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In This Issue

Submitted by:
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Project Summary: The Effect of Almond Shell Mulch Application on Established Alfalfa Fields

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Project Overview:

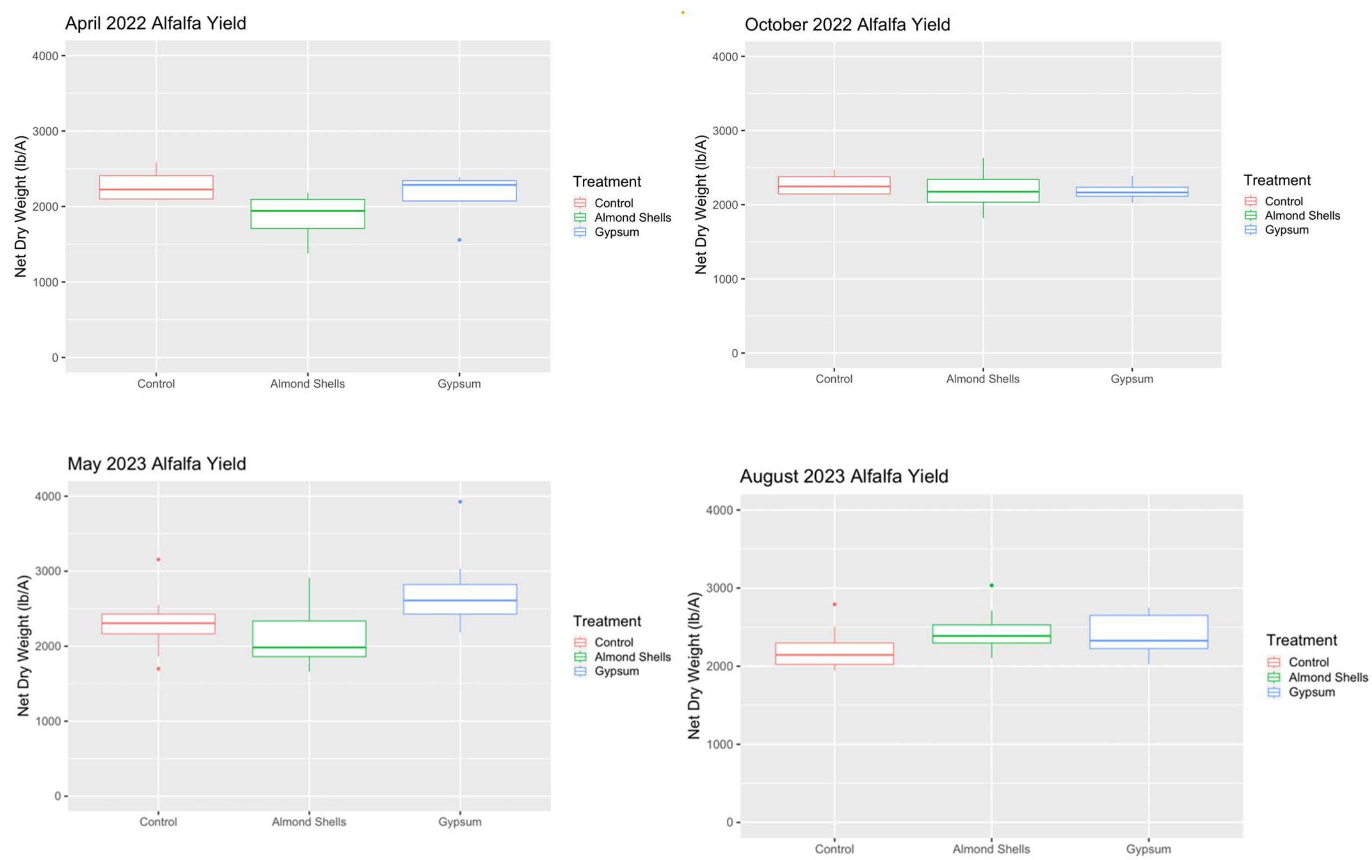
Almond shells were applied to an established alfalfa stand in Yolo County over two years. The intent of the study was to see if alfalfa could serve as a sink for almond shell byproducts after processing, without affecting stand productivity. Alfalfa is deep rooted and fixes nitrogen, which may allow for application of high carbon materials like almond shells.

