Integrated Crop Pollination Bridging Funds

Project No.: **13-POLL13-Williams**

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Objectives:

To gain a better understanding of the scale, configuration, and economic costs and benefits of creating bee forage habitat in almond orchards. Specifically we will (1) determine establishment success of forage plantings in different locations in and adjacent to orchards; (2) test three specific bee forage mixes in one setting; (3) evaluate forage plant success and bloom timing in the orchard setting; (4) determine if these forage resources compete via honey bee visitation with almond pollination when plantings and orchards co-flower; and (5) assess the cost of such plantings. UC Davis portion of the project will be carried out in southern area Paramount Farming Westside area.

Interpretive Summary:

- Drought conditions and unusually cold temperatures in winter 2013-14 suggest caution in interpreting results from this season. Timing and performance of all mixes was substantially delayed and reduced from expectation.
- Despite difficulties with establishing plantings due to drought and unusually cold temperatures in winter 2013-2014, all seed mixes provided some bloom. Border plantings strongly out-performed within-orchard plantings in terms of establishment success and floral display. This planting design is also likely to be most compatible with existing orchard management practices.
- Unusual timing of bloom and the failure of Great Valley phacelia (which in previous trials has been the earliest and most honey-bee attractive wildflower) to establish in the wildflower mix make comparisons among seed mixes difficult to interpret.
- Mustard was very attractive to honey bees for a brief window, but at times the wildflower mix was most attractive despite a smaller floral display.
- Proper weed management is critical to establishment of most tested seed mixes.

- We found no evidence for competition with forage plots for almond pollination, but forage bloom times were unusually late and largely non-overlapping with almond.
- Cost analysis of operations is ongoing.

Materials and Methods:

Objective 1

To determine establishment success of forage plants in different orchard locations we focused on a single native wildflower mix consisting of early-flowering native annual forbs (non-woody species) that were selected based on their bloom time and performance during two seasons of preliminary trials near Modesto and Lost Hills, CA (**Table 1**). The mix was sown and some species plug planted in three test configurations: (A) in a border strip outside, but adjacent to the orchard block, (B) along one orchard row, and (C) at the ends of alternating rows abutting the beeways (**Figure 1**). The border planting of the wildflower mix ran the length of one block (approx. 640 ft long x 16 ft wide). The within row planting ran 640 ft x 6 ft (along the row from beeway to beeway). The row-end planting consisted of twenty 6 ft x 9 ft patches tucked each within the spray range of a micro- sprinkler. The location of the plantings was assessed for ability to irrigate on a timely basis, and for how plantings are damaged by field equipment used for required orchard management from time of planting through time when bees are in flight.

Table 1. Wildflower seed mix tested in border, in-row and end-row plantings for Objective 1, and additional forage mixes tested in Objective 2.

Wildflower seed mix	PAm* mustard mix	PAm* Capay clover mix	Wildflower plugs
Baby blue eyes California blue bells California poppy** Chinese houses Five spot Great Valley phacelia Lacy leaf Phacelia	Braco white mustard Canola Daikon radish Nemfix mustard	Alyssum Crimson clover Frontier balansa clover Hykon rose clover Nitro Persian clover	Chinese houses Lacy leaf phacelia

* Project Apis m. (PAm)

**California poppy was excluded from within-orchard plantings to avoid pesticide exposure to bees when orchards are sprayed with pesticides after almond bloom

To prepare the plots for seeding the border strip outside the orchard (A) was disked, and in-row (B) and end-row (C) planting areas were hand-raked the first week of October, 2013. The border strip and end-row areas were then irrigated by overhead spray to initiate weed germination. In-row plantings were not watered because irrigation of the orchard trees does not reach the whole orchard floor.

During the last week of October, germinating weeds were sprayed with glyphosate, the border planting area was re-disked and the border planting and end-row plots were irrigated a second time. By November 12 no additional weeds had germinated so no further herbicide sprays were conducted. The wildflower mix was sown in the border and in-row planting areas on November 19 with a Brillion Sure Stand 558 seeder. End-row plots were hand-sown on the same day.

Due to severe drought conditions in the winter of 2013/2014 the border planting and end-row plantings were overhead-watered weekly. Germination and subsequent onset of bloom were delayed by frosts. In order to ensure the presence of bloom an additional 16 ft x 640 ft plot of was planted with nursery plugs of Phacelia tanacetifolia and Collinsia heterophylla.

