources.

***Markers for quality***: For the pasta wheat, we used markers to accelerate the introgression of genes associated with low cadmium (*Cdu1*) improved yellow pigment (*PSY1*) and color stability in pasta (*LPX1.1*), increased gluten strength (*Glu-D1*$_{2+12}$), and higher grain protein content (*GPC-B1*). For bread wheat, we used molecular markers to accelerate the introgression of a low molecular weight glutenin allele for improved gluten strength and elasticity and the 7BxOE allele for strong gluten. We initiated the evaluation of a new gene for improved dough elasticity and loaf volume designated *wbm1*.

In the area of resistant starch, we are currently developing new durum and common wheat varieties by introgressing the five-*sbeII* mutations into our best pasta and wheat varieties and breeding lines. We have also developed a doubled haploid population from the cross between UC-Lassik-RS x UC-Patwin515-RS to mapping locus that can reduce the negative impact of the *sbeII* mutations on grain yield. Finally, we combined mutations in the D genome for the *SBEIIa* and *SBEIIb* genes to develop a common wheat carrying six *SBEII* mutations to compare with our current lines carrying 5 mutations (UC-Desert King-RS, UC-Lassik-RS and UC-Patwin515-RS).

***Markers for disease resistance***: During the last year, we completed the cloning of the resistance gene *Yr15* and now we have a perfect marker to monitor its introgression in the California wheat varieties. We used molecular markers to introgress *Yr5*, *Yr15*, *Yr36* and *Yr78* in several of our breeding lines. We completed and published a QTL for stripe rust resistance that identified four new QTL for resistance to the races currently present in California. We developed a high-resolution map for the adult plant resistance gene *Yr29* and generated closely linked molecular markers that can be used efficiently to introgress this gene into our advanced breeding lines. Finally, we completed the cloning of the stem rust resistance genes *Sr13*, *Sr21* and *Sr60* that confer resistance to stem rust to be prepared for the arrival of the virulent Ug99 races that are currently expanding its area in Africa and Asia.

**Publications and Grants**: We published ten research articles on wheat improvement in 2018 in peer-reviewed scientific journals and made seven scientific presentations. We obtained $183,541 grant for laboratory equipment and renewed the HHMI grant for another year (2018-2019) with a research support of approximately $800,000 per year. We also renew the Wheat CAP national grant for $2.5 million (UCD $258,627) and obtained a new USDA-NIFA-BBSRC grant for $300,000 for the development of double haploids in wheat using *CENH3* mutants and genome editing.

## 2018 RESEARCH (Major Accomplishments)

## OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION TO ACCOMPLISH OBJECTIVES:

This annual report is organized starting with the most advanced materials evaluated in the regional trials, followed by the lines evaluated in the elite, advanced and preliminary, and observation yield trials. I also describes the short-row screening nurseries, the segregating populations at the different generations and the new hybrid combinations.

## VARIETY RELEASES

New HRS variety UC-Central Red and Desert Durum UC-Desert Gold were submitted for PVP. Foundation seed was produced for both varieties (>11,000 lb each) and 50-100 acres of certified seed are currently being grown by Penny Newman and Baglietto Seeds. Foundation seed was produced for the resistant starch varieties UC-Lassik-RS (6,450 lb), UC-Patwin-RS (8,297 lb), and UC-Desert King-RS (9,617 lb) and UC-Desert Gold (14,725 lb) and ~50 acres of certified seed for each variety are been grown by LimaGrain. Breeder seed of UC1107$_{5+10\ 515\ 2NS\ Lr19}$/yellow pigment was produce in 2018. The seed was plant in November to produce foundation seed in 2019.

## REGIONAL TRIALS

**Common wheat:** Five new hard red spring wheat lines UC1879, UC1880, UC1882, UC1884 and UC1885; and two hard white spring wheat lines UC1815 and UC1883, were included in the 2018 regional trial based on their high yield performance and good bread making quality. UC1880 and UC1882 are being retested in the 2019 Regional Trials, and UC1884 and UC1885 in the elite yield trial. UC1879 was dropped from the regional trial because of low yield performance

**Durum wheat:** Four durum wheat lines UC1870, UC1871, UC1872 and UC1873 were included in the 2018 regional trial. All these lines had good yield performance and good pasta quality. UC1873 was drop from the regional trial because of low yield performance. UC1870 and UC1871 are being retested in the 2019 Regional Trial.

**Quality Collaborators Program**: Three hard red spring wheat lines UC1817 'UC-Central Red', UC1879 Yecora Rojo-515 and UC1880, and hard white spring wheat line UC1815 were include in the 2018 Collaborators Testing Program. All four lines got very good quality scores and excellent comments from the mills that tested the lines. Three new common wheat lines UC1839 (HWS), UC1882 (HRS) and UC1909 (HWS-yellow pigment); and two new durum lines UC1870 and UC1910 were included in the 2019 collaborators testing program.

## ELITE YIELD TRIALS

Common wheat: The elite yield trial of common wheat included 20 breeding lines and 5 control varieties and was plant at Davis, Colusa and Fresno. The elite yield trial of durum wheat included 18 breeding lines and 4 control varieties and was planted at Davis, Fresno and Imperial Valley. The trial at Colusa and Fresno were conducted by Dr. Mark Lundy and the trial at Imperial Valley was conducted by Francisco Maciel. During the growing cycle, notes of heading date, disease severity (stripe rust, leaf rust, and septoria), plant height, lodging, and shattering

were scored at each location. The lines were evaluated for grain yield, test weight, 1000 kernel weight, and grain protein content after harvest. Fourteen breeding lines of common wheat and 16 lines of durum wheat were selected and samples of grain from each location was sent to the CWC laboratory for complete quality analyses. Based on the agronomic data, disease scores, grain yield and quality data, one hard red spring wheat line 18010/5 ‘UC1908’and two hard white spring wheat lines 18010/4 ‘UC1907’and 18010/20 ‘UC1909’ were advanced to the 2019 regional trial. Eleven lines of common wheat and 10 lines of durum wheat are being retested in the 2019 Elite yield trial.

## ADVANCED YIELD TRIALS

**Common wheat:** 88 breeding lines and 8 control varieties were evaluated in the 2018 advanced yield trials at Davis. After selecting for agronomic characteristics, disease resistance, yield performance, grain protein content, and grain appearance, 28 lines were selected and sent to the CWC laboratory for complete quality analyses. Nine lines were selected and advanced to the 2019 elite trial and five lines are being retested in the 2019 advanced yield trial.

**Durum wheat:** 39 breeding lines and 6 control varieties were evaluated at Davis and Imperial Valley. After selecting for agronomic characteristics, disease resistance, yield performance, protein content, and grain appearance; 16 lines were selected and sent to the CWC laboratory for complete quality analyses. Seven lines 18216/5, 18216/6, 18216/7, 18216/21, 18216/23, 18216/24 and 18216/26 were advanced to the 2019 Elite trial.

## PRELIMINARY YIELD TRIALS

**Common wheat:** 272 breeding lines and 5 control varieties were evaluated in preliminary yield trials. After selection for agronomic characteristics, disease resistance, yield performance, grain protein content, and grain appearance, six lines were selected and sent to the CWC laboratory for complete quality analyses. All six lines were selected and included in the 2019 advanced yield trial.

**Durum wheat**: 121 breeding lines and two control varieties of durum wheat were evaluated in preliminary yield trials in 2018; based on agronomic characteristics, disease resistance, yield performance, grain protein content, and grain appearance, 27 lines were selected and retested in the 2019 preliminary trial.

## OBSERVATION PLOTS

**Common wheat**: 495 breeding lines and three control varieties of common wheat were evaluated in observation plots in 2018, after selection for agronomic characteristics, disease reaction, grain yield, grain appearance, and grain protein content, 253 lines were advanced to the 2019 preliminary yield trials.

**Durum wheat:** 243 breeding lines and two control varieties of durum wheat were evaluated in observation plots in 2018, after selection for agronomic characteristics, disease reaction, grain yield, grain appearance, and grain protein content, 231 lines were advanced to the 2019 preliminary yield trials.

**New introductions:** 544 breeding lines of common wheat and 164 breeding lines of durum wheat from the wheat program of CIMMYT-Mexico were planted as screening rows in Davis in 2018. After selection for agronomic characteristics, disease resistance, grain appearance and

grain protein content, 71 lines of common wheat and 26 lines of durum wheat were advanced to the 2019 observation plots. 755 breeding lines of common wheat and 124 breeding lines of durum wheat from the wheat program of CIMMYT-Mexico were cleared through quarantine during the winter 2018 and planted in the field as screening rows in 2019.

## NEW HYBRIDS AND SEGREGATING POPULATIONS

**New Hybrids:** 98 new crosses were made among common wheat and 52 among durum wheat. The $F_1$ generations were plant at Tulelake during the summer of 2018.

**Segregating generations:** The $F_2$-$F_5$ segregating generations were handled as selected bulk populations. The best individual plants from each population were selected and one spike from each selected plant was harvested. The selected spikes were threshed in bulk and a sample of 500 seeds from each population was planted as selected bulk population in the next generation. In the $F_5$ generation, the selected spikes were thresh individually and after selecting for grain appearance the seed was used to plant headrows in the $F_6$ generation. In the $F_6$ generation, selection was made among and within families. If the selected rows were phenotypically homogenous they were harvested in bulk. Otherwise three spikes were harvested from each row to have one more cycle of headrow selection.

**Common wheat:** The $F_2$ generation included 91 populations of common wheat. After selection, all 91 populations were advanced to the $F_3$ generation in 2019. The $F_3$ generation of common wheat included 85 $F_3$ segregating populations. After selection, all 85 populations were advanced to the $F_4$ generation in 2019. The $F_4$ generation of common wheat included 56 segregating populations. After selection, 55 populations were advanced to the $F_5$ generation in 2019. The $F_5$ generation of common wheat included 45 segregating populations. After selection, 2158 lines from 45 populations were advanced to the $F_6$ generation in 2019. The $F_6$ generation of common wheat included 1467 lines from 85 families. After selection, 684 lines from 85 families were advanced to be tested as observation plots in 2019.

**Durum wheat:** The $F_2$ generation included 55 populations of durum wheat. All 55 populations were advanced to the $F_3$ generation in 2019. The $F_3$ generation of durum wheat included 77 $F_3$ segregating populations. After selection, 73 segregating populations were advanced to the F4 generation in 2019. The $F_4$ generation of durum wheat included 52 segregating populations. After selection, 47 populations were advanced to the $F_5$ generation. The $F_5$ generation of durum wheat included 37 segregating populations. After selection, 1115 lines from 36 populations were advanced to the $F_6$ generation in 2019. The $F_6$ generation of durum wheat included 592 lines from 36 families. After field selection, the grain of each line was evaluated for its appearance and 196 lines from 34 families were advanced to observation plots in 2019.

### Organic Wheat Testing Program

Seed of 19 advanced breeding lines, 4 common wheat varieties (Lassik, Yurok, Patwin-515HP and UC-Central Red), and 2 durum wheat varieties (Desert King and UC-Desert Gold) were tested with the help of Allison Krill-Brown under organic practices. Four lines of common wheat were drop for showing low weed tolerance score. The remaining 14 advanced breeding lines and the 6 varieties will be retested in 2019. The advanced breeding line 17014/15 '$UC1107_{5+10\ 515\ 2NS\ Lr19/yellow\ pigment}$' was select and was included in the 2019 regional trial as UC1909. Breeder seed of this line was produce in 2018 and foundation seed will be produce in 2019.

**Publications and Grants**: We published ten research articles on wheat improvement in 2018 in peer-reviewed scientific journals and made 7 scientific presentations. We obtained $183,541 grant for laboratory equipment and renewed the HHMI grant for another year (2018-2019) with a research support of approximately $800,000 per year. We also renew the Wheat CAP national grant for $2.5 million (UCD $258,627) and obtained a new USDA-NIFA-BBSRC grant for $300,000 for the development of double haploids in wheat using *CENH3* mutants and genome editing.

# A. COVER PAGE

**PROJECT TITLE**

Development of wheat varieties for California 2017-2019

**PRINCIPAL INVESTIGATOR**

Jorge Dubcovsky

**OTHER INVESTIGATORS**

Oswaldo Chicaiza, Alicia del Blanco (50%), Xiaoqin Zhang (70%), and Marcelo Soria (20%).

**SUMMARY:**

The objective of the UC wheat-breeding program is to develop common and durum wheat varieties adapted to different California environments. The specific objectives are: 1) introduce new sources of disease resistance, improved yield and end-use quality characteristics; 2) create new segregating populations by hybridization and select the best lines using field based selection; 3) determine the genetic basis for grain yield and disease resistance and develop markers to accelerate the introduction of favorable alleles into breeding lines; and 4) produce Breeder's seed of lines targeted for variety release. The field-based selection program will be complemented by marker-assisted selection to accelerate the introgression of novel genes associated with increased yield and resistance to stripe rust and stem rust in common wheat. In both common and durum wheat, we will continue the introgression of the *gw-A2* mutation associated with increased grain weight and initiate the introgression of the *TmELF3* allele to increase number of grains per spike. In durum wheat we will continue the deployment of the low cadmium gene *Cdu1*, QTLs for improved pasta color, and mutations for increased resistant starch. In common wheat we will complete projects to map genes contributing to increased grain yield.

**CALIFORNIA WHEAT COMMISSION**

May 1, 2017 to April 30, 2019

## B. OBJECTIVES

The overall objective of the UC Wheat Breeding Program is to develop common and durum wheat varieties adapted to different California environments. The main target traits include grain yield, disease resistance and quality, and the main market classes include white and red bread wheat and Desert Durum wheat. During the 2017-2018 funding cycle, we will emphasize the introgression of new gene variants to increase grain size and number in both durum and common wheat. For increasing grain-size, we will backcross the *gw-A2* mutation and for increasing grain number, we will introgress the *Elf3* allele from *T. monococcum* into both durum and common wheat. In durum wheat, we will continue our efforts to reduce cadmium levels and improve color and gluten strength. We will also continue our efforts to deploy slow rusting genes in combination with the race specific genes *Yr5* and *Yr15.* In the area of wheat nutritional value, we will continue the introgression of the mutations for resistant starch into different durum and common wheat backgrounds and the evaluation of their effects on agronomic and quality performance. The specific objectives for 2017-2018 growing season are:

**Objective 1:** Introduce new sources of disease resistance to stripe rust, stem rust, leaf rust and septoria tritici blotch and valuable alleles for grain yield components and end-use quality from wheat varieties from different parts of the world and from wild wheat relatives. We will also incorporate new alleles associated with increased grain size and number and with increased levels of resistant starch. We will incorporate the new stripe rust resistance genes *Yr77* and *Yr78* validate in 2016.