Picture 1: Spreading almond shells

The first year, shells were applied in October 2021 to a three-year-old stand at 4-8 tons per acre. By spring 2022, almond shells were hardly visible in treatment areas. Almond shells were applied to the same plots in November 2022 at a rate of 12.5 tons of almond shells per acre. Additional treatments included gypsum application (2 tons/acre for both years) and an untreated control. In addition to multiple yield measurements per season, plots were evaluated for stand vigor, as well as percent cover (bare soil, alfalfa, weeds), and weed pressure. Soil fertility and soil health measurements (such as aggregate stability, compaction, soil moisture, and soil cracking) were collected during this trial.

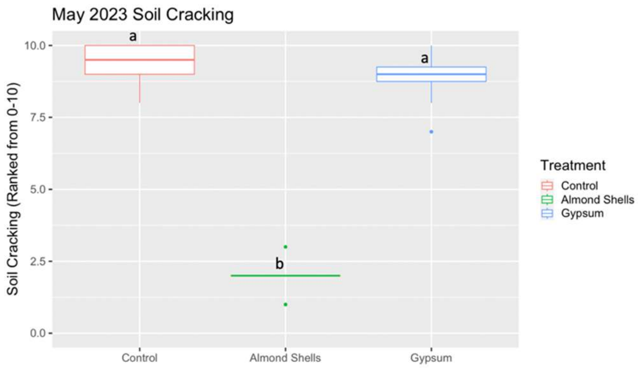
Picture 2: Almond shell cover shortly after application.

Results: Letters above treatment means indicate that differences were statistically significant (P=0.05). Almond shell application did not reduce stand vigor as measured by the number of plants per square foot. Alfalfa yields trended lower in almond shell plots for the first cutting of the spring (Figures 1 and 3) and then evened out and were slightly higher than control plots in late summer (Figures 2 and 4). There were no statistically significant differences (P=0.05) in yield at any date though seasonal trends were consistent in both trial years. Almond shells are high in carbon and low in nitrogen (high C:N). Amendments with a high C:N ratio can tie up nitrogen as they break down. This slight reduction in spring yields may be due to initial spring tie up of nitrogen for feeder roots after almond shell application.



Figures 1-4. Alfalfa yields trended slightly lower in the springtime followed by increased yields in midsummer where almond shells were applied to established alfalfa stands the previous fall in both 2022 and 2023 (both years of data shown).

No differences in weed pressure were seen after two years of almond shell application. Regarding soil health metrics, almond shell application reduced soil cracking (Figure 5) and soil compaction in the top three inches of soil (Figure 6). Soil cracking is common in clay heavy soils and can tear feeder roots in perennial crops like alfalfa. There were no changes to other soil health metrics like aggregate stability and bulk density after two years of this trial.



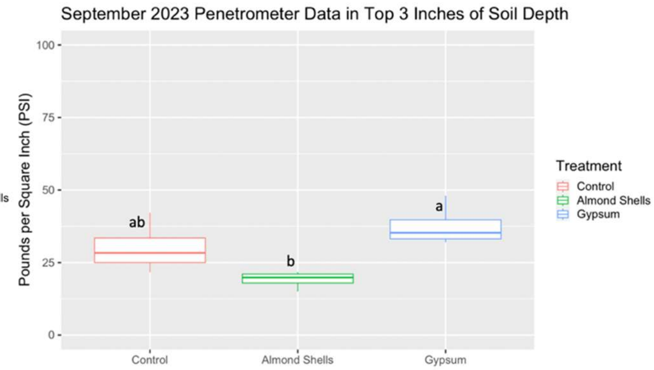
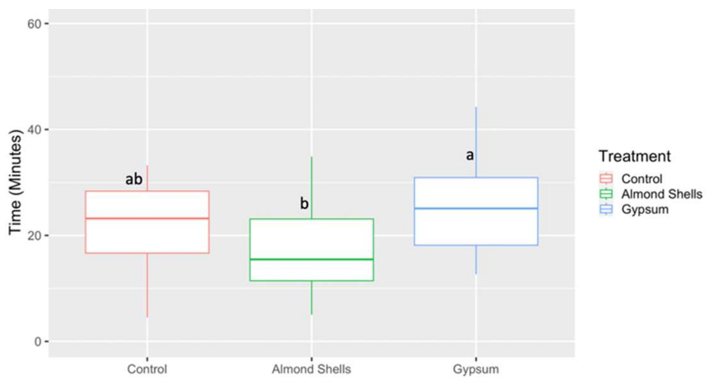


Figure 5: One measure of soils health is the degree of cracking as soils dry. Applications of almond shells to an alfalfa field grown on relatively heavy clay soil significantly reduced levels of cracking.