Weed pressure was unusually high in the border planting area because the area had not received weed treatment in previous years. A hand crew removed weedy black mustard that was crowding out the native wildflower mix on March 5, 2014.

Objective 2

In addition to the wildflower mix, we tested two honey bee-focused forage mixes (a mustard mix and a clover mix, both developed by Project Apis m, in the A location only). This allowed us to compare bloom phenologies of these mixes with the wildflower mix. Each mix was sown in a 16 ft x 640 ft strip adjacent to the wildflower strip in location A (**Figure 1**). The site preparation, seeding methodology, and seeding date for these plots mirrored those for the wildflower border planting. The clover plot was weeded for black mustard the same day as the native wildflower planting.

Objective 3

Beginning February 25 at the onset of bloom of the forage plantings, we carried out bi-weekly observations of floral area (number of flowers x corolla area per flower) in all plots within and adjacent to the orchard to assess overall performance and bloom phenology. These observations also allowed us to assess overlap of bloom in the mixes with that of the almond orchards. On these same dates we also monitored honey bee and wild bee visitation to each mix and to an unenhanced control area using standardized timed samples. This allowed us to assess mixes' function in providing pollinator forage.

Objective 4

In order to assess competition for bee visits between forage plantings and almond, we made timed observations of bee visitation to marked branches of blooming almond trees at 0 and 50 m into the orchard at locations adjacent to plantings paired with adjacent control blocks with no forage plantings. At each distance from the orchard edge, we assessed the proportion of open almond flowers that were visited by honey bees during two minute observations per tree on 30 trees at each distance, during two samples a week apart.

Objective 5

To make an economic assessment of the input versus the gains of habitat enhancement, we collected data on costs of seeds, hardware, equipment, and labor throughout the year. Such economic assessment represents part of the ongoing Specialty Crop project and will involve collaboration with Dr. Karen Klonsky (UC Davis).