**Objective 2:** Create new variable populations of red and white bread wheat and durum wheat by hybridization, select the best lines from the segregating populations, and evaluate the selected progenies for quality and performance in different production areas of California.

**Objective 3:** Determine the genetic basis of wheat grain yield and resistance to diseases, develop molecular markers associated with these traits, and used them to accelerate gene deployment into adapted breeding lines.

**Objective 4:** Increase grains of new promising lines to perform extensive testing trials in multiple locations and for distribution to other breeding programs. Select pure seed of the best lines to produce Breeder's Seed, and send that seed to the Foundation Seed Program (FSP).

## C. PROCEDURES

### PROCEDURES FOR OBJECTIVE 1

**Incorporation of new genetic diversity:** The incorporation of new sources of genetic diversity is a continuous objective of our breeding program. We will evaluate roughly 1,000 new advanced lines of common wheat and durum wheat in observation plots at Davis. These lines are received from CIMMYT, disease nurseries, and from different collaborating breeding programs around the world.

New sources of resistance to diseases are constantly required because of the ability of these pathogens to evolve and overcome current sources of resistance. The incorporation of different sources of stripe rust resistance is important to be prepared to a change in the current races of the pathogen. We will study the effect of combining different partial resistance genes in a single background to select the best combinations for our breeding program. A source of new resistance genes will be the lines carrying the adult plant resistance genes *Yr77* and *Yr78* identified in our recent survey of the NSGC core collection (validated in 2016). We will combine the *Yr15* and the strong gluten allele 7BxOE to be able to transfer both genes together. We will also introgressed the combined *Yr5* and low PPO allele in our durum wheat program.

We will devote some efforts to the preventive incorporation of stem rust resistance genes effective against UG99. This race has recently spread from Africa to Iran and, is a serious potential threat to the wheat industry. In hexaploid wheat we will incorporate the slow rusting gene *Sr2* and the *Sr35* resistance gene from *T. monococcum.* We have reduced the chromosome segment carrying *Sr35* and will continue its deployment into the program. In tetraploid wheat, we will incorporate the partial resistance gene *Sr13* from *T. turgidum* ssp. *dicoccon* that was recently identified in our lab.

For Septoria tritici blotch (STB) we will continue the crosses with "Milan" and its derivatives, which have shown good resistance to STB in field trials in California. Although STB epidemics do not occur every year, when they did they have produced devastating losses and we need to be prepared.

In the durum program, we will continue the introgression of the low cadmium allele *Cdu1* and combine it with the favorable QTL for increased yellow pigment and improved color stability identified in previous studies.

In both durum and common wheat, we will incorporate new genetic diversity generated from our mutant TILLING population including the *gw-A2* mutation associated with increased grain size, a mutant associated with increased grain number identified in hexaploid wheat, and the mutations in the *SbeIIa* and *SbeIIb* genes associated with increased levels of resistant starch.

## PROCEDURES FOR OBJECTIVE 2

Approximately 150 crosses will be made in the greenhouse during the winter and planted at Tulelake to produce $F_2$ seeds in the summer. The new $F_2$ populations will be planted in the field in November at UC Davis. Individual heads from selected plants will be harvested and planted as $F_3$ families. The $F_{4-6}$ families will be handled using the modified pedigree method. The best $F_6$ and $F_7$ lines will be harvested in bulk and advanced to a small observation plot.

Observation plots will be selected by agronomic characteristics and yield. The best lines will be analyzed for protein content and the selected lines will be tested for HMW-GS analysis to eliminate the poorest quality lines. Approximately 200 lines will be selected and advanced to preliminary yield trials. A preliminary screening of gluten strength will be performed at the CWC quality lab to eliminate lines with low gluten strength.

"Preliminary" and "Advanced" yield trials will be grown only at UC Davis. The best lines will be included in separate "Elite" experiments for common and durum wheats (4 replications) at Davis, and two other locations in the San Joaquin and Sacramento Valleys for common wheat and the San Joaquin and Imperial Valleys for durum wheat. Lines selected from the Elite trials

will be evaluated in the statewide regional trials for potential release. Selection of the more advanced yield trials will be complemented by quality tests performed at the CWC.

## PROCEDURES FOR OBJECTIVE 3

To accelerate the incorporation of valuable traits, the traditional breeding effort will be complemented with a marker assisted selection program focused on the genes described below.

***Grain yield components*:** In 2016, we demonstrated that the incorporation of the *gw-A2* mutation is associated with significant increases in grain weight (published in 2016). We will use the perfect marker for this mutation to introgress it in both durum and common wheat top varieties and breeding lines. We will also combine this mutation with mutations in the homoeologs in *gw-B2* and *gw-D2*. Preliminary results from 2016 indicate that these additional mutations add a 2-3% increase to the 6% increase observed with the *gw-A2* mutation alone (total 9% increase). We have also identified two novel alleles that increase the number of spikelets in the grain and we will introgress those in the top durum and common wheat lines. The first one is a mutation in the *ELF3* gene introgressed from *T. monococcum* and the second one is a QTL on chromosome arm 7AL identified in two association studies and validated in a biparental population (2015-2016).

***Increased resistant starch content in the grain:*** We will introgress the mutation in the different copies of the *SbeII* genes into new tetraploid and hexaploid lines and evaluate their positive effects on resistant starch and the negative pleiotropic effects on agronomic performance. We are trying to identify the best environments and genetic backgrounds to deploy the *SbeII* mutations associated with a 10-fold increase in resistant starch. We are intercrossing lines with the same *sbeII* mutations (but different genetic backgrounds) to identify chromosome regions that can be used to ameliorate the negative pleiotropic effects of the *sbeII* mutations on grain yield.

***Low Cadmium:*** In durum wheat, we will use a perfect marker for the *Cdu1* low-Cd allele to continue its introgression in additional top yielding varieties. We will combine the low-Cd allele with other genes with positive effects on quality using MAS backcrossing. In addition, we will genotype ~1000 breeding lines with the *Cdu1* marker in collaboration with the high-throughput Genotyping Laboratory at WA Pullman to increase the frequency of the low cadmium allele in our breeding populations.

***Quality genes:*** in durum wheat, we will continue the introgression of the *Glu-D1*$_{2+12}$ and the 7BxOE alleles to improve gluten strength and the *Gpc-B1* allele to increase grain protein content. To improve color we will introgress the 7BL *PSY-AB* allele for higher accumulation of lutein and the mutation in the lipoxygenase gene (*Lpx-B1.1*) that favors the stability of the yellow pigments during pasta production. For bread-making quality, we will combine the *Gpc-B1* allele with high- and low-molecular weight glutenin alleles for gluten strength.

***Drought tolerance:*** In the area of drought tolerance, we will continue our efforts to identify the gene in the distal region of the 1RS arm from rye that is associated with longer roots and drought tolerance. This segment will be combined with the *Yr15* stripe rust resistance genes and with the strong gluten allele (7BxOE) to compensate for the lower gluten strength associated by the loss of the *Glu-B3* allele. All three genes are located on chromosome 1B.

***Stripe rust resistance genes*:** We will use molecular markers to introgres the new stripe rust resistance genes *Yr77, Yr78* and the *QYr.ucw.1BL* validated in 2016 into our susceptible breeding lines with good yield potential. Meanwhile, we will continue the incorporation of the partial

resistance genes *Yr18* and *Yr36* and the major genes *Yr5* (combined with the linked low-PPO allele) and *Yr15* (linked with the 7BxOE) into our top breeding lines.

***Stem rust resistance genes:*** We will introgress the UG99 resistance gene *Sr35* into our hexaploid wheat lines. *Sr35* confers near immunity to Ug99 and will be a useful preventive measure if the UG99 arrives to the US. We have reduced the chromosome segment from *T. monococcum* carrying this gene, and this reduced segment will be used for the introgression. In 2016, we identified *Sr13*, an additional resistance gene effective to Ug99. A survey of 452 durum lines from NSGC demonstrated that only 8.6% of the durum lines carry the *Sr13* resistance gene. We will expand the number of durum lines in our program carrying this resistance gene.

***Septoria tritici blotch:*** We will continue our crosses with the septoria resistance variety Milan and the selection of resistant breeding lines.

## PROCEDURES FOR OBJECTIVE 4

As lines are advanced in the breeding program through yield tests, each line is represented by few progeny rows that are also advanced by selection each year. Thus, when lines are selected for potential release there is a source of pure seed that can be used to produce breeder seeds. Seeds produced from head rows of varieties approved for release by the UC Genetic Release Committee are transferred to FSP for multiplication and distribution. We will seek PVP protection for all our released common and durum wheat varieties.

## D. JUSTIFICATION

Continuous monitoring and breeding is needed to meet the challenges of changing and new pathogens and to increase the yield potential of wheat. The University's wheat breeding effort complements the private breeding effort by testing new sources of resistance genes and by incorporating them into adapted lines or varieties that can be efficiently used by the private sector. For the new genes to improve yield the UCD program is taking the risk of evaluating novel genes in the different CA environments. Once validated, we make these genes available to the private breeding companies working in CA. The UCD program is well equipped to incorporate new genes and technologies and to do preventive breeding programs (e.g. Ug99).

Because of the reduced profitability of wheat breeding, California wheat breeding companies cannot afford large germplasm screenings or large investments in biotechnology. Large companies also place limited breeding efforts on CA because of its relatively small acreage. The UC Davis wheat-breeding program has a long-term objective to improve wheat specifically for CA and has active collaborations with companies interested in breeding for CA in the area of Marker Assisted Selection: Arizona Grain Inc., Limagrain, and Syngenta. The UC wheat breeding program is a valuable back up for the private efforts, which are susceptible to market fluctuations. Reduced wheat profitability may result in the elimination of some private breeding programs. It is not possible to fund public breeding only during periods of inadequate private investment, because the process of developing and testing new varieties in self-pollinated species from new crosses takes several years. The UC wheat varieties have contributed for many years to sustain and improve wheat production in California.

## E. COMBINED BUDGET BREEDING AND TESTING 2017-2018

| Breeding Program | 2017-18 | 2018-19 | Sources of funding | 2017-18 | 2018-19 |
|---|---|---|---|---|---|
| Oswaldo Chicaiza. SRAIV (1 FTE) | $78,396 | $80,748 | CWC planned request | $ 195,000 | $ 198,000 |
| Benefits (51.8%) | $40,609 | $41,827 | CCIA request breeding | $ 81,000 | $ 85,000 |
| Marcelo Soria PGRI (0.15 FTE) | $ 8,431 | $ 8,684 | Royalties wheat varieties | $ 22,600 | $ 22,600 |
| Benefits (51.8%) | $ 4,367 | $ 4,498 | Reserves breeding | $ 9,300 | $ 9,800 |
| Xiaoqin Zhang Lab Assist. III (70%) | $36,490 | $37,584 | Private companies | $ 27,000 | $ 27,000 |
| Benefits (51.8%) | $18,902 | $19,469 | Total | $ 334,900 | $ 342,400 |
| Alicia Del Blanco Proj. Sci. (50%) | $32,400 | $33,372 | | | |
| Benefits (38.3%) | $12,409 | $12,781 | | | |
| Labor hours at DREC | $ 8,000 | $ 8,240 | | | |
| Labor hours at IREC | $ 3,000 | $ 3,090 | | | |
| Contract labor at UCD | $36,000 | $37,080 | | | |
| Total Salaries and Contract labor | **$279,004** | **$287,374** | | | |
| Truck ½ ton. One year | $ 7,000 | $ 7,000 | | | |
| Greenhouse space. One year | $ 6,000 | $ 6,000 | | | |
| Field operation | $13,000 | $13,000 | | | |
| Mark Lundy Reg. and Elite fees | $ 8,000 | $ 8,000 | | | |
| Field acreage recharge | $12,000 | $12,000 | | | |
| Travel to El Centro and Tulelake | $ 2,000 | $ 2,000 | | | |
| Expendables | $ 2,000 | $ 2,000 | | | |
| Supplies for lab tests | $ 1,000 | $ 1,000 | | | |
| Equipment repair and use fee | $ 4,000 | $ 4,000 | | | |
| **Total supplies and equipment** | **$55,000** | **$55,000** | | | |
| **Total Breeding** | $334,004 | $342,400 | | | |

### Budget justification

The budget for the wheat breeding program includes support for wheat breeders Oswaldo Chicaiza (100%) and Alicia del Blanco (50%). Alicia works 50% for the wheat breeding program and the other 50% is included in other barley and oat proposals. Support is also requested for Xiaoqin Zhang (70%) to provide MAS support to the breeding activities and for Marcelo Soria (15%) for database support. Contract labor for the breeding program is budgeted at $36,000. The 2017-2018 budget has a normal increase in salaries (~3%) and a similar increase was calculated for the 2018-2019 budget. Requests for supplies, equipment and field facilities are similar to previous years for both years. Since the testing program is now run independently of the testing program, we now pay the regular testing fees. These fees represent an additional $8,000 that are now transferred from my program to Mark Lundy's program.

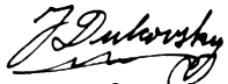
The total cost of the breeding and testing programs for 2017-2018 is $334,004 and for 2018-2019 $342,400. Funding requests for the breeding program from the CWC are $195,000 for 2017-

2018 and $198,000 for 2018-2019. The CCIA request is $81,000 from the CCIA for 2017-2018 and $85,000 for 2018-2019.

Based on the average of previous years, we estimate an income of $22,600 for our wheat varieties research fees. We also expect an income of $27,000 from collaborative agreements with Syngenta for growing their rows and yield trials at Davis. TO balance the budget we will add $9,300 in 2017-2018 and $9,800 in 2018-2019 from our reserves generated from returned overhead from our department.. In addition, to this funding, the University contributes the salaries of J. Dubcovsky and its laboratory space.

We are aware that the reduced acreage of wheat has taken a toll on the funding collected by the CWC so we have not make any increases beyond the annual salary increases and the new testing fees. We have been successful in obtaining new additional sources of funding for these difficult years and we have tried to reduce our requests from the CCIA and CWC as much as possible.

**Additional support to the breeding activities**: We obtained a new grant from USDA for the next five years ($9.7M, 20 collaborators) that will help us fund must of the genetic research on yield genes. I also renewed my support from HHMI ($4.2 M) to generate novel genomics tools and for basic research in wheat. Additional research activities are covered by grants from USDA-NIFA, BARD and International Wheat Yield Partnership (IWYP). These additional sources of funding complement the industry support for the core breeding activities. The funding provided by the CCIA and CWC has been critical to leverage these additional grants, which multiply several fold the generous support from the CCIA and the California wheat growers.