Figure 6: Soil compaction is measured using a penetrometer, which measures pounds per square inch (PSI). Less pressure was needed to penetrate soil in the top three inches in plots with almond shells. Almond shells were applied to the soil surface and not incorporated so changes to soil compaction were not expected deeper in the soil.

Figure 7: Water infiltration was measured for the first 4 inches of water. This simulates how long it takes water to move into the soil during a heavy rain event. The almond shell plots were the fastest (fewest minutes required per inch) for all measurements. The 4th inch of water is shown.

December 2023 Infiltration time for 4th inch of water



With the exception of EC, which measures salinity levels in soil, other soil measurements were not significantly different by treatment. Gypsum is a highly soluble salt, and the EC was higher in the gypsum plots compared to the almond shell or control plots. Despite the fact that differences were not statistically significant, there were some interesting differences in soil measurements. Specifically, almond shell byproducts have about 29 pounds of potassium per ton (35 lb K_20/ton), likely from pieces of hulls mixed in with the shells, which can eventually leach into the root zone with rain or irrigation as almond shells decompose. In this project, there was more potassium in soils with almond shell application compared to gypsum or control plots. In addition, plots with almond shells had more total carbon and total organic matter. Other measurements like cation exchange capacity (CEC), magnesium, calcium, and total nitrogen were not different by treatment.

Soil water measurements were collected in this trial. Infiltration measurements were taken for the first four inches of water applied. Infiltration measures the rate at which water moves into the soil. Infiltration was fastest in plots with almond shells for all four inches of water. However, the differences were only statistically significant for the fourth inch of water (Figure 7). In a heavy rain event, rapidly moving water into the soil is advantageous to reduce flooding and runoff. Saturated hydraulic conductivity measures the rate that water flows through saturated soil. Though not statistically significant, almond shell plots also had a faster saturated hydraulic conductivity (faster water flow rate) compared to other treatments.

Volumetric water content was measured in the top six inches of soil. The total differences in soil water content at any point in the season were negligible for on farm irrigation decisions. However, some interesting trends were observed. In rainy months, almond shell plots had higher water content after rain events likely because of increased infiltration and hydraulic conductivity. However, in the summer months, almond shell plots had slightly less water in the top six inches of soil. These are the months when the yields trended slightly higher in the almond shell plots. Alfalfa is a crop that yields relative to water applied; this reduction in water content is likely due to the increased alfalfa yield in plots with almond shell application.

<u>Summary and conclusions:</u>
Almond shell application to established alfalfa fields (which have deep roots and fix nitrogen) does not appear to negatively affect overall stand productivity at the rates of almond shells applied in this study. Alfalfa fields may provide an opportunity for diverting almond shells from nearby orchards, improving organic matter recycling in the region. Almond shells are both bulky and very lightweight, making them challenging to work with compared to other amendments. Good soil coverage requires a high volume of shells per acre. Shells are a dry material and transportation costs are not lost to water weight as with other soil amendments like compost. However, multiple truckloads per field would be required to achieve soil coverage, which increases hauling and spreading costs. This practice is best suited for established alfalfa fields located near to a source of almond shells. Since almond shells are not incorporated, any nitrogen tie up would be slow, and only in the soil surface. Incorporating almond shells to alfalfa stands prior to planting or applying shells to first year stands is not recommended due to issues with tying up nitrogen with a high C:N products that could affect plant growth. This project was an initial evaluation and did not quantify the impact of application rate to alfalfa fields.

<u>Acknowledgements:</u>
Funding was provided by the California Alfalfa and Forage Research Foundation. Thanks to Chamberlain Farms in Yolo County for collaborating with us on this project.