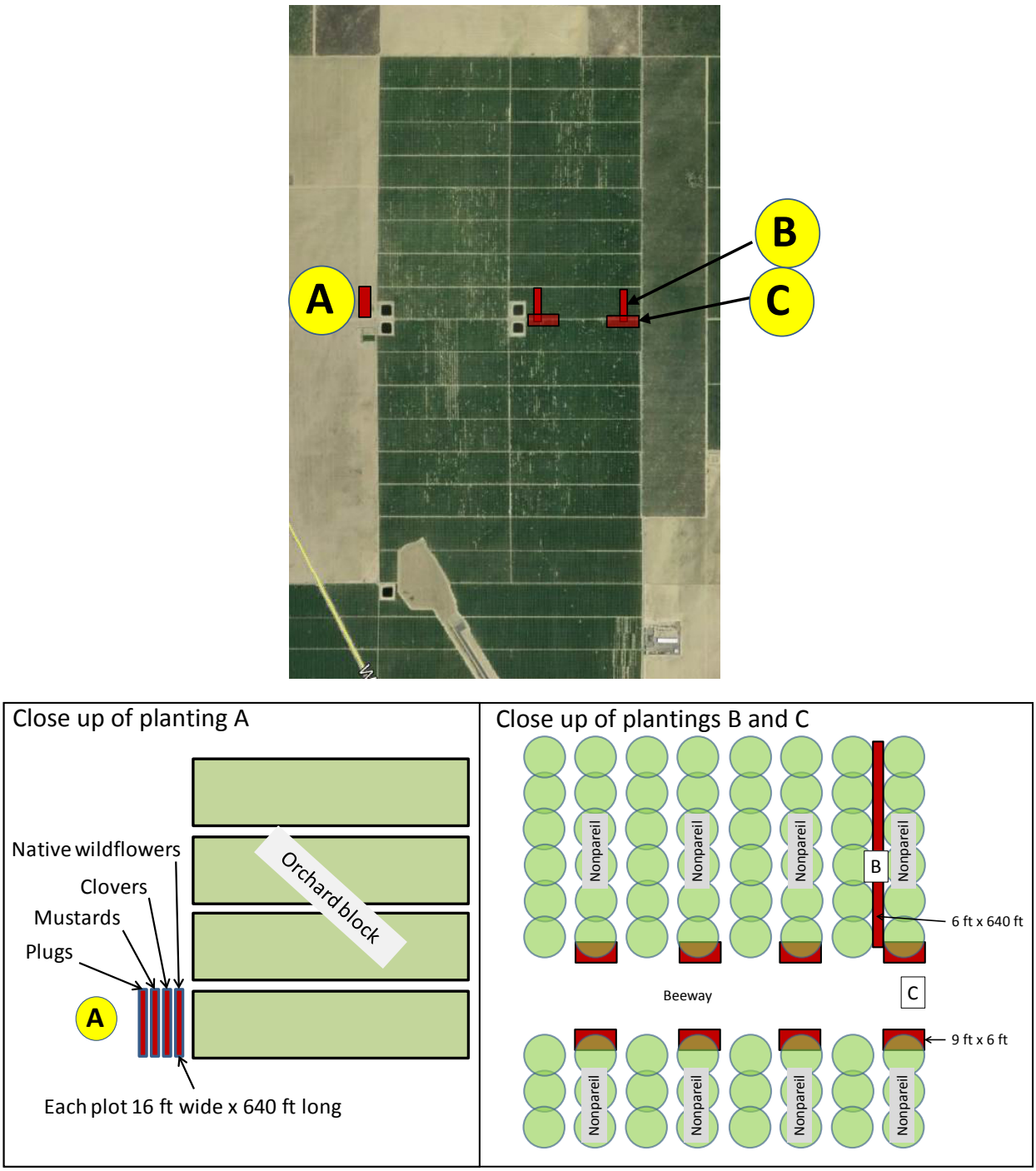

Figure 1. Layout for three pollinator test plantings. A. Border strips B. Between-row planting, C. row-end planting. B and C are planting within 1 section of a block, where C is on north and south sides of the beeway and B runs on section from beeway to beeway in a single row.

Results and Discussion:

Objective 1

Location of forage planting strongly influenced establishment of wildflower plots (**Figure 2**), with the border planting providing between 58 and 135 times more floral resources per given area than the within-orchard plantings. Contributing factors to this difference include the unusually low rainfall and inability to irrigate the in-row plantings, vole damage in the end-row plantings, and we suspect severe soil compaction in both within-orchard planting designs.

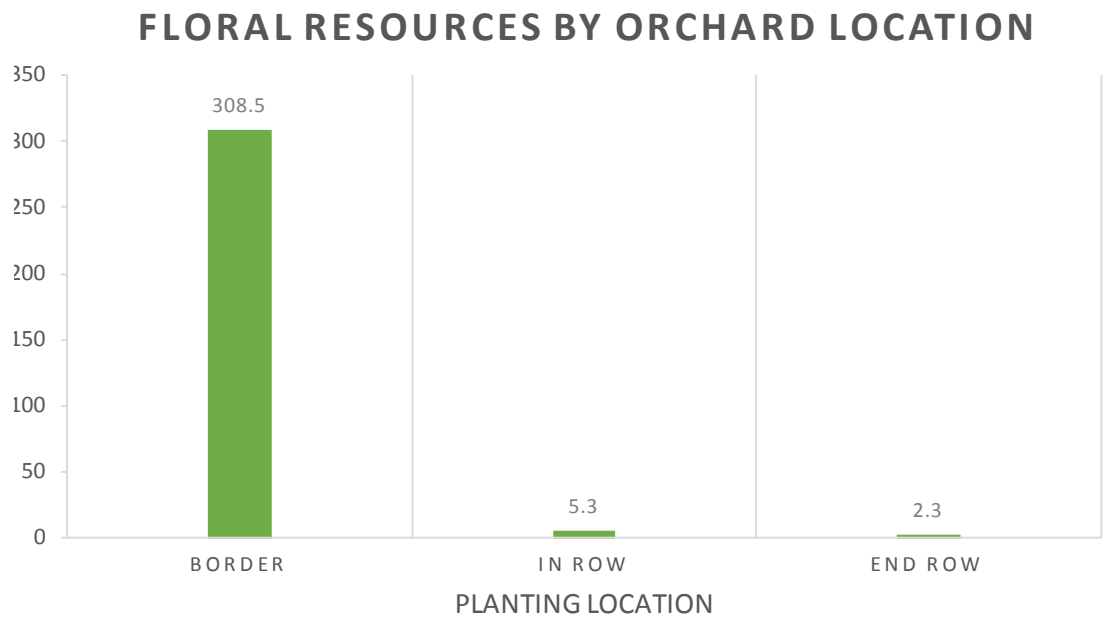

Figure 2. Season-long average floral area per square meter provided by the native wildflower mix planted on the border adjacent to the almond orchard, as a strip within the orchard rows, or in small plots at the ends of orchard rows. Floral area was assessed for planted species only.