Jorge Dubcovsky
**Principal Investigator**

**CALIFORNIA WHEAT COMMISSION**

**ANNUAL RESEARCH REPORT**

**April 1, 2017 to March 31, 2018**

**PROJECT TITLE:**

Evaluation of Small Grains in California 2017-2018 (UC Small Grain Variety Testing Program—Continuing Proposal)

**PRINCIPLE INVESTIGATOR:** Mark Lundy, CE Specialist, Grain Cropping Systems, UC Davis

**OTHER INVESTIGATORS:** Department of Plant Sciences UCD: N. George, M. Rodriguez, T. Nelsen, J. Dubcovsky, L. Jackson, O. Chicaiza, A. del Blanco, J. Jackson, F. Stewart. UC Cooperative Extension-UCANR: R. Wilson, D. Culp, S. Orloff, S. Wright, R. Hutmacher, R. Solorio, B. Marsh, F. Maciel, O. Bachi, and K. Bali

**LEVEL OF 2017-2018 FUNDING:** $135,000

**OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION TO ACCOMPLISH OBJECTIVES:**

The overall objective of this research is to provide productivity information for new and existing small grain cultivars to growers in various regions of California as well as to public and private breeding programs. Small grain varieties and advanced breeding lines are evaluated for yield, agronomic characteristics, disease & pest reactions, and grain quality in representative environments throughout California. The resulting information is used to justify the release of advanced breeding lines from both public and private breeding programs and to identify where and under which conditions cultivars are best adapted. Specific project objectives in the 2016-17 season were as follows:

*Objective 1: Measure crop productivity, quality, disease resistance and agronomic characteristics for commercially available small grain varieties and advanced breeding lines across a range of environmental and management conditions that represent California agro-ecosystems.*

Commercially available and advanced breeding lines of common and durum wheat, triticale, and barley were grown in statewide multi-environment trials in the 2016-17 season. Fall-sown spring wheat (45 entries) and triticale (9 entries) were tested at nine locations; fall-sown winter wheat (41 entries) was tested at two locations; spring-sown spring wheat (48 entries) was tested at one location; durum wheat (28 entries) was tested at five locations; fall-sown spring barley (12 entries) was evaluated at four locations; and spring-sown spring barley (42 entries) was evaluated at one location. Trials were established at University of California Research and

Extension Centers and in fields of cooperating growers. Randomized complete block designs with four replications were used for all tests. Each plot was six to nine drill rows wide (5 to 8-inch row spacing) and 15 to 20 feet long, with a target planted area of 100 $ft^2$.

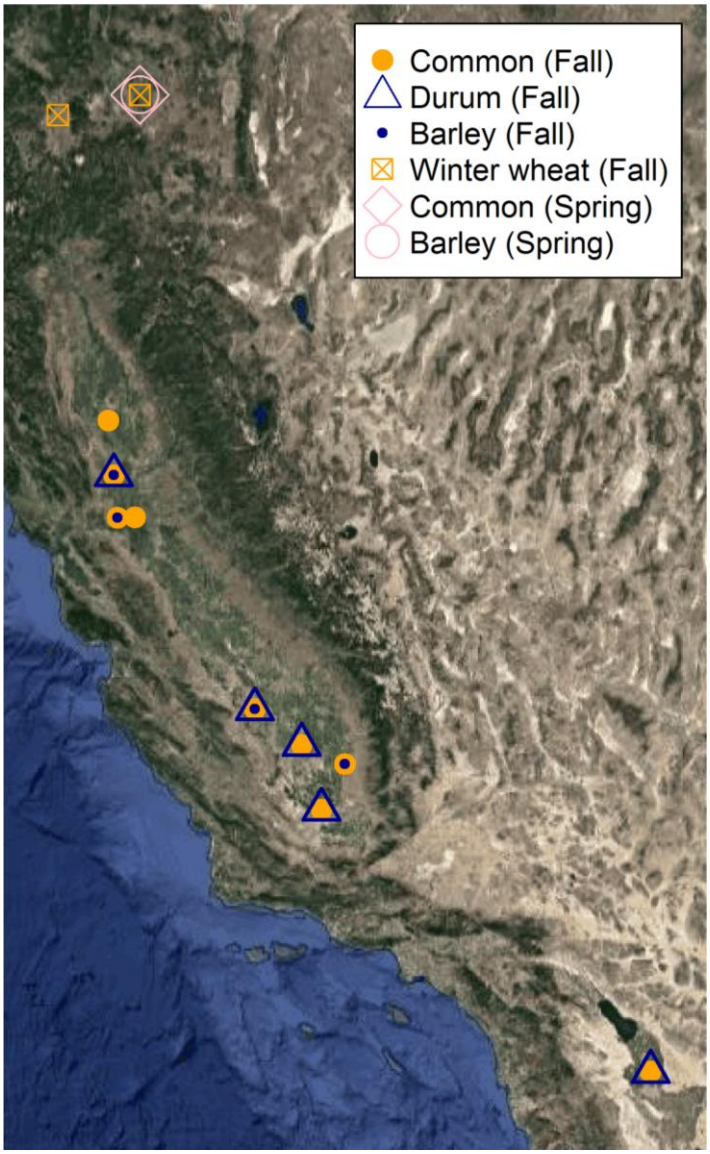



*Figure 1. University of California small grain regional trial test locations in the 2016-17 season.*

At all locations, comprehensive agronomic data were recorded for each variety at the plot level. In-season data regarding heading and maturity were taken at least twice weekly at the Davis and Imperial locations. At harvest, mean plant height, lodging, and shattering were recorded. Observations of diseases, and other disease-like symptoms, were made at all test locations. Stripe rust, leaf rust, septoria, and barley yellow dwarf virus were routinely rated at all trial locations. To facilitate the interpretation of trial results, climate data and physio-chemical soil properties were recorded at all test locations.

All the trial locations established in the 2016 season were successfully harvested in 2017. Grain was harvested with a Wintersteiger Seedmaster Universal 150 plot combine. The harvested grain from each location was used to estimate variety yields and also analyzed for protein and moisture content, two-hundred-seed-weight, and test weight. Grain samples from the test locations were also supplied to the California Wheat Commission for grain and flour quality analyses.

Yields in 2017 were high in comparison to previous seasons. Above average rainfall and temperatures, particularly in northern parts of the state, are likely to have contributed to this. From 2014 to 2017, average grain yields of common wheat ranged from 4,500 lb/acre at the rainfed locations to 6,300 lb/acre in the Imperial Valley. Average grain yields for durum wheat were similar across sub-regions, ranging from 6200 lb/acre at the southern San Joaquin Valley to 7,000 lb/acre in the Sacramento Valley. Average yields of triticale ranged from 4,200 lb/acre at rainfed locations to 6,000 lbs/acre in the Imperial Valley. Average yields of Barley ranged from 2,700 lb/acre in the Southern San Joaquin to 5,200 in the Northern San Joaquin Valley. Stripe rust ratings were not notably higher than previous years, although powdery mildew and septoria, which had not been documented in the statewide tests in recent seasons, were observed. Stripe rust samples sent for race analysis identified race PSTv-37, which is virulent to Yr6, Yr7, Yr8, Yr9, Yr17, Yr27,

Yr43, Yr44, YrTr1 and YrExp2, but avirulent to Yr1, Yr5, Yr10, Yr15, Yr24, Yr32, YrSP and Yr76, the most predominant race in recent years and in 2017.

For more detailed information regarding Objective 1 please see the *Performance summaries* and *Disease & agronomic summaries* sections of the complete UC Small Grains Annual Report (http://smallgrains.ucanr.edu/files/281262.pdf).

*Objective 2: In a subset of trial locations, directly manipulate crop water and nitrogen availability and measure variability in genotypic reactions to these varying management conditions.*

At the Davis and Fresno locations, duplicates of the common wheat trial were grown under conventional management, low nitrogen fertilization, and low irrigation treatments. Relative to the conventionally managed trial, the low water common wheat trial at Fresno received 5-inches less irrigation overall. This resulted in a reduction in median yields of approximately 1250 lbs/acre relative to the conventional management. Due to above average rainfall at Davis in 2016-17 no low-water treatment was available for that location. The conventionally managed common wheat at Davis and Fresno both received 200 lbs/acre of nitrogen, while the common wheat at Davis and Fresno grown under low nitrogen received no fertilizer. The median reduction in yields caused by the reduced nitrogen fertilization was approximately 3500 lbs/acre and 5000 lbs/acre at Davis and Fresno, respectively. Reduced irrigation and nitrogen fertilization also caused notable changes in grain and flour quality.

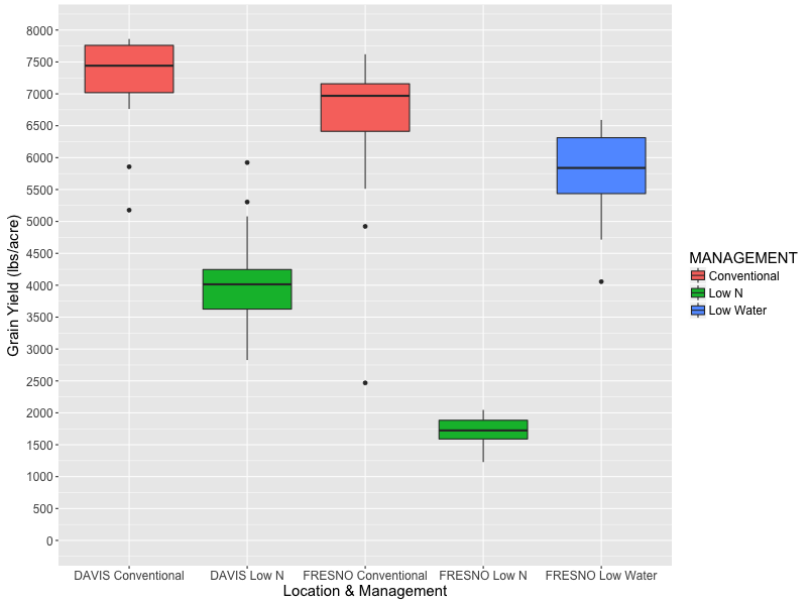



*Figure 2. Overall effects of reduced water and reduced nitrogen at the Fresno location and reduced nitrogen availability at the Davis location on common wheat and triticale yield.*

A reduction in nitrogen resulted in changes in variety rankings relative to the conventionally managed trial, and these rank changes were similar at both the Davis and Fresno locations. This result demonstrates the importance of management factors for dictating the relative variety performance and quality of small grains, and it emphasizes the need to continually develop a quantitative understanding of the effect of nitrogen and water management for applied small grain agronomy in California. Similar studies will therefore be continued in future seasons, as will the quantification of nitrogen and water status of statewide test locations in future seasons to facilitate a better understanding of trial results.

For more information relating to Objective 2 please see *Nitrogen & Water* sections of the UC Small Grains Annual Report.

*Objective 3: Measure in-season changes and variety-specific differences in growth directly and via crop phenotyping platforms.*

Crop phenotype, in the form of canopy spectral reflectance data, was obtained throughout the growing season from all plots of the conventionally managed common wheat and durum wheat regional trials at Davis using both a hand-held GreenSeeker and a 3DR solo small Unmanned Aircraft System (sUAS) with a Parrot Sequoia camera. Canopy spectral reflectance data was also taken at targeted phenological stages at the Fresno, Colusa and Imperial locations. Plot-specific NDVI values measured as a time-series across the season, were summarized quantitatively using the segmented() package in R. For each variety, a 3-slope, 2-breakpoint model was fit with initial breakpoints values that were average days to heading and initiation of senescence across all varieties. The variety-specific parameter values resulting from these broken-line regression models were then used as quantitative variables to describe the variance in crop productivity among varieties in a multiple regression environment.

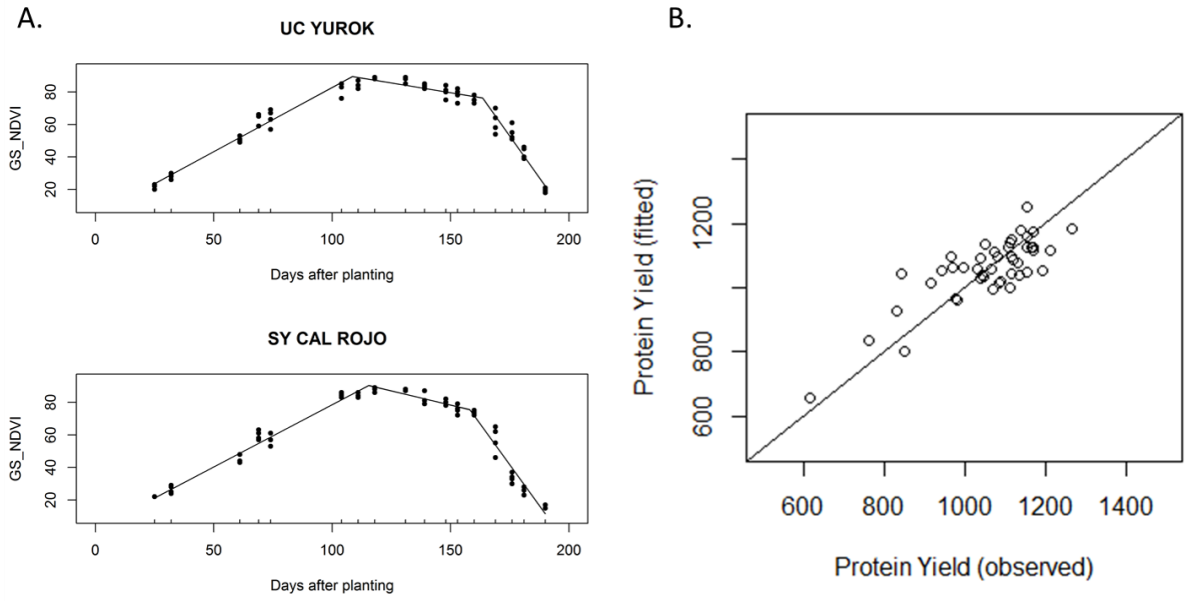



*Figure 3. Example of 3-slope, 2-breakpoint model fit to all varieties, with two selected varieties to illustrate (A), and a regression of observed to fitted values of multiple regression model describing protein yield outcomes as a function of variety specific slope and breakpoint values and their interactions.*

Initial analysis of these data suggest that these phenotyping and modeling approaches are able to account for a significant portion of the variability in crop productivity. More work is ongoing to relate these measurements to changes in phenological stages and changes in biomass across the season. In addition, during the current season, we are taking similar measurements at a broader range of locations to test the consistency of this approach across multiple site-years. If these phenotyping efforts continue to produce useful information, they may permit the development of more robust and quantitative variety information that can be used both in breeding selection and in site-specific variety selection moving forward.