Managing Root-knot Nematodes in Crop Rotations

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A question came up several years ago about managing root-knot nematodes in processing tomato and lima bean rotations. Root-knot nematodes are tiny worm-like soil dwelling pests that cause root galling on plant roots, resulting in significant yield and quality losses. Symptoms of severe root-knot infestations include patches of chlorotic, stunted, necrotic, or wilted plants. These nematodes also predispose plants to other soilborne pathogens that cause root rot and wilt diseases. For example, a bean variety resistant to infection by the Fusarium wilt pathogen will become susceptible to this disease if infected with root-knot nematodes.

What is the link between nematodes in tomatoes and limas? Dr. Phil Roberts, Nematologist at UC Riverside shared the following response: There are several root-knot nematode species and they differ in their response to resistance in tomato and various bean crops. Most common in our Sacramento Valley area are *Meloidogyne incognita* and *M. javanica*. These nematodes are normally controlled by Mi-1 gene based resistant tomatoes, but there are resistance-breaking populations so that could be the reason for the infection on tomato (unless the tomatoes grown were not actually resistant). A further possibility is that the species is *M. hapla*, which is not controlled by the tomato resistance. *M. hapla* tends to induce smaller pearl-like galls on tomato roots and is not common in the Sacramento and northern San Joaquin Valleys.

As to rotating with lima beans, limas are susceptible to these root-knot species but there are resistant varieties available. Beja Flor baby lima has strong root-knot resistance. It was bred to contain three resistance genes that do a good job of blocking *M. incognita* and *M. javanica*. It yields well with the caveat that Steve Temple (former UCCE legume specialist) used to remark that it is more Lygus bug susceptible than some varieties, so if a grower went with UC Beja Flor they would need to keep up on the Lygus management. UC Luna baby lima has no root knot resistance. Other lines carrying *M. incognita* (but not *M. javanica*) resistance are the large limas White Ventura N and UC92.

If root-knot nematodes are present in a field with a history of Fusarium wilt, choose varieties that are resistant to root-knot nematodes as well as to the particular Fusarium wilt race present when possible. Another option is to rotate with root-knot nematode resistant cowpeas (blackeyes) instead of limas. Based on host-range tests, some varieties of cowpea have more root-knot nematode resistance than tomato. For example, some root-knot nematode races are virulent and highly pathogenic to Mi-1 gene based resistant tomatoes but not to nematode resistant cowpeas.

Root-knot nematodes causing galling on tomato roots (UC IPM).

Processing tomato field showing symptoms of root-knot nematode damage (photo credit: Vinchesi-Vahl).

Milo (Grain Sorghum) Yield Performance in Three Locations in Central Valley

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Grain sorghum, Latin name *Sorghum bicolor L. Moench*, is the fifth-largest cereal crop produced globally. Often called milo, grain sorghum is recognized for its resilience and adaptability, and offers a drought-tolerant solution for sustainable crop rotation practices on farms. Sorghum is water and nutrient efficient usage. When incorporated into rotation plans, growers can mitigate issues such as dust pollution, weed infestations, pest pressures, and disease outbreaks in fields that would otherwise be left to fallow. This approach not only enhances soil health and productivity but also contributes to the overall sustainability of agricultural systems. Grain sorghum was introduced in the United States as animal feed for beef and dairy industries, but recently has expanded to pet food, swine and poultry feed, bird seed industries, renewable fuels, and most recently food and confectionary systems. Grain sorghum is increasingly used for food and beer in the gluten-free market. The University of California Agriculture and Natural Resources (UC ANR) began sorghum grain hybrid evaluation trials in 2016. By establishing relationships with breeders and growers, we run performance variety trials to better understand how the environment in California affects the agronomic qualities of grain sorghum varieties selected from Texas and other great plains regions. The following is a short summary of the information available in the annual UC ANR Sorghum Grain Field Research Reports.

In 2022, we collaborated with two seed companies that provided 11 commercial grain sorghum varieties planted in three research sites in the Central Valley of California.

Location & Soil Type

The soil compositions varied across our research sites: Hanford sandy loam at Kearney Agricultural Research and Extension Center (KARE) in Parlier, CA; Panoche clay at West Side Research and Extension Center (WSREC) in Five Points, CA; and Yolo loam at UC Davis in Davis, CA.