Objective 2

Onset of bloom in all plantings was delayed by frosts so no forage mixes flowered prior to almond bloom in 2014 (**Figure 2**). This differs from a previous trial in 2013 where the same wildflower mix began flowering before almond.

The earliest-blooming wildflower, Great Valley phacelia, did not establish in this trial, either because of poor seed quality, suppression by weeds, intolerance of the drought and cold or incompatibility with site conditions. Despite the absence of this species, the wildflower mix provided consistent bloom for three months until the end of the sampling period. The clover mix provided similarly sustained bloom.

The mustard mix provided the greatest floral area during a single sample period, although its bloom duration was relatively short in comparison to native wildflowers and clovers. Severe weed pressure limited establishment and reduced floral resources provided by the wildflower and clover mixes as well as by the plug-planted wildflowers, while the mustard mix competed well with weeds.

Bloom of the plug-planted wildflowers peaked in early May. The late flowering likely resulted from the late planting date, as these plants were added to the study late in an attempt to ensure bloom when the seeded plots appeared to be delayed.

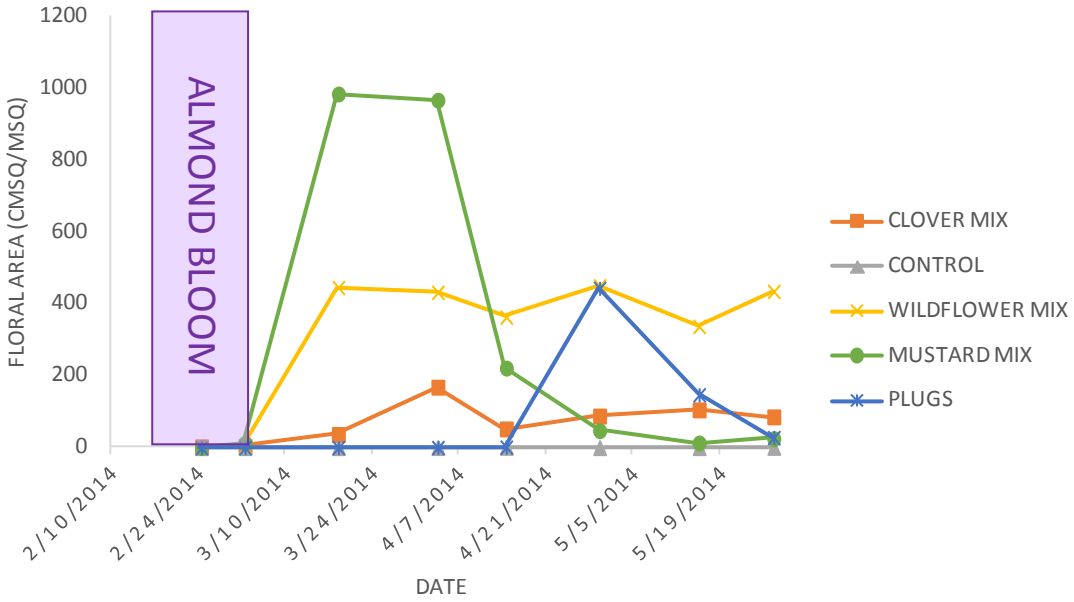

Figure 2. Floral area of planted species only (weeds excluded) in border plantings, and the control (including weeds) in relation to almond bloom and throughout the flowering season.

Objective 3

Honey bees and wild bees differed in their attraction to the four border seed mixes (**Figure 3**). Honey bees were strongly drawn to the mustard mix, but only for one of the eight samples, and the wildflower mix attracted more honey bees than mustard on the April 7 sample even though mustard had higher floral resources at that time (**Figure 2**). The clover mix attracted honey bees consistently for over a month, but this did not begin until nearly two months after almond bloom. The plug planting of lacy-leaf phacelia and Chinese houses was quite attractive to honey bees, but similar to mustard, this combination of species provides only a brief pulse of resources.

Wild bees appeared to prefer the wildflower mix and wildflower plug planting. The extremely low number of wild bees observed in the landscape of these plantings makes robust assessments of wild bee preference difficult.