For more information regarding Objective 3 please refer to the *Crop Model Testing* and *Canopy Spectral Reflectance* sections of the UC Small Grains Annual Report.

*Objective 4: Apply multi-level statistical models to trial data to understand and communicate varietal differences due to genotypic, environmental and management effects.*

To generate estimates of variety performance, trial data from the 2016-17 season were combined with trial data from preceding seasons and then analyzed and summarized using linear mixed models and least squares means. A Genotype plus Genotype-by-Environment (GGE) analysis of trial data was conducted to describe the yield performance patterns of small grain varieties across sub-regions of California. Variety performance, summarized on a multi-year and multi-location basis, is presented in detail in our annual report. To summarize briefly: the individual trials demonstrated evidence of GxE separation, with the average variety ranking based on the historical regional groupings diverging to some degree. However, there was greater GxE divergence among individual trial locations, independent of regional grouping, than the average of sites within regions. Also, the degree of GxE divergence was not entirely consistent across crop types. Moving forward, it may be most appropriate to summarize similar locations via linear mixed models and least squares means independent of regional grouping using the GGE analysis to determine within and across-year groupings.

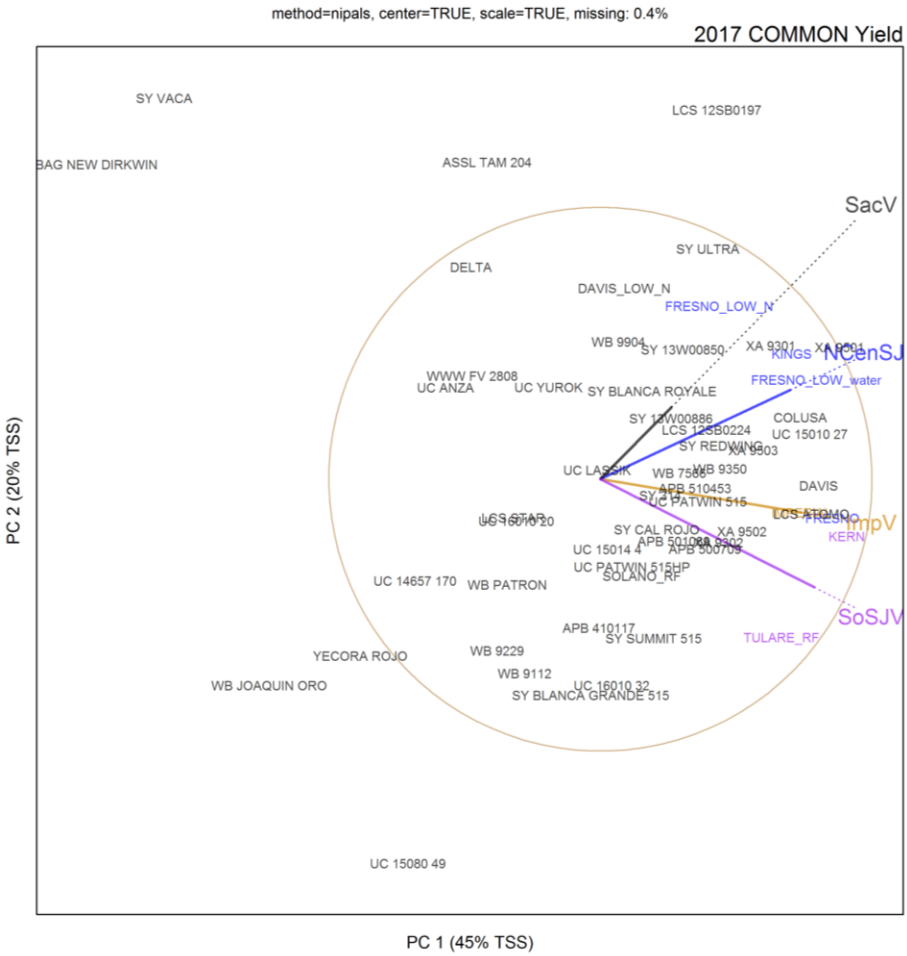



*Figure 4. GGE biplot depicting the relative effect of genotype (x-axis) and genotype-by-environment (y-axis) on common wheat variety performance in the 2016-17 trial.*

For more information regarding Objective 4 please refer to the *Multi-environment Trial Summary & Analysis* sections of the UC Small Grains Annual Report.

*Objective 5: Report results of the research and analysis on our program website, in extension meetings and other agricultural forums.*

Web Development: During the reporting period, we successfully released an interactive web-based variety selection tool (http://smallgrainselection.plantsciences.ucdavis.edu/) as part of ongoing improvements and developments from the UC Agronomy Research and Information Center (AgRIC). The tool is designed to help pinpoint small grain varieties that have performed well in particular regions and environments of California using data from multi-year, multi-location field trials. The main features of the tool are: a series of selection menus that interact with a map to give the user real-time feedback on how particular crop selections are represented geographically in the trial data; a custom table that is returned based on these selections; and a second series of selection options that can modified/narrow the table based on user choices. A video demonstrating how to use the tool is also available. In addition, a second tool designed to navigate site-specific and multi-year data interactively in a similar manner is under development and should be finished during the spring of 2018.

This tool and other updates to the Variety section of the Small Grains portion of the AgRIC (http://smallgrains.ucanr.edu/Variety_Results/2017/) have resulted in increased usage and traffic on our websites. Traffic on http://smallgrains.ucanr.edu/ is up 270%, and average session duration increased 450% during Fall 2017 compared to Fall 2016 on the former site. The site was viewed over 11,000 times during 2017.

In addition to the efforts to update the web reporting related to variety selection, we have continued a UC Small Grains Blog, begun during the previous reporting period (http://ucanr.edu/blogs/smallgrains/). The goal for the blog is that it serve as a place for field notes, announcements, and timely discussions of interest to growers, consultants, agronomists and others involved in the California small grain industry. We produced 14 posts in 2016-2017 season, and the blog was viewed over 7000 times during the reporting period. The top posts were: 2017 University of California Small Grains Survey Results, California small grain disease notes from the field, and Topdress of nitrogen at tillering stage is something to seriously consider over the coming weeks.

Extension Events: In collaboration with CCIA and the California Wheat Commission, we hosted our annual Small Grains/Alfalfa-Forages Field Day on 11 May in Davis, with over 200 people in attendance. In addition, in collaboration with the California Grain Foundation and the California Wheat Commission, we hosted the annual Wheat Collaborators Meeting on 25 October in Davis. There were approximately 100 people in attendance. Our group also hosted a 2-day training on the use of sUAS in agricultural research and a field tour of a Fresno County trial. Finally, as detailed in the Publication or Reports section, the Grain Cropping Systems group collectively gave 16 public presentations related to small grains at extension forums during the reporting period (4/1/2017-4/1/2018).

Student Training and Development: The Grain Cropping Systems Lab supported 3 graduate students and 6 undergraduate students during the reporting period. Taylor Nelsen, who began as a MS student in Horticulture and Agronomy at UC Davis, is leading our efforts to improve the precision of N fertilizer management on UC malting barley varieties. She has also been instrumental to the integration of sUAS into our small grain trial efforts. Leah Puro, a MS student in the International Agricultural Development program at UC Davis, collected biomass accumulation, physiological stage, grain accumulation, and regrowth potential data on different

nitrogen and water management practices in our wheat trials. These measurements are contributing to our model calibration and validation efforts. From these same measurements Leah estimated grain re-growth potential and has summarized the potential for dual purpose wheat production under high and low-productivity environments. Taylor Becker, a MS student in Horticulture and Agronomy at UC Davis, began in the Fall 2017 and is leading efforts to develop an empirical relationship between crop evapotranspiration and N uptake in California corn crops. The undergraduate students working in our group are majoring in agricultural and environmental sciences and eager to gain exposure to the day-to-day details involved in agronomic research. They contribute greatly to the plant and soil processing and analysis in our research as part-time employees.

**PUBLICATION OR REPORTS (since 4/1/2017):**


Lundy, M.E., Rosa, G., Turner, C., George, N. (2017). Interactive Webtool for Smallgrain Variety Selection. *Ongoing*. Available: http://smallgrainselection.plantsciences.ucdavis.edu/

Lundy, M.E., Rodriguez, M.V., Puro, L., Nelsen, T., Mathesius, K., Leinfielder-Miles, M., Wright, S., Orloff, S., Wilson, R., Culp, D., George, N.A., (2017). 2017 California Small Grain Variety Testing Data. September 27, 2017. Available: http://smallgrains.ucanr.edu/Variety_Results/2017/

Lundy, M.E., Quinton, M. University of California Agronomy Research and Information Center Small Grains Variety Selection. *Ongoing*. Available: http://smallgrains.ucanr.edu/Variety/

Lundy, M.E., UC Small Grains Blog. *Ongoing*. Available: http://ucanr.edu/blogs/smallgrains/

Lundy, M.E., et al. "Developing Nitrogen Management Strategies to Optimize Grain Yield and Protein Content while Minimizing Leaching Losses in California Wheat." Report to the California Department of Food and Agriculture Fertilizer Research and Education Program. May 23, 2017.

Lundy, M.E. et al. California small grain disease notes from the field. UC Small Grains Blog. April 10, 2017.

Lundy, M.E., 2017 University of California Small Grains Survey Results. UC Small Grains Blog. July 17, 2017.

Lundy, M. E. Glume darkening symptom observed in 2016-17 season has no apparent yield penalty in UC trial. UC Small Grains Blog. July 20, 2017.

Lundy, M.E. et al. Preliminary yield results from fall-planted 2016-17. UC Small Grains Blog. August 4, 2017.

Lundy, M.E., et al. Start planning your nitrogen management strategy for fall-planted wheat now (and consider using a N-rich reference strip to manage your N more precisely). UC Small Grains Blog. August 24, 2017.

Lundy, M.E. et al. Preliminary yield results from fall-planted 2016-17. UC Small Grains Blog. August 4, 2017.

Lundy, M.E. et al. 2017 California Small Grain Variety Testing Data. UC Small Grains Blog. September 27, 2017.

Lundy, M.E. et al. Announcing an Interactive Webtool for Small Grain Variety Selection. UC Small Grains Blog. October 9, 2017.

Mathesius, K. et al. A Slow Start to Winter Rains: checking your stand before nitrogen topdressing in wheat. UC Small Grains Blog. January 18, 2018.

Lundy, M.E. Statewide small grain testing program update. UC Small Grains Blog. January 23, 2018.

Lundy, M.E. Adapting in-season N rates for wheat during a dry year. UC Small Grains Blog. February 20, 2018.

Leinfelder-Miles, M. et al. Frost Injury in Wheat. UC Small Grains Blog. March 7, 2018.

Presentations and Trainings

Lundy, M.E., et al. "Achieving Efficient N Fertilizer Management in California Spring Wheat." San Joaquin Valley CCA Nitrogen Management Training Meeting, California Institute for Water Resources, 6 March, 2018.

Lundy, M.E., "Statewide Wheat and Barley Variety Trial Updates." Sacramento Valley Field Crops Winter Grower Meeting. Woodand, CA, 21 February, 2018.

Nelsen, T. and Lundy, M.E., "How does rate and timing of N fertilizer management affect yield and quality in California malting barley?" California Plant and Soil Conference. Fresno, CA, 6 February, 2018.

Puro, L. and Lundy, M.E., "The agronomic and economic potential for wheat to be harvested as a dual-purpose crop in California" California Plant and Soil Conference. Fresno, CA, 6 February, 2018.

Lundy, M.E., "Tools for Selecting Small Grain Varieties from UCCE Statewide Trials." Delta Field Crops Winter Grower Meeting. Stockton, CA, 12 January, 2018

Nelsen, T. and Lundy, M.E., "sUAS in Agricultural Research Training Workshop." Department of Plant Sciences. UC Davis. 18-19 December, 2017.

Lundy, M.E., "UC Small Grains Research and Extension Update." California Quality Collaborators Program. Davis, CA. 25 October, 2017.

George, N., "2016-17 Collaborative Trials Overview." California Quality Collaborators Program. Davis, CA. 25 October, 2017.

Nelsen, T. and Lundy M.E., "Will Spectral Reflectance from UAS Predict In-Season Barley Nitrogen Status?" UC Davis Small Grain and Alfalfa/Forages Field Day. Tulelake, CA, 26 July, 2017.

Lundy, M.E., "Development of Small Grain Varieties in California." Intermountain Research and Extension Center Field Day. Tulelake, CA, 26 July, 2017.

Rodriguez, M. and Lundy, M.E., "Potential agronomic and soil carbon contributions from the perennial wheatgrass Kernza in California?" 2017 Russell Ranch Field Day. Winters, CA, 7 June, 2017

Nelsen, T., "Will Spectral Reflectance from UAS Predict In-Season Barley Nitrogen Status?" UC Davis Small Grain and Alfalfa/Forages Field Day. Davis, CA, 11 May 2017.

Lundy, M.E, "Common Wheat, Durum, Triticale and Barley Variety Evaluations: Comments on Methods, Productivity, and Cropping Season Observations." UC Davis Small Grain and Alfalfa/Forages Field Day. Davis, CA, 11 May 2017.

Lundy, M.E, "UC small grains research and extension update." UC Cooperative Extension Agronomic Crops Program Team Meeting. Davis, CA 12 May 2017.

Lundy, M.E, "Update on the Wheat Variety Testing Program to the California Wheat Commission." California Wheat Commission Quarterly Meeting. Woodland, CA, 12 April 2017.

George, N., "UC small grains variety testing update." Westside Research and Extension Center Field Day. Five Points, CA 19 April 2017.

**CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:**

The California small grain crop in 2016-17 consisted of approximately 450 thousand planted acres. Approximately 45% of the planted area of wheat was harvested for grain. Total wheat acres in California were at their lowest in a decade. The declines are likely to be the result of drought conditions in the 2013-14 and 2014-15 seasons and concurrent low grain prices.