Planting and plant population

All locations were planted during the first week of June 2022. The varieties were planted at 1-2 inch spacing in four rows on a 30-inch raised bed. This was a planting rate of 70,000 seeds per acre. Plots were 20 feet long and treatments were replicated three times. Plant populations are important for good yield potential (check variety specific number/lbs.). In the arid areas such as Sacramento where irrigation is used, seedling rate for milo is 70,000 plant per acre this can help sorghum to tolerate stress and maintain yields. https://www.sorghumcheckoff.com/our-farmers/grain-production/planting-row-spacing-and-seeding-rate/

The soil temperature is one of the early considerations made before planting. The minimum daily soil temperature should be 60 degrees since low temperature delays gemination and emergence. Secondly, sorghum seeds need soil moisture content of around 50-75% of the soil field capacity, this ensures the seeds have enough moisture to initiate the germination process.

Irrigation

In addition to the rainfall, locations were furrow irrigated weekly to match ET° demand during the season (weekly irrigation by site: KARE 2.0 inches, WSREC 3 inches, and UC Davis 3.5 inches). You may need 2-3 inches of irrigation or adequate soil moisture to encourage good emergence and root establishment. Do not impose moderate to severe water stress on plants during the first 30-35 days after emergence especially during panicle differentiation since this will affect the yield potential. The irrigation water required to grow sorghum in California generally falls within the range of 12-22 inches per growing season, depending on the specific conditions such as rainfall received and Evapotranspiration (ET).

Additional inputs:

At KARE 200 lbs/ac of pre-plant nitrogen were applied as urea (46-0-0) an additional 100 lbs/ac nitrogen and phosphorus was applied as monoammonium phosphate (11-52-0) and 400 lbs/ac of potassium sulfate or sulfate of potash (0-0-50) were applied at pre plant. An additional 100 lbs/ac of nitrogen were applied as urea at layby. Pre-plant herbicides were also applied and included Dual Magnum at 1 1/3 pints/ac, later Gramoxone at 48 oz/ac and Maestro 4 EC at .5 pint/ac.

WSREC fertilizer treatments consisted of 250 lbs/ac of nitrogen applied as urea (46-0-0) and 100 lbs/ac of nitrogen and phosphorus applied as monoammonium phosphate (11-52-0) at pre-plant, and later an additional layby application of 100 lbs/ac 46-0-0. WSREC pre-plant herbicides consisted of Dual Magnum 24 oz/ac as pre-emergent and an application of Clarity 8oz/ac at layby. WSREC also received two applications of Sivanto Prime 14oz/ac to control sugarcane aphid.

UC Davis applied 20 lbs. of an 8-28-6 as a pre-plant fertilizer and later in the season a layby of 200 lbs/ac of nitrogen applied as urea (46-0-0). Dual Magnum was used as a pre-emergent herbicide. No pesticides were applied.

Results

Grains are harvested between September and October, when they have achieved physiological maturity. Grain sorghum matures from the top of the head and progresses downward to the base. Mature grain will be hard to penetrate when pinching the bottom of the kernel between your fingernails and should have a black spot at its base. It is advisable for growers to wait for the grain to naturally dry down in the field to reduce the cost of drying especially if the temperature is favorable.

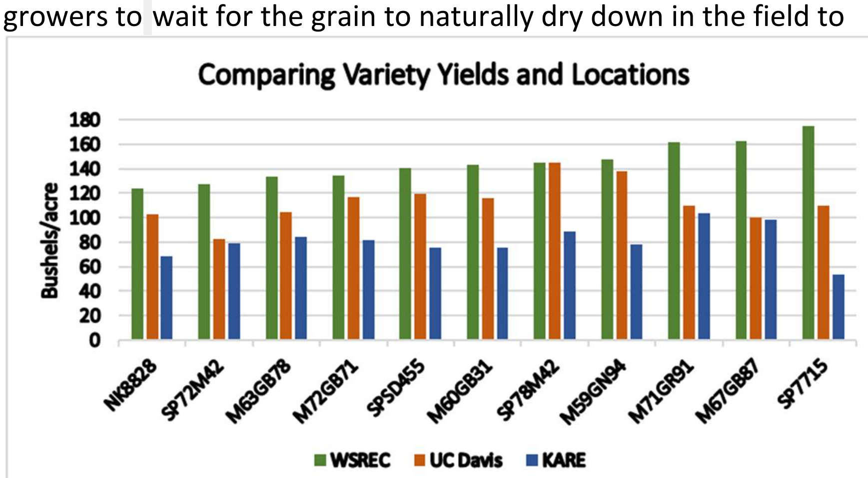

Figure 1:2022 grain sorghum yields of different varieties evaluated at three locations, Kearney REC, Westside REC and UC Davis.