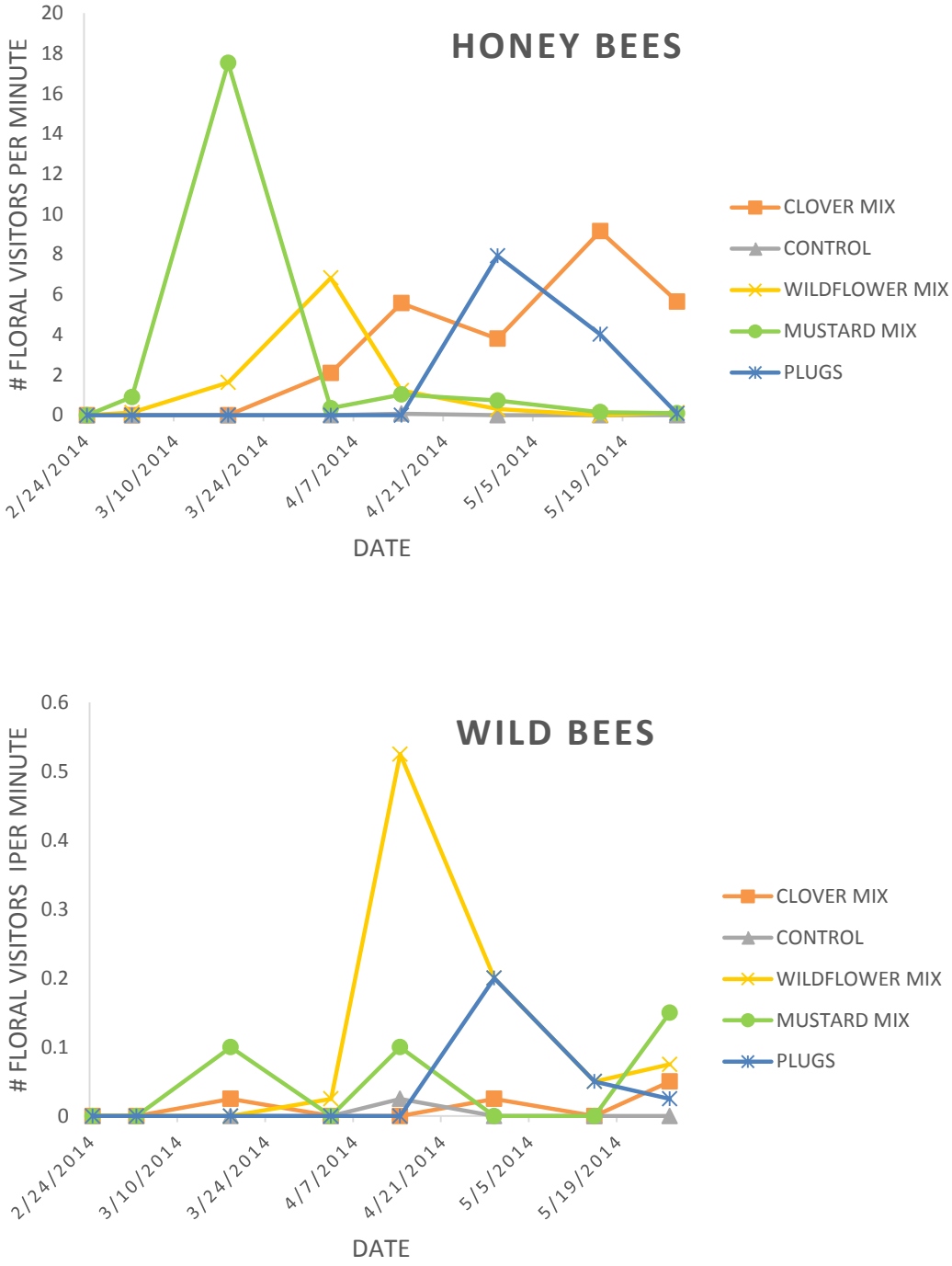

Figure 3. Abundance of honey bees and wild bees sampled per minute in each plot of the border planting throughout the spring of 2014.

Objective 4

Forage plots on the border of the almond orchard did not begin blooming until almond bloom was approximately 80% complete, but the overlap allowed us to assess honey bee visitation rates to the crop for evidence of competition from forage plots. We found no evidence for competition, even in the later sample when there were fewer almond flowers to attract bees because on average trees had only 4% bloom remaining. Importantly, in this cold dry year, bloom was just initiating in the border forage plots on these dates and may be earlier in other seasons (**Figure 4**). Further assessments for competition should be conducted in a more typical year when forage bloom overlaps with almond more completely.