The 2014-15 and 2015-16 seasons were characterized by considerably below average rainfall and growing season temperatures that were above average. In contrast, higher-than-average rainfall was received throughout California in the 2016-17 seasons, particularly in northern parts of the state during the period from late January to early March. Consequently, locations in the Sacramento Valley, notably Colusa and Davis, that may have received supplemental irrigation in

more average seasons did not receive any supplemental water. In comparison to previous seasons, grain yields at most locations in 2016-17 were above average. Rust ratings were not notably higher than previous years, although the warm and wet conditions may have resulted in the high incidence of powdery mildew in Southern San Joaquin Valley and presence of septoria, neither of which had been documented in the statewide tests in recent seasons.

Detailed results for yield, agronomic characteristics, disease resistance and quality evaluations are presented at the UC Davis Small Grains web site:

http://smallgrains.ucanr.edu/Variety_Results/2017/

**Acknowledgements:** I greatly appreciate the efforts of the UC Grain Cropping Systems Lab members and to Jorge Dubcovsky and the members of his research group for their contributions to our work. In addition, I would also like to thank the CE Advisors, the UC research station staffs and the cooperating growers involved with the trials. We could not do this without you! We look forward to continued progress in the coming year and we are grateful for the support of our program by the California Wheat Commission and the California Crop Improvement Association.

Sincerely,

Mark Lundy

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Mark Lundy, CE Specialist, Grain Cropping Systems, UC Davis
Overview of 2017-18 research activities prepared for California Wheat Commission Research Board
21 February, 2019

An overview of the research activities carried out by my UC Grain Cropping Systems lab during the 2017-18 season are organized according to the objectives articulated in the 2017 California Wheat Commission research proposal as follows:

**Objective 1:** *Measure crop productivity, quality, disease resistance and agronomic characteristics for commercially available wheat varieties and advanced breeding lines across a range of environmental and management conditions that represent California wheat agroecosystems.*

My research and extension program managed 26 separate wheat variety trials across the state during the 2017-18 growing season representing a total of 1025 unique genotype x environment combinations and 4100 wheat plots measured. These included:

Fall-sown common spring wheat: 41 varieties in 9 unique locations and 13 total environments. Grain yield, grain protein content, test weight, thousand kernel weight, plant height, incidence of lodging at soft dough, incidence of lodging at harvest, and disease reactions were estimated.

Fall-sown durum wheat: 30 varieties established in 5 locations. Grain yield, grain protein content, test weight, thousand kernel weight, plant height, incidence of lodging at soft dough, incidence of lodging at harvest, and disease reactions were estimated.

Fall-sown common winter wheat: 40 varieties in 2 locations. Grain yield, grain protein content, test weight, plant height, and incidence of lodging at harvest were estimated.

Fall-sown wheat, organic production system: 23 varieties in 1 locations. Grain yield and grain protein content were estimated.

Fall-sown common spring wheat elite nurseries: 90 elite lines were evaluated in 2 locations for UC and private breeding companies with a presence in California. Grain yield and grain protein content were estimated.

Spring-sown common spring wheat: 42 hard spring wheat varieties and 17 soft spring wheat varieties in 1 location. Grain yield, grain protein content, test weight, plant height, and incidence of lodging at harvest were estimated.

In addition to the above trials, the following activities contributed to developing more in depth understanding of wheat quality:

Wheat Quality (Statewide trials): During the 2017-18 season, sufficient quantities of grain from wheat trials were collected, cleaned, and processed to permit more extensive evaluation of grain quality by the California Wheat Commission Quality Lab. In collaboration with the CWC and Jorge Dubcovsky, a quality classification system was developed during the previous year based on the quality results obtained from these samples and those from recent seasons.

Wheat Quality (Collaborative trials): 9 fall-planted common spring wheat varieties and 4 fall-planted durum wheat varieties were grown alongside appropriate control varieties in large plots in two separate locations (Davis and Fresno for common wheat, and Fresno and Imperial for durum wheat). The larger scale plots permitted production of sufficient grain such that each variety could be processed and distributed to a number of collaborating wheat quality labs for an unbiased assessment of wheat quality.

**Objective 2:** *In a subset of trial locations, directly manipulate crop water and nitrogen availability and measure the variability in genotypic reactions to these varying management conditions.*

2017-18 was the second season that managed stress trials were included as part of the UC Statewide Variety Testing Program experimental efforts. At 2 of the 9 fall-planted, common spring wheat trial locations (Davis and Fresno), replicates of the trials were grown under conditions of nitrogen (N) stress and terminal drought stress in addition to the trial grown under conventional management practices. Soil

nitrogen and water from the varying management scenarios was measured before, during and at the conclusion of the cropping season. Changes in relative variety performance under stressed and non-stressed conditions were quantified so that wheat varieties could be classified according to their relative tolerance to N and drought stress. In addition to the variety-specific information, changes in absolute performance of wheat under conditions of managed stress are also being used to develop and calibrate California-specific wheat growth models. These models will help to deliver more customized management recommendations to California growers in the coming years.

**Objective 3:** *Directly measure site-characteristics and increase the measurement of in-season changes and variety-specific differences in growth directly and via crop phenotyping platforms.*

Environmental variability is by far the most influential factor on overall wheat productivity and quality in California. Over the 2016-17 and 2017-18 seasons we developed and implemented a system of crop phenotype measurement that is allowing us to quantify and contextualize environmental variability as it affects wheat growth generally, and, more particularly, relative variety performance under contrasting growing conditions. Biophysical measurements of site-specific characteristics were recorded prior to, during, and after the 2017-18 season. These included pre-plant soil nitrate concentrations, soil water content prior to and subsequent to the cropping season, and in-season canopy and leaf colorimetric reflectance values. The soil measurements provide a quantitative context for the productivity results obtained from a particular site so that its results can be more precisely extended to other locations and years. The canopy reflectance values provide information about why particular varieties perform better/worse than others do under one set of conditions but less so under another set of conditions. These additional measurements are multiplying the value of our experimental efforts and will continue to add information as they are more fully explored and analyzed in the coming year.

**Objective 4:** *Apply multi-level statistical models and crop models to trial data to better understand and communicate varietal differences due to genotype, environment and management effects.*

We have updated the methods of analysis applied to variety trial results to create more robust estimates of absolute and relative variety performance and to more clearly communicate results both to growers and breeders of wheat. These new approaches make use of multi-year, multi-location data when possible and appropriate, while still providing site-specific summaries when desired. This multi-pronged approach is on display in the pair of variety selection webtools we developed and released during the 2016-17 and 2017-18 season. In addition, variety performance results derived from the managed stress trials alongside the high-frequency crop reflectance data are providing insight relating to specific crop varieties as well as more generalized crop phenotypes that are best adapted to California growing conditions. In addition to the variety-specific information, the productivity of wheat measured under a wide range of environmental conditions is assisting in the development and calibration California-specific wheat growth models. These models will help to deliver more customized management recommendations to California growers in the coming years. Finally, we have made significant progress in connecting our field-based data to high spatial and temporal resolution environmental data customizable for any location or period. Connecting site- and time-specific environmental data to our agronomic dataset is allowing us to analyze how environmental conditions interact with wheat productivity and quality more directly and thoroughly. In time, the output of these efforts will greatly enhance our ability to quantify and communicate site-specific variety recommendations and management options.

**Objective 5:** Report results of the research and analysis on our program website, in extension meetings and other agricultural forums.

Extension Events during 2017-18 season: In collaboration with CCIA and the California Wheat Commission, we hosted our annual Small Grains/Alfalfa-Forages Field Day on 17 May in Davis, with over 200 people in attendance. In addition, on 8 May we hosted a field tour of over 40 individuals across

several farms in Yolo County where we were conducting experimental work related to N management and small grain variety selection. In collaboration with the California Grain Foundation and the California Wheat Commission, we hosted the annual Wheat Collaborators Meeting on 3 October in Davis. There were approximately 100 people in attendance. In addition, we have delivered 10 public presentations related to small grains at extension forums during 2018.

Web Development: During the reporting period, we successfully released a second interactive web-based variety trial data exploration tool (http://smallgrainselection.plantsciences.ucdavis.edu/explore) as part of ongoing improvements and developments on the UC Small Grains Research and Information Center website. The tool communicates single-location trial data in an interactive interface that permits user-customized results. This additional site complements the interactive variety selection tool released the previous year (http://smallgrainselection.plantsciences.ucdavis.edu/), which was designed to pinpoint small grain varieties that have performed well in particular regions and environments of California using data from multi-year, multi-location field trials. We also continue to provide results in tabular and pdf formats on our program website (eg. http://smallgrains.ucanr.edu/Variety_Results/2018/).

The http://smallgrains.ucanr.edu/ site and associated web tools were viewed over 13,000 times during 2018 with over 900 California-based users. In addition to the efforts to update the web reporting related to variety selection, we have continued to expand our UC Small Grains Blog (http://ucanr.edu/blogs/smallgrains/), which serve as a place for field notes, announcements, and timely discussions of interest to growers, consultants, agronomists and others involved in the California small grain industry. We produced 13 posts in 2017-2018 season, and the blog was viewed over 2600 times by over 800 California-based users during 2018.

**Extension of improved N management in California wheat and associated web development**

In addition to the activities described above, we have continued to work actively with a number of growers on improved N fertilizer management practices in wheat. This includes: 1) extending the use of soil nitrate quick test methods we have developed for pre- and in-season measurement of available soil nitrate; 2) demonstrating/implementing the use of site-specific calibration strips in combination with hand-held and drone based sensors to inform site-specific, in-season N fertilizer management; and 3) providing regionally- and temporally-specific summaries of seasonal weather patterns on the UC Small Grains blog that help to situate general N management principles in the context of the current year's conditions. We are also developing an interactive web tool that will allow a user to easily access site-specific, real-time estimates of wheat phenological changes and seasonal precipitation alongside historical averages over any period they select for any location in California's primary wheat growing regions. These developments are helping to improve N management in California wheat while creating a foundation for further extension efforts that incorporate site-specific, real-time data into the delivery of agronomic information.

**PROJECT TITLE:**

Evaluation of wheat varieties in California 2017-2019 (UC Small Grain Variety Testing Program)

**PRINCIPAL INVESTIGATOR:**

Mark Lundy

**OTHER INVESTIGATORS:**

*Department of Plant Sciences UCD*: J. Dubcovsky, Alicia del Blanco, O. Chicaiza, N. George; *UC Cooperative Extension-UCANR*: R. Wilson, D. Culp, S. Orloff, M. Leinfelder-Miles, S. Wright, B. Marsh, K. Mathesius, R. Hutmacher, R. Solorio, N. Clark, F. Maciel.

**BUDGET REQUEST: $135,000 (2017-2018) & $137,000 (2018-2019)**

**A. SUMMARY:**

The objective of this research is to test commercial and advanced wheat varieties across a wide range of environmental conditions in the state of California in order to determine genotypes with potential for economic productivity. The requested funding will be used to support common wheat and durum wheat trials in the major small grain producing areas of California. The UC Small Grain Variety Testing Program will include evaluation nurseries of advanced breeding lines and new and standard cultivars obtained from public and private breeding programs. Trials will be located at representative environments in the Sacramento, San Joaquin, Imperial, and northern Intermountain region and will be grown using production practices appropriate for each environment. The performance of the entries will be documented and summarized on the UC Small Grains Program website (http://smallgrains.ucanr.edu/Variety/). The resulting information will be used as supporting data for justifying the release of advanced breeding lines from both public and private breeding programs and to identify where and under which conditions cultivars are best adapted. The program will also manage elite germplasm nurseries for the UC wheat breeding program in two selected locations to help accelerate the development of public cultivars.

**CALIFORNIA WHEAT COMMISSION**

May 1, 2017 to April 30, 2019

**B. OBJECTIVES:** The overall objective of this research is to provide productivity information for new and existing small grain cultivars to growers in various regions of California as well as to public and private breeding programs. The performance (which includes yield, agronomic characteristics, diseases & pest reactions, and grain quality) of cultivars and advanced breeding lines from public and private breeding programs will be evaluated in representative environments throughout California. The UC Small Grain Variety Testing Program will cover the main grain-producing areas (including the Sacramento, San Joaquin, Imperial, and northern Intermountain Region) of California. The resulting information will be used to justify the release of advanced breeding lines from both public and private breeding programs and to identify where and under which conditions cultivars are best adapted.

**Objective 1:** Measure crop productivity, quality, disease resistance and agronomic characteristics for commercially available small grain varieties and advanced breeding lines across a range of environmental and management conditions that represent California agroecosystems.

**Objective 2:** In a subset of trial locations, directly manipulate crop water and nitrogen availability and measure variability in genotypic reactions to these varying management conditions.

**Objective 3:** Measure in-season changes and variety-specific differences in growth directly and via crop phenotyping platforms.

**Objective 4:** Apply multi-level statistical models to trial data to understand and communicate varietal differences due to genotypic, environmental and management effects.

**Objective 5:** Report results of the research and analysis on our program website, in extension meetings and other agricultural forums.

**C. PROCEDURES**

**Objective 1:** The following replicated yield tests are planned for the 2017-18 season:

Common wheat and triticale: The Regional fall-sown test (30-50 entries, predominantly HRS, but including HWS, HWW, HRW, triticale and other classes or subclasses made available by cooperating breeders) will be planted at 6-8 sites in the Central Valley and surrounding areas, and in the Imperial Valley.

The fall-sown elite nurseries established in collaboration with the UCD wheat breeding program

(20-30 entries, HWS and HRS) will be planted at two sites in the Central Valley.

The quality collaborators nursery, which includes 12-15 elite lines and new cultivars for the collaborative testing program, will be planted at 1-2 sites in the Sacramento and San Joaquin Valleys. This program involves domestic millers and bakers, grain dealers, and private breeding programs.

A fall-sown winter wheat test (approximately 40 entries) and a spring-sown wheat test (approximately 30 entries) will be planted at the UC IREC in Tulelake, CA in cooperation with Oregon State University.

Durum wheat: The Regional fall-sown test (30-50 entries) will be conducted in 3-4 sites in the Central Valley and one site in the Imperial Valley.

The fall-sown elite nursery conducted in collaboration with the UCD wheat breeding program (20-30 entries) will be planted at one site in the San Joaquin Valley.

A durum wheat quality nursery consisting of 6-12 elite lines and new cultivars will be planted to provide grain samples for quality analyses for the durum wheat collaborative testing program, at one site in the San Joaqauin Valley and one site at the Imperial Valley.

UC Elite nurseries: In order to accelerate the development and release of public cultivars, off-station testing of elite germplasm from the UC wheat breeding program will be conducted at key locations. Selected materials can then be more rapidly advanced to the UC Variety Testing Program nurseries. When combined with early generation quality testing, the time required for cultivar release can be shortened.