Days To Flowering (DTF) reflects the various maturity periods recorded amongst the grain sorghum hybrids. And in 2022 it ranged as early as 58 days after planting, to late flowering at 90 days for some hybrids at UC Davis (Table 1).

Plant heights ranged from 36.7 to 45.9 inches and averaged 41.97 inches across the UC Davis site. The highest yielding varieties at Davis included SP78M42 (144.94 bu/ac) from S&W Seed company and M59GN94 (137.94 bu/ac) from Dyna-Gro but these yields were not significantly different from most varieties evaluated in 2022 except SP72MA2 (82.97 bu/ac) that had low yields (Table 1). Yields were adjusted to 13% moisture.

Table 1. Various agronomic characteristics for grain sorghum hybrids grown at the UC Davis Research Farm, Davis, California in 2022

Hybrid Information			**Agronomic Measurements***		
Entry	**Company**	**Hybrid**	**DTF[1]**	**Plant Height (inch)**	**Yield bu ac^{-1}**
1	Dyna-Gro	M59GN94	58.00 d	41.20 ac	137.94 a
2	Dyna-Gro	M60GB31	82.00 a-b	39.63 c	115.64 a-b
3	Dyna-Gro	M63GB78	62.00 c-d	41.07 a-c	104.23 a-b
4	Dyna-Gro	M67GB87	72.00 b-c	42.65 a-b	99.82 a-b
5	Dyna-Gro	M71GR91	66.00 c-d	45.93 a	109.41 a-b
6	Dyna-Gro	M72GB71	64.00 c-d	43.17 a-b	117.19 a-b
7	S&W Seed	SP7715	90.00 a	41.34 a-c	109.41 a-b
8	S&W Seed	SP72M42	61.00 c-d	41.34 a-c	82.97 b
9	S&W Seed	SP78M42	71.00 b-c	45.14 a-b	144.94 a
10	S&W Seed	NK8828	64.00 c-d	40.02 b-c	102.67 a-b
11	S&W Seed	SPSD455	65.00 c-d	36.70 c	119.79 a-b
12	S&W Seed	Filler NK8828	63.00 c-d	40.63 a-c	126.53 a-b
	Means		**68.17**	**41.97**	**114.21**
	CV		**10.42**	**6.96**	**22.42**

*Means followed by the same letter do not significantly differ using LSD Duncan (alpha=0.05)
1 DTF=days to 50% flowering

Take home messages:

- Select varieties with appropriate maturity periods for your region to avoid harvesting during adverse weather conditions, most of the varieties screened had early to mid-maturities.
- Look for varieties that have consistently shown high yield potential in local or regional trials.
- Choose varieties that are well-suited to the local climate, including temperature ranges, rainfall patterns, and potential drought conditions.
- Plant sorghum at the right soil temperature (60 degrees) and soil moisture to have good germination and root establishment.
- Make sure not to water stress the plant during panicle differentiation (30-35 days after emergence).

For the full report go to https://sorghum.ucdavis.edu/sites/g/files/dgvnsk14556/files/inline-files/381800.pdf. In addition to the Grain Sorghum Reports, you will find Sorghum Forage Reports and Sorghum Production Guides.

Save the Date!

UCCE Hedgerow Field Day in Colusa!

When: Wednesday, August 14th, 9am to noon

Where: the field is just south of the intersection of Lodi Rd and Tule Rd in Colusa (39.012861, -121.931859).

Follow UCCE signs from the intersection.

Agenda to follow.

UC Dry Bean Field Day in Davis!

UC Davis and UC Cooperative Extension will provide updates on dry bean research and management.

When: Thursday, August 15th, 9:30-11:30am

Where: UC Davis campus, specific location will be forthcoming

What: Information from UC research on lima, blackeye, and garbanzo beans. Continuing education credits, light refreshments, shade, and seating will be provided.

Please check the UC Dry Bean Blog for the final location: https://ucanr.edu/blogs/beanblog/index.cfm