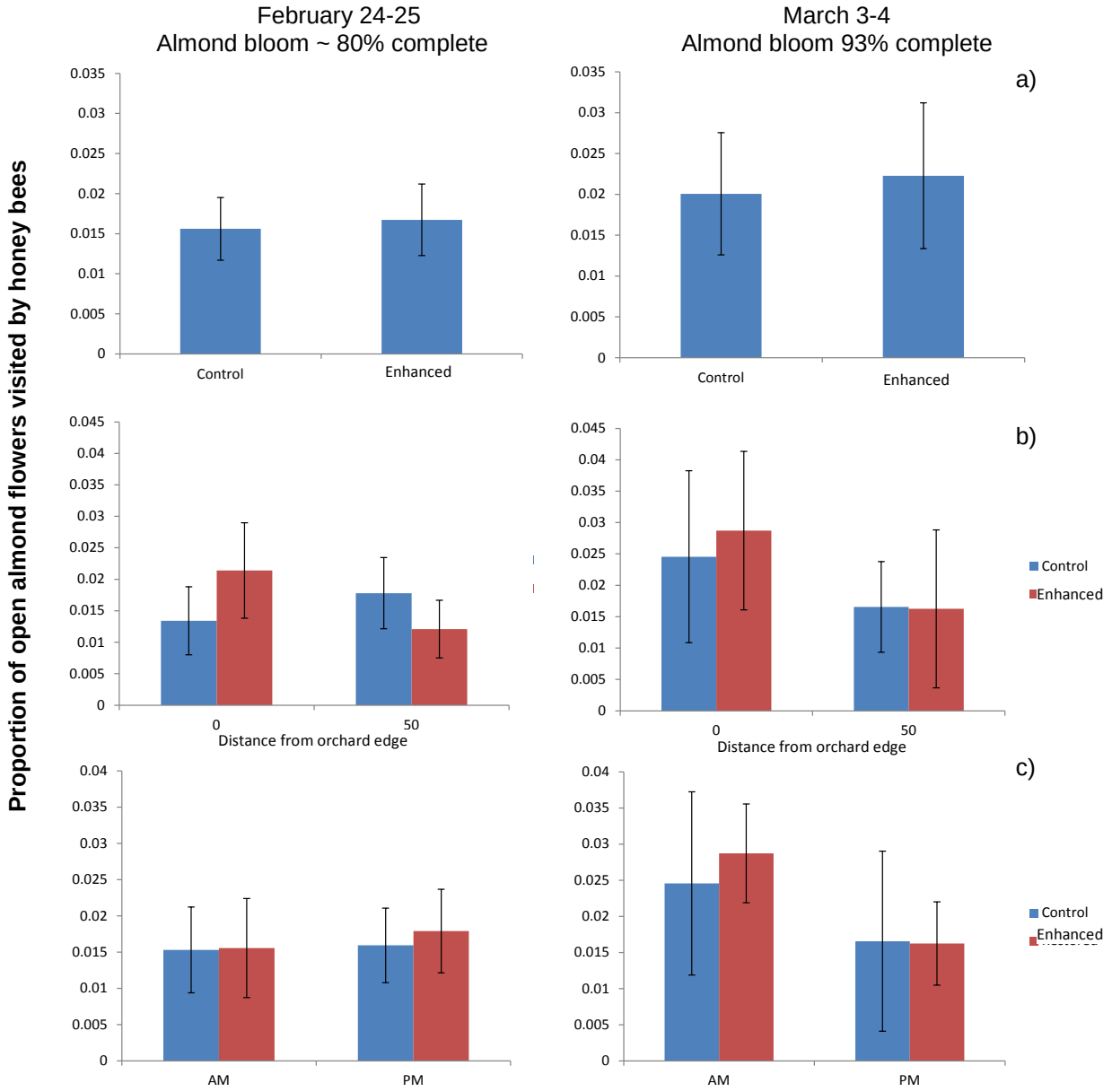

Figure 4. Proportion of open almond flowers visited by honey bees during two minute observations per tree on 30 trees at each distance from the orchard edge, within an orchard enhanced with a border wildflower planting and a nearby unenhanced control orchard.

Objective 5

Labor and equipment inputs for site preparation, planting, and maintenance including weed control and irrigation have been recorded and will be incorporated into the ongoing economic assessment as part of the Specialty Crop project.

Research Effort Recent Publications:

None.

References Cited:

None.