Quality Collaborators Trials: Elite germplasm (both common and durum wheat) from public and private breeding programs will be produced under optimum cultural conditions in the San Joaquin and Imperial Valleys for collaborative end-use (milling and baking) tests in cooperation with the California Wheat Commission and California's milling and baking industries.

Intermountain Region: For the Intermountain region of northern California, germplasm from both public and private small grain breeding programs operating in the Pacific Northwest will be evaluated at the UC Intermountain Research and Experiment Station in Tulelake in cooperation with Oregon State University and the USDA-ARS. This effort will help accelerate the development of cultivars for the Intermountain region of northern California.

Field methods: All small grain tests will be conducted on University of California research farms or grower fields under irrigated or rainfed conditions. Nurseries will be planted at seeding rates required to achieve plant densities of 1.0 million plants per acre for rainfed wheat tests and at 1.2 million plants per acre for irrigated wheat tests. Randomized complete block designs with 4 replications will be used, and individual plots will measure 15 to 20 feet in length and 6 to 9 drill rows (6-9" spacing) in width.

Data on yields, bushel weights, kernel weights, agronomic characteristics (plant height, lodging, dates of heading and maturity, shatter) and reactions to important diseases and pests will be recorded and analyzed. Seed samples from grain harvests at selected locations will be analyzed

for protein content and milling and baking performance (common and durum wheat tests).

**Objective 2:** At two trial locations, one in the Sacramento Valley and another in the San Joaquin Valley, the common wheat and triticale trial will be replicated three times. One trial will be conducted with water and N fertility delivered to optimize productivity. A second trial will be conducted where soil nitrogen availability limits crop growth and no N fertilizer is provided but water is not limiting within the season. A third trial will be conducted where water is managed to limit crop growth but N fertility is managed to avoid nitrogen deficiency. These 3 side-by-side trials, replicated in two locations and in forthcoming seasons, will create an opportunity to being to quantitatively differentiate the effects of N limitation, water limitation and unrelated environmental factors and measure how these management factors change the relative productivity of the common wheat and triticale varieties in the trial.

**Objective 3:** Cultural, management, and biological characteristics of test locations will be recorded, including soil coring for chemical and physical characterization, the deployment of in-field weather stations in areas poorly served by other weather monitoring equipment. Pre-plant and post-harvest soil moisture throughout the rooting zone will be measured in order to improve estimates of crop water availability and in-season use. In order to improve the understanding of environmental effects on crop growth and development at the diverse trial sites, in-season phenotypic measurements such as plot-specific Normalized Difference Vegetation Index (NDVI) and other forms of canopy spectral reflectance will be recorded at key phenological stages via drone-mounted multispectral cameras and other proximal sensing devices. This information will aid in the interpretation of variety trial results and improve our understanding of site-specific environmental interactions and their differential effects on cultivar performance. In addition, the identification of agro-ecological regions to which new cultivars are best adapted will be facilitated by this information. Information regarding the biophysical details of the production locations will also permit variety trial data to be used for validating computer-based crop production models that can then serve as new research and production tools for the California small grains industry.

**Objective 4:** In order to improve the understanding of genotype×environment patterns within the state, variety tests will be designed to more directly measure these patterns. Principle component analysis (PCA) and associated biplots will be used for classification and grouping of trials. Linear mixed models and least-squared means will be used for analyzing and summarizing trial data across multiple site-years. Together, these new methods will generate more precise, accurate, and useful variety performance estimates for the California small grains industry. The Agricultural Production Systems Simulator (APSIM) is a computer program that combines biophysical and management modules to simulate cropping systems and is widely used both for farm management and research in other parts of the world. The program can accurately simulate wheat production under a variety of production conditions. Trial data will be used to test the reliability of the model as a tool for simulating small grains production in California. Efforts will be made to begin integrating this modeling into the delivery of site-specific, real-time extension information.

**Objective 5:** Results of the analyses will be published online on the UC Small Grains website

(http://smallgrains.ucanr.edu/Variety/). Presentations of results of the research will be made at industry meetings, field days and other extension venues throughout the state each year.

**D. JUSTIFICATION:**

Advanced breeding lines that might become cultivars are evaluated first throughout California in the UC Small Grain Variety Testing Program. Areas where advanced breeding lines are best adapted are identified. Concurrently, the suitability of the germplasm from both agronomic and quality standpoints is determined, and forms the basis for variety recommendations. The UC Small Grain Variety Testing Program serves as the foundation for the small grains research program and is extremely important to California's small grains growers, advisors, seed companies, plant breeders, end-users and others in the industry.

Between 450 thousand and 750 million acres of various market classes of small grains (primarily wheat and barley, but also oat and triticale acreage for grain and forage) are grown each year in California, with some acreage in most counties. Production occurs under a wide range of environmental conditions and management practices, and supplies a variety of food, feed, and forage markets, for both domestic use and export. The acreage of individual cultivars changes from year to year as new cultivars are tested, approved, and released for commercial production to replace cultivars that have become susceptible to diseases or other pests or lack key characteristics. New cultivars should represent improvements in specific characteristics of the crop, meet specific needs of the grain industry, and decrease vulnerability to stresses resulting from diseases, pests, and unfavorable physical environments. In order to assure that new cultivars do represent such improvements, it is essential that advanced breeding lines are evaluated throughout California before they are released as cultivars. The evaluations result in the identification of regions where breeding lines are best adapted and, conversely, reveal which breeding lines are not adapted, have unacceptable characteristics, and should not be released as cultivars. Both public and private breeding programs use results from the UC Small Grain Variety Testing Program as supporting data for justifying the release of advanced breeding lines as cultivars. The UCD wheat breeding program also uses these data in the PVP applications for their varieties.

New cultivars that combine appropriate agronomic characteristics, specific end-use quality traits, resistance to multiple diseases, and high yield potential are needed for the economic survival of small grain growers in California. The continued appearance of new races of the pathogens that cause stripe rust, leaf rust, *Septoria tritici* leaf blotch, net blotch, and scald has made wheat and barley extremely vulnerable to disease epidemics and yield loss. Stripe rust remains the major threat. The regional testing program is an important component of the monitoring network required for early warning of new virulence.

The addition of more explicit measurement of the pre- and post-season soil water status at the sites along with in-season phenotypic measurements, such as plot-specific NDVI and canopy spectral reflectance at key phenological stages, will add important information to the trial data in the 2017-18 and 2018-19 cropping seasons. The increasing availability of relatively low-cost

measurement technology and computing platforms is fundamentally changing the way crop phenotyping is performed around the world. In order to remain relevant and competitive in the scientific landscape of the future, the statewide variety testing program must begin to integrate more ambitious measurements of the crop-soil environment into future research trials, and incorporate the analytical methods described previously.

In time, our goal is to transition the program toward more explicit in-season measurement of the crop environment and introduce more explicit management-related variability to a subset of these environments. This will allow us to develop a more direct, quantitative understanding of the contribution of repeatable biophysical management effects to overall genotype×environment effects. In this way, we will multiply the information created by the trials both for the purposes of more informed breeding and variety selection, and increase the crop management information that can be gleaned from the effort. For the 2017-18 season, drone-based crop phenotyping, site soil characteristics, and in-field data loggers represent the first step in this transition.

The likelihood of success in meeting the stated objectives is high if adequate funding is provided because of participation in the project by most plant breeders, both public and private, currently developing small grain cultivars for California. The information on the program website (http://smallgrains.ucanr.edu/Variety/CropType/) documents the extensive work done across all small grain growing areas in California. These results demonstrate the ability of the UC Small Grain Variety Testing Program to deliver relevant and in-depth information on small grain adaptability throughout California. We look forward to continuing this service for the California small grains industry.

## E. BUDGET FOR REGIONAL TESTING 2017-2019

| Regional Testing program | 2017-2018 | 2018-2019 |
|---|---|---|
| Staff Salaries (N. George, M. Rodriguez) | $106,854 | $111,128 |
| Staff Benefits ((N. George, M. Rodriguez)) | $43,810 | $45,562 |
| Part time labor (UCD student interns) | $16,000 | $17,000 |
| Total Salaries and Contract labor | **$166,664** | **$173,690** |
| UCCE Advisor Collaborator reimbursement | $8,000 | $8,000 |
| Acreage Rental/Recharge (UD Davis) | $12,000 | $12,000 |
| Research and Extension Center labor and service charges (UCANR) | $26,000 | $30,000 |
| Total UC collaborator funding | **$46,000** | **$50,000** |
| Seasonal truck rental x 2 | $16,800 | $17,136 |
| Box truck rental (harvest) | $1,500 | $1,530 |
| Statewide Travel | $4,000 | $4,000 |
| Equipment maintenance, repair, use and replacement | $7,500 | $7,500 |
| Consumable supplies and materials | $3,000 | $3,000 |
| Total supplies and equipment | **$32,800** | **$33,166** |
| **Total Regional Testing Program** | **$245,464** | **$256,856** |

| Sources of funding | 2017-2018 | 2018-2019 |
|---|---|---|
| **CWC-Regional testing request** | **$135,000** | **$137,000** |
| Quality Collaborators Program | $5,000 | $5,000 |
| CCIA-Regional testing request | $54,000 | $56,500 |
| Statewide testing fees | $15,000 | $15,000 |
| Elite-line testing | $15,000 | $15,000 |
| Testing program reserve funding | $21,464 | $28,356 |
| **Total** | **$245,464** | **$256,856** |

### Budget justification

The budget for the regional testing program includes support for UC Davis Department of Plant Science staff members, who are essential for implementing the field research, communicating with the various collaborators, curating the trial data and seed stocks, maintaining the equipment, and producing written and web-based summaries associated with the research. In addition to the full-time staff, part-time labor is a necessary supplement for tasks such as weighing entries, preparing seeds for planting, and recording the necessary in-season and post-harvest measurements associated with the experiment. The increase in budget between 2017-18 and 2018-19 reflects anticipated 4% increases in salary and benefits rates and a 6% increase in wage rates for hourly workers.

Relative to previous years, the proposed budget devotes a larger proportion of the requested funds to collaborators within UC Cooperative Extension. In recent years, new Agronomy Advisors have been hired in the San Joaquin and Sacramento Valleys. The contributions to the trials from the UC Advisors are invaluable to the integrity of the overall experiment, and UCCE Advisors make important contributions due to their more nuanced understanding of the particular variables of importance in a given region. The program has actively sought more explicit involvement from the UCCE Advisors in these trials in the past season and the budget includes money to reimburse the participating Advisors for trial-related expenses. This small investment to ensure the buy-in from current, new and future CE Advisors will provide manifold benefits in terms of the quality and quantity of the data produced and the information communicated from the trials across the state.

In a similar vein, the proposed budget devotes more resources to labor and service charges at the Research and Extension Centers where 4 trials are conducted annually. As mentioned above, over the next several seasons the program will begin to more explicitly measure and manipulate agronomic variables to develop a more quantitative understanding of the contribution of management effects to overall genotype×environment effects. To successfully control and integrate management variables, such as nitrogen and water, we will need to rent larger portions of the acres at the REC sites so that we can grow rotational crops in the non-trial areas in order to prepare and control the ground for effective measurement of key variables during the trial period. Control over the rotation on a 2-3 year timescale is essential to producing high-quality management data, but it will result in greater rental and labor costs at these sites. Independent of these increases, UCANR has proposed dramatic rate increases at the Research and Extension Centers (RECs). While we are actively opposing these increases through appropriate organizational channels, it does appear likely that the overall cost for our use of these resources will increase over the next two seasons. Nevertheless, we anticipate that this investment, over the medium-term, will multiply the information produced by the trials, bringing novel information into the breeding and variety selection efforts and adding valuable management information to the experimental outputs that are not currently within the scope of the trial. It may also provide leverage to more effectively supplement these efforts with other outside funding.

The budget also reflects an increase in costs related to vehicle rentals. It includes the rental of 2 fleet trucks from UCDavis Fleet Services and a box truck during the harvest season. Previous budgets included a larger truck that is required to pull our heavy-equipment trailer around the state and is double the cost of a light-truck rental. We have added a light-truck rental because it is necessary for participation in fieldwork by students who have no independent transportation to the trial location, and we frequently have multiple needs for vehicles on the same day. Because we have begun to measure protein content on three experimental replications, it is more efficient to subsample our grain in the field where it is being harvested. The box truck enables us to bring these larger quantities of grain back to UCDavis for processing. We have reduced the overall travel expenditures to reflect a decrease in the use of personal vehicles and travel expenses. For example, when working in the San Joaquin Valley overnight, our group now stays at WSREC in the dormitories rather than incurring hotel rental expenses as was the previous practice.

The budget reflects an overall deficit requiring $49,820 from other program resources over the 2017-19 seasons. This is in addition to the CE Specialist salary and benefits covered by UC ANR for M. Lundy.

We are aware that the drought, low grain prices and increasing competition for wheat acres from higher-value crops have taken a toll on the funding collected by the California Wheat Commission. As such, the 3.8% and 1.5% year-over-year increases in funding requests from the California Wheat Commission for the 2017-18 and 2018-19 budget years, are less than half of the 8% and 4% year-over-year increases in costs we anticipate. We are actively exploring options for broadening the base of funding for applied grain cropping system research through new grants and collection mechanisms. We believe that the proposed changes to the trial structure will gradually enable us to multiply the outputs from the existing effort and thereby increase its value to a broader range of funding sources. We are hopeful that these efforts will be successful in the medium-term. Regardless, we appreciate and depend on the basic support of this program that the California Wheat Commission generously provides.

Sincerely,

Mark Lundy

Mark Lundy
Assistant CE Specialist
Grain Cropping Systems
Department of Plant Sciences
University of California, Davis

# California Wheat Commission

## Cash Flow Projection

11.30.18

| | ACTUAL FY 2014-2015 | | ACTUAL FY 2015-2016 | | ACTUAL FY 2016-2017 | | ACTUAL FY 2017-2018 | | PROJECTED FY 2018-2019 | | PROJECTIONS FY 2019-2020 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Beginning Cash Reserve** | $ 1,230,018 | | $ 838,853 | | $ 821,628 | | $ 866,729 | | $ 661,211 | | $ 464,676 | |
| **INCOME** | | | | | | | | | | | | |
| **Total Assessment Income** | $ 619,028 | | $ 852,860 | | $ 765,850 | | $ 595,097 | | $ 575,000 | | $ 470,000 | |
| **Lab Income** | $ 75,228 | | $ 75,002 | | $ 96,652 | | $ 124,169 | | $ 136,565 | | $ 140,000 | |
| **Other** | $ 4,287 | | $ 3,838 | | $ 9,169 | | $ 6,330 | | $ 6,100 | | $ 4,100 | |
| **Refunds** | $ (5,401) | | $ (2,167) | | $ - | | $ (15,064) | | $ (5,000) | | $ (10,000) | |
| **Total Income** | $ 693,142 | | $ 929,533 | | $ 871,671 | | $ 710,532 | | $ 712,665 | | $ 604,100 | |
| **EXPENSES** | | | | | | | | | | | | |
| **General & Administrative** | $ 327,947 | **47%** | $ 287,151 | **31%** | $ 269,435 | **31%** | $ 318,927 | **45%** | $ 274,000 | **38%** | $ 339,422 | **56%** |
| **Market Development & Outreach** | $ 194,054 | **28%** | $ 78,832 | **8%** | $ 89,440 | **10%** | $ 83,670 | **12%** | $ 85,600 | **12%** | $ 75,500 | **12%** |
| **Laboratory Expense** | $ 230,195 | **33%** | $ 203,557 | **22%** | $ 176,313 | **20%** | $ 173,059 | **24%** | $ 165,000 | **23%** | $ 180,500 | **30%** |
| **Capital Expense** | $ - | **0%** | $ - | **0%** | $ - | **0%** | $ - | **0%** | $ 28,600 | **4%** | $ - | **0%** |
| **Research** | $ 338,811 | **49%** | $ 344,586 | **37%** | $ 284,275 | **33%** | $ 328,333 | **46%** | $ 339,000 | **48%** | $ - | **0%** |
| **Research In-Kind Expenses** | | | | | | | $ 137,500 | **19%** | | | | |
| **Other Expenses (Ex. Depreciation)** | $ 21,813 | **3%** | $ 16,765 | **2%** | $ 20,762 | **2%** | $ 17,474 | **2%** | $ 17,000 | **2%** | | |
| **Total Expenses** | $ 1,112,820 | | $ 930,891 | | $ 840,225 | | $ 1,058,963 | | $ 909,200 | | $ 595,422 | |
| **NET INCOME** | | | | | | | | | $ (196,535) | | $ 8,678 | |
| **Ending Cash Reserves** | $ 838,853 | | $ 821,628 | | $ 866,729 | | $ 661,211 | | $ 464,676 | | $ 473,354 | |

Note: Based on our Reserve Policy our year-end reserves needs to be minimum $222,985

| | ACTUAL FY 2014-2015 | ACTUAL FY 2015-2016 | ACTUAL FY 2016-2017 | ACTUAL FY 2017-2018 | PROJECTED FY 2018-2019 | PROJECTIONS FY 2019-2020 |
|---|---|---|---|---|---|---|
| Research Expenses | | | | | | |
| UC Davis Breeding Program | $ 204,000 | $ 192,000 | $ 165,000 | $ 193,750 | $ 198,000 | $ - |
| UC Davis Regional Trials | $ - | $ 133,000 | $ 119,275 | $ 134,583 | $ 137,000 | $ - |
| UCCE Grants | $ 63,254 | $ 19,586 | $ - | $ - | $ - | |
| Other Research | $ 71,557 | $ - | $ - | $ - | $ - | |
| **Total UC Davis Research** | $ 338,811 | $ 344,586 | $ 284,275 | $ 328,333 | $ 335,000 | $ - |
| **UC In-Kind Lab Research** | | | | | | |
| UC Davis Breeding Program | $ 23,250 | $ 21,780 | $ 43,800 | $ 48,200 | $ 32,250 | |
| UC Davis Regional Trials | $ 21,510 | $ 24,140 | $ 23,500 | $ 89,300 | $ 90,000 | |
| Collaborators | $ 5,280 | $ 4,860 | $ 6,100 | $ 10,450 | $ 4,900 | |
| PNW | $ 855 | $ 2,375 | $ 2,365 | $ 1,650 | $ 5,400 | |
| Organic Seed Alliance | $ 2,400 | $ - | $ - | $ - | $ - | |
| **Total In-Kind Lab Research** | $ 53,295 | $ 53,155 | $ 75,765 | $ 149,600 | $ 132,550 | $ - |

Claudia Carter 2/15/19

**Dear Research Committee,**

**Variety Survey Updates**

Based on the received VS:

Yecora Rojo is the number one planted variety of all - over 4,000 acres reported.

HW: Patwin 515 is the number one reported HW variety > 500 acres

Durum: Desert King HP > 3,000 acres so far.

USDA reported Winter wheat planted acres 330,000 and Durum 43,000 acres. After calling a few handlers, the winter wheat seems accurate (more or less), but Durum is off. Imperial will have ~10,000 and SJ ~10,000. Total durum ~20,000 acres.

The good news - because of the rain the dryland growers will have a decent crop this year – so we might see an increased in harvested acres due to this. Also, based on the growers' responses – more than 90% reported wheat planted for grain.

| 2019 | Planted* | Harvested | Yield | Production |
|---|---|---|---|---|
| Winter wheat | **330,000** | **132,000** | **2.31** | **304,920** |
| Durum | **43,000** | **15,000** | **2.85** | **42,750** |
| TOTAL | **373,000** | **147,000** | | 347,670 |
| Assessment Revenues | | | ~ | **$ 469,355** |

**As of 2/8/2019 USDA Seeding Report Report**

**Commodity Board NIFA – USDA Grants**

Several months ago, the Commission applied to become eligible to apply for the Commodity Board NIFA grant program – matching grant. The program accepts a minimum of $150,000 in funds from the Commodity Boards. UC Davis researchers help us to apply and submitted their topics and the topics were approved. The next step in this process is to review the co-funding agreement.

At the level of $150,000, the grants are highly competitive. Our researchers will send their proposals to NIFA, they will pre-select the proposals. The proposals are then sent out to us for further revision. The Commission will need to make a recommendation regarding the proposal we would like to co-fund. The problem: there is a significant chance that our proposal from UC Davis does not make it to the first round of selection. At this point, we have already committed the funds and will need to select the best proposal which aligns best with our general research objectives. I encourage you to read more about this program here:

https://nifa.usda.gov/commodity-boards-frequently-asked-questions

We will need to discuss about this at the upcoming meeting.

Sincerely,

Claudia Carter.

(Insert NIFA's Form Number Here)

NIFA Agreement No. (NIFA will provide number)

Commodity Board Agreement No. (optional, provided by board)

**CO-FUNDING AGREEMENT**
**Between The**
**CALIFORNIA WHEAT COMMISSION**
**And The**
**U.S. DEPARTMENT OF AGRICULTURE, NATIONAL INSTITUTE OF FOOD AND AGRICULTURE**

This CO-FUNDING AGREEMENT is hereby entered into by and between the California Wheat Commission (hereinafter referred to as "Commodity Board") and the United States Department of Agriculture, National Institute of Food and Agriculture (hereinafter referred to as "NIFA") under the Commodity Board-related provisions of section 2(b) of the Competitive, Special, and Facilities Research Grant Act (7 U.S.C. 3157(b)).

Title: Research on small grain management and breeding that results in small grain varieties and production systems that optimize water and nitrogen use while maintaining or increasing crop productivity and quality

**I. PURPOSE:** The purpose of this Co-funding Agreement is to document the contribution of funds from the Commodity Board to NIFA for the purpose of jointly funding awards made by NIFA under the Agriculture and Food Research Initiative Competitive Grants Program ("AFRI"), pursuant to the Commodity Board-related provisions of section 2(b) of the Competitive, Special, and Facilities Research Grant Act (7 U.S.C. 3157(b)).

Under authority provided in section 7404 of the Agricultural Act of 2014 (Pub. L. 113-79), which amended section 2(b) of the Competitive, Special, and Facilities Research Grant Act (7 U.S.C. 3157(b)), NIFA allows eligible national and state Commodity Boards to propose topics, separately or in collaboration, for AFRI research that they are willing to equally co-fund with NIFA. Such topics must relate to the established priority areas of AFRI to be considered for inclusion in future AFRI Requests for Applications (RFAs). For each topic proposed, the Commodity Board is required to include a clear description of the proposed topic, the total co-funding contribution that will be made by the Commodity Board, and a justification that describes how the proposed topic supports a specific AFRI priority area. Topics submitted by an eligible Commodity Board are then reviewed by an internal panel at NIFA based on established evaluation criteria. Submitted topics that are selected for inclusion in an RFA are known as "sponsored topics." Sponsored topics will be incorporated into the appropriate AFRI RFA, and AFRI eligible entities may compete for funding in that topic area through the AFRI competitive

review process. To be eligible to receive joint funding, applicants addressing sponsored topics will be required to submit a letter of support from the Commodity Board that proposed the topic no later than 60 days after the application deadline. If the application for a project within that topic area is selected for award by NIFA, the grant will include the NIFA contribution and the equal co-funding contribution from the Commodity Board. The topic submission and evaluation procedures are set forth in Notices published in the Federal Register. The most recent Notice was published on May 31, 2018, at 83 FR 24968. The grant application and evaluation procedures will be set forth in the applicable RFAs.

When NIFA selects a proposed topic for inclusion in an RFA, NIFA will enter into a Co-funding Agreement with the Commodity Board. If the topic has been submitted as a collaboration among eligible Commodity Boards, a lead Commodity Board will need to be identified and serve as the signatory on the Co-funding Agreement. NIFA will provide the Commodity Board with further details on the procedures and requirements associated with the contribution of funds from the Commodity Board to NIFA and confidentiality about selected RFA topics.

This Co-funding Agreement establishes the requirements for the contribution of funds from the Commodity Board to NIFA for the sponsored topic areas identified in the Financial Plan (see Section V of this Co-funding Agreement).

## II. STATEMENT OF MUTUAL BENEFIT AND INTERESTS:

**Rationale**

Decreasing availability of water alongside increasing regulation of nitrogen as an environmental pollutant require that California growers improve water and nitrogen use efficiency in their small grain crops. Therefore, new research on small grain management and breeding is required to develop and deploy new varieties with increased water and nitrogen use efficiency and establish more efficient production systems.

Nitrogen management in California grain crops is under increasing regulatory scrutiny based on recent legislative mandates in the state. In addition, winter small grain acreage has been disproportionately affected by recent drought events in the state. There is also an urgent need to address decreased crop water and nitrogen availability through coordinated breeding and agronomic research that pinpoints genotypes, genes and management practices to improve crop water and nitrogen use efficiency in the state.

Funding for these efforts would fall within the AFRI Sustainable Agricultural Systems Program, which lists the optimization of water and nitrogen as priorities. In addition, the Critical Agricultural Research and Extension (CARE) program within the AFRI Foundational and Applied Science Program would be an appropriate target for these matching funds as CARE intends to create solutions to pressing needs of agricultural producers.

(Insert NIFA's Form Number Here)

**Topic Priority for inclusion in the Plant Breeding for Agricultural Production (program code A1141) program area within the FY 2019 AFRI Foundational and Applied Science RFA:**

**Commented [KO_N1]:** If the co-funding amount changes to $150,000, then the program will be the Critical Agricultural Research and Extension (CARE) program (code A1701).

"Research on small grain management and breeding that results in small grain varieties and production systems that optimize water and nitrogen use while maintaining or increasing crop productivity and quality."

NIFA provides leadership and funding for programs that advance agriculture-related sciences. NIFA invests in and supports initiatives that ensure the long-term viability of agriculture. Since the Food, Conservation, and Energy Act of 2008 (Pub. L. 110-246) authorized its creation, NIFA has taken significant strides toward enhancing the impact of food, agriculture, natural resources, and human sciences. NIFA applies an *integrated approach* to ensure that groundbreaking discoveries in agriculture-related sciences and technologies reach the people who can put them into practice. NIFA collaborates with leading scientists, policymakers, experts, and educators in organizations throughout the world to find innovative solutions to the most pressing local and global problems. Scientific progress, made through discovery and application:

- Advances the competitiveness of American agriculture.
- Bolsters the U.S. economy.
- Enhances the safety of the nation's food supply.
- Improves the nutrition and well-being of American citizens.
- Sustains natural resources and the environment.
- Builds energy independence.

All NIFA AFRI awards that include Commodity Board funds are subject to, *inter alia*, 7 U.S.C. 3157(b), 2 C.F.R. Part 200, 7 C.F.R. Part 3430, other applicable administrative and policy requirements, NIFA award general terms and conditions, as well as the NIFA administrative grants process (see http://nifa.usda.gov/grants).

Both NIFA and the Commodity Board have an interest in pursuing topics that further NIFA's AFRI program and the Commodity Board's research goals and targets, and when agreed to, jointly funding projects that further that aim.

In consideration of the above premises, the parties agree as follows:

## III. COMMODITY BOARD PROVISIONS:

A. The Commodity Board, or in the case of a collaboration between two or more Commodity Boards, the lead Commodity Board, has the legal authority to enter into this Co-funding Agreement. The term Commodity Board in this Co-funding Agreement refers to the Commodity Board or the lead Commodity Board contributing funds to the sponsored AFRI topics identified in Section V of this Co-funding Agreement.

B. The Commodity Board will comply with all applicable legal requirements, including, but not limited to, the terms and conditions in this Co-funding Agreement.

C. The Commodity Board will, within 14 days of the effective date of this Co-funding Agreement, establish an Escrow Account and deposit into the Escrow Account the amount(s) identified in the Financial Plan for each sponsored topic (see Section V of this Co-funding Agreement). NIFA does not have specific requirements for the structure or location of the Escrow Account.

D. The Commodity Board will hold the funds in the Escrow Account until the funds are moved for deposit in a U.S. Treasury Deposit Fund Account at the National Finance Center (NFC) or the funds are withdrawn by the Commodity Board, in accordance with the following procedures:

(1) If the Commodity Board receives a Bill for Collection (Bill) for a sponsored topic identified in the Financial Plan (see Section V of this Co-funding Agreement), the Commodity Board will, within 5 days of receipt of such Bill, send payment for the amount of funds identified in the Bill for Collection to the National Finance Center for deposit into the NIFA Deposit Fund Account established at the U.S. Treasury. If the amount of funds identified in the Bill is less than the amount of funds listed for that sponsored topic in Section V of this Co-funding Agreement, then the Commodity Board may withdraw those excess funds from the Escrow Account. Such withdrawn funds will revert to the Commodity Board and no longer be subject to the terms of this Co-funding Agreement.

(2) If the Commodity Board receives a Notification from NIFA that no application for a sponsored topic identified in the Financial Plan (see Section V of this Co-funding Agreement) has been selected for award by NIFA, then the Commodity Board may withdraw from the Escrow Account all funds listed for that sponsored topic in Section V of this Co-funding Agreement. Such withdrawn funds will no longer be subject to the terms of this Co-funding Agreement. The Commodity Board will maintain a balance in the Escrow Account sufficient to support all remaining topics where a final decision of award has not been made by NIFA.

E. The Commodity Board must contribute a minimum of $150,000 but may not exceed the maximum of $2.5 million, for each sponsored topic. In no case may the Commodity Board provide more than $10 million in any year for all sponsored topics.

F. The Commodity Board will respond to requests from AFRI applicants for letters of support in a timely fashion. These letters will be due to NIFA within 60 days of the application deadline, so it is incumbent on the Commodity Board, if they receive such requests, to either provide a letter of support to the applicant that specifically states that the Commodity Board supports the application for co-funding, or notify the applicant in writing that the Commodity Board declines to provide a letter of support.

G. As part of this agreement, the Commodity Board does not share in any grant management role or responsibility, including, but not limited to, proposal selection, funding amounts, monitoring and evaluating, grant policy and management decisions, reporting, and payments.

H. Because this agreement is pursuant to a competitive grant process, the Commodity Board agrees not to disclose sponsored topics or the Commodity Board contribution amounts reflected in the Financial Plan (see Section V of this Co-funding Agreement), to potential applicants for AFRI grants prior to NIFA releasing Requests for Applications that include such topics, except where required by law. In addition, the Commodity Board agrees not to disclose information regarding potential jointly funded projects, prior to NIFA announcing awards.

I. Grants that are jointly funded by NIFA and the Commodity Board will be subject to the Intangible Property provisions of 2 C.F.R. § 200.315 and the applicable regulations governing patents and inventions, including Government wide regulations issued by the Department of Commerce at 37 CFR Part 401, "Rights to Inventions Made by Nonprofit Organizations and Small Business Firms Under Government Awards, Contracts and Cooperative Agreements."

## IV. NIFA PROVISIONS:

A. NIFA will comply with all applicable legal requirements in administering this Co-funding Agreement.

B. NIFA will identify in the Financial Plan (see Section V of this Co-funding Agreement) each topic that is suggested by the Commodity Board and approved by NIFA for inclusion in an RFA ("sponsored topic").

C. NIFA will use the following process for incorporating sponsored topics into the current AFRI framework.

(1) If a topic (funding idea) suggested by the Commodity Board is accepted by NIFA, NIFA will incorporate the sponsored topic as a distinctly marked part of the most relevant priority area in the appropriate AFRI RFA.

(2) Eligible applicants wishing to submit an application for joint AFRI/Commodity Board funding for a project on the sponsored topic will be required to obtain a letter of support from the co-funding Commodity Board. NIFA will not consider an application for joint AFRI/Commodity Board funding unless the applicant submits a letter of support from the Commodity Board within 60 days of the application deadline. The applications submitted in response to the Commodity Board-supported topic will compete against all proposals submitted in the same RFA priority area. Supported applications will receive no preference regarding the evaluation of their scientific merit; letters of Commodity Board support will be used by NIFA solely to determine that the application fits within the Commodity Board-supported topic and that the Commodity Board is willing to co-fund that application if it is evaluated by the NIFA review panel as being meritorious and ranked within the funding range. NIFA may incorporate sponsored topics from other Commodity Boards into the same AFRI RFA and priority area as the sponsored topic of the Commodity Board.

D. NIFA will use the following procedures for the handling and disposition of funds contributed by the Commodity Board under this Co-funding Agreement:

(1) NIFA has established a Deposit Fund in the U.S. Treasury for purposes of receiving funds deposited by Commodity Boards for the purpose of co-funding AFRI awards.

(2) If an AFRI grant application for joint NIFA/Commodity Board funding for a sponsored topic identified in the Financial Plan (see Section V of this Co-funding Agreement) is selected for award by NIFA, NIFA will send a Bill for Collection to the Commodity Board (see Section III.D.1 of this Co-funding Agreement), or in the case of a collaboration, the lead Commodity Board.

(i) Up to 4% of funds contributed by the Commodity Board may be used by NIFA to pay for grant administration expenses.

(ii) Within 5 days of receiving the Bill, the Commodity Board must transfer from the Escrow Account to the Deposit Fund Account established for NIFA in the U.S. Treasury, the amount referred to in Part V below. Detailed instructions on the process for transferring these funds will be provided as an attachment to the Bill.

(iii) Such amounts transferred from the Commodity Board to NIFA will be deposited by the National Finance Center (NFC) into the NIFA Deposit Fund Account and will remain available for obligation and expenditure by NIFA in accordance with the provisions of section 2(b) of the Competitive, Special, and Facilities Research Grant Act (7 U.S.C. 3157(b)), the terms of this Co-funding Agreement, and other applicable laws and regulations.

(iv) The period of funding for the AFRI awards will not exceed the period of performance of this Co-funding Agreement. NIFA will notify the Commodity Board of any co-funded AFRI awards that are extended beyond a 3-year period of performance.

(v) NIFA will provide co-funding from the AFRI program equal to the amounts contributed by the Commodity Boards.

(3) If no application for joint NIFA/Commodity Board funding for a sponsored topic identified in the Financial Plan (see Section V of this Co-funding Agreement) is selected for award by NIFA, NIFA will send a Notification to the Commodity Board (see Section III.D.2 of this Co-funding Agreement), or in the case of a collaboration, to the lead Commodity Board.

(4) Billings and Notifications shall be sent to:
Claudia Carter
1240 Commerce Ave, Suite A
Woodland, CA 95776
Commodity Board Tax ID Number: 68-0022557
Or by email to the following address: carter@californiawheat.org

E. NIFA may establish a minimum and maximum amount for Commodity Board co-funding. For FY 2019, for each sponsored topic, the minimum amount the Commodity Board may contribute is $150,000 and the maximum amount is $2.5 million total. For all sponsored topics by the Commodity Board, NIFA will not match contributed funding in excess of $10 million per year.

F. NIFA may monitor several metrics to gauge the impact of implementation of the Commodity Board-related provisions of section 2(b) of the Competitive, Special, and Facilities Research Grant Act (7 U.S.C. 3157(b)). Those metrics may include:

(1) The topics submitted by Commodity Boards.

(2) The topics accepted by NIFA and included in AFRI RFAs (sponsored topics).

(3) The number of grant applications submitted for sponsored topics.

(4) The number of grants awarded for sponsored topics.

(5) Other metrics as determined by NIFA.

G. Funds transferred by the Commodity Board from the Escrow Account to the NIFA Deposit Fund Account in support of sponsored projects are subject to the following requirements:

(1) Such funds shall be available to NIFA for obligation and remain available until expended for the purpose of making grants under paragraph (6)(E) of section 2(b) of the Competitive, Special, and Facilities Research Grant Act (7 U.S.C. 3157(b)(9)(B)(ii)(I)) for the sponsored topic selected for funding.

(2) Of such funds, NIFA may use four percent (4%) for grant administration (7 U.S.C. 3157(b)(9)(B)(ii)(II)).

(3) Such funds may be used only to fund AFRI grants for projects to carry out that sponsored topic (7 U.S.C. 3157(b)(9)(B)(ii)(III)).

(4) Such funds that remain unobligated at the time of grant closeout shall be returned to the Deposit Fund and made available to be withdrawn by the Commodity Board (7 U.S.C. 3157(b)(9)(B)(ii)(IV)).

(5) Awardees will be authorized to use such funds for the indirect costs of the award, subject to the same indirect cost rate limitations applicable to the funds appropriated by Congress to NIFA to carry out AFRI (7 U.S.C. 3157(b)(9)(B)(ii)(V)).

H. Awardee will not be required to provide performance reports associated with carrying out this Co-funding Agreement to the Commodity Board; however, the Commodity Board may track activities at http://www.usaspending.gov.

I. NIFA will provide to the Commodity Board, or in the case of a collaboration, to the lead Commodity Board, a Bill for Collection which will include award amount to be co-funded by the Commodity Board.

J. NIFA is solely responsible for the grant administration of all co-funded AFRI awards.

## V. FINANCIAL PLAN

| (a) Sponsored Topic(s) | (b) Contribution(s) ($) |
|---|---|
| Research on small grain management and breeding that results in small grain varieties and production systems that optimize water and nitrogen use while maintaining or increasing crop productivity and quality | |
| Commodity Board Contribution | $250,000 |
| Administrative Costs | -$10,000 |
| NIFA Contribution | $250,000 |
| | |
| Total | $490,000 |

**Commented [KO_N2]:** These amounts will be updated if the board switches co-funding amounts.

**Of the total contributed by the Commodity Board, up to 4% may be used by NIFA to support grant administration. NIFA will provide the full contribution amount to co-fund grant awards, up to the total amount contributed by the Commodity Board.**

## VI. IT IS MUTUALLY AGREED AND UNDERSTOOD BY AND BETWEEN THE PARTIES THAT:

A. PRINCIPAL CONTACTS. Individuals listed below are authorized to act in their respective areas for matters related to this Co-funding Agreement.

**Principal Commodity Board Contacts:**

| Commodity Board Program Contact | Commodity Board Administrative Contact |
|---|---|
| Name: Claudia Carter<br>Address: 1240 Commerce Ave, Suite A<br>City, State, Zip: Woodland, CA 95776<br>Telephone: 530-661-1292<br>FAX:<br>Email: carter@californiawheat.org | Name: Claudia Carter<br>Address: 1240 Commerce Ave, Suite A<br>City, State, Zip: Woodland, CA 95776<br>Telephone: 530-661-1292<br>FAX:<br>Email: carter@californiawheat.org |

**Principal NIFA Contacts:**

| NIFA Program Contact | NIFA Administrative Contact |
|---|---|
| Name: Mark A. Mirando, Ph.D.<br>Address: 800 9th St., SW<br>City, State, Zip: Washington, DC 20024<br>Telephone: (202) 401-4336<br>FAX: (202) 401-6071<br>Email: commodityboards@nifa.usda.gov | Name: Mfon Umoh<br>Address: 800 9th St., SW<br>City, State, Zip: Washington, DC 20024<br>Telephone: (202) 401-5042<br>FAX: (202) 401-4381<br>Email: mfon.umoh@nifa.usda.gov |

B. NON-LIABILITY. NIFA will not be liable to the Commodity Board or third parties for any damages incident to the performance of this Co-funding Agreement, except when permitted by law.

C. REFUNDS. Funds contributed to NIFA under this Co-funding Agreement that are not obligated and expended by NIFA for grants for projects in the sponsored topics identified in the Financial Plan (see Section V of this Co-funding Agreement) will be refunded to the Commodity Board. NIFA will provide the Commodity Board with further details on requirements associated with accessing refunds, which may include the Commodity Board having a Data Universal Numbering System (DUNS) number and an active registration in the Central Contractor Registry (CCR).

D. FREEDOM OF INFORMATION ACT (FOIA). This Co-funding Agreement and any related AFRI grant agreements are subject to the Freedom of Information Act (FOIA).

E. PARTICIPATION IN SIMILAR ACTIVITIES. This Co-funding Agreement in no way restricts NIFA or the Commodity Board from participating in similar activities with other public or private agencies, organizations, and individuals.

F. ENDORSEMENT. Any Commodity Board contributions made under this Co-funding Agreement do not by direct reference or implication convey NIFA endorsement of the Commodity Board's products or activities.

G. NOTICES. Any communication between NIFA and the Commodity Board, or notices given by one party to the other, in connection with this Co-funding Agreement will be sufficient only if in writing and delivered in person, mailed, or transmitted electronically by e-mail or fax, as follows:

To NIFA Program Contact and NIFA Administrative Contact, at the addresses specified in Part VI. of this Co-funding Agreement.

To Commodity Board Program Contact and Program Administrative Contact, at the Commodity Board's addresses specified in this Co-funding Agreement.

H. NIFA ACKNOWLEDGED IN PUBLICATIONS, AUDIOVISUALS, AND ELECTRONIC MEDIA. Proper acknowledgment of NIFA co-funding in published manuscripts, presentations, press releases, and other communications is critical for the success of NIFA's programs. This includes proper acknowledgment of the program and agency, as well as the Department and, as appropriate, the grant number. The Commodity Board will use the following language to acknowledge work that is done with partial support from NIFA, as appropriate:

"This project was supported by Agriculture and Food Research Initiative Competitive Grant no. XXX-XXXXX-XXXXX co-funded by the USDA National Institute of Food and Agriculture and the California Wheat Commission."

I. TERMINATION OF CO-FUNDING AGREEMENT. NIFA may terminate, in writing, this agreement in whole, or in part, at any time before the date of expiration. Excess funds will be refunded within 60 days after the effective termination date. Due to the financial commitments NIFA will be making upon receiving funds from the Commodity Board, the Commodity Board may terminate this agreement only with the prior written consent of NIFA. The termination of the agreement shall not terminate the grant applications that have been approved for funding.

J. DEBARMENT AND SUSPENSION. The Commodity Board will immediately inform NIFA if it or any of its principals are presently excluded, debarred, or suspended from entering into covered transactions with the Federal Government according to the terms of 2 CFR Part 417 and Part 180. Additionally, should the Commodity Board or any of its principals receive a transmittal letter or other official Federal notice of exclusion, debarment, or suspension, they will notify NIFA without undue delay. This applies whether the exclusion, debarment, or suspension is voluntary or involuntary.

K. MODIFICATIONS. Modifications within the scope of this Co-funding Agreement will be made by mutual consent of the parties, by the issuance of a written modification signed and dated by all properly authorized, signatory officials, prior to any changes being performed. Requests for modification should be made, in writing, at least 30 days prior to implementation of the requested change.

L. COMMENCEMENT/EXPIRATION DATE. This Co-funding Agreement is executed as of the date of the last signature and is effective through [INSERT END DATE, USUALLY 7 YEARS AFTER AWARDS WILL BE ISSUED] at which time it will expire, unless extended by an executed modification, signed and dated by all properly authorized, signatory officials.

M. AUTHORIZED REPRESENTATIVES. By signature below, each party certifies that the individuals listed in this Co-funding Agreement as representatives of the individual parties are authorized to act in their respective areas for matters related to this Co-funding Agreement. In witness whereof, the parties hereto have executed this Co-funding Agreement as of the last date written below.

| | |
|---|---|
| Claudia Carter, Executive Director<br>California Wheat Commission | Date |
| J. Scott Angle, Director<br>National Institute of Food and Agriculture | Date |