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Cooperative Extension
Agricultural Experiment Station
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IN THIS ISSUE

EVALUATION OF WHEAT STRAW MULCH FOR MANAGEMENT OF THE CORN LEAFHOPPER AND CORN STUNT DISEASE IN THE SAN JOAQUIN VALLEY

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Abstract

Corn plants grown over wheat straw mulch had significantly lower numbers of corn leafhopper for up to a month following seedling emergence than did plants growing over bare soil. The incidence of corn stunt disease was approximately three-fold higher in plants growing over bare soil compared to those growing over wheat straw mulch, and yields were 25% higher in plots mulched with wheat straw.

Introduction

The corn leafhopper, *Dalbulus maidis* (DeLong and Wolcott), is found on corn (*Zea mays* L.) throughout much of the southeastern and southwestern United States. In addition to yield losses caused by feeding injury (Bushing and Burton 1974), corn leafhopper is an important vector of corn stunt disease caused by *Spiroplasma kunkelii* (CSS). Corn stunt is a debilitating disease that can cause even greater yield losses than those attributable to leafhopper feeding alone (Nault 1985). In the United States, both feeding injury and corn stunt disease have been of greatest significance on late planted corn (Bushing and Burton 1974). However, since 1996, the problem in California has appeared earlier each year and in 2002, significant losses occurred as early as June. In California, the corn leafhopper has been reported from Los Angeles, Riverside, Kern, Kings, Tulare, Fresno, Madera, Merced, Stanislaus, San Joaquin, Sacramento, Solano and Yolo counties (Summers et al. 2003a). *Spiroplasma kunkelii* was also detected in leafhoppers from Sacramento County (Summers et al. 2003a).

Insecticides evaluated for corn leafhopper control appear to give mixed results, with most providing only minimal, short-term protection (Bhird and Pitre 1972, Bushing and Burton 1974, Bushing et al. 1975, Summers and Stapleton 2002, Summers et al. 2003a). There is some indication that insecticides actually increase the incidence of corn stunt (Summers and Stapleton 2002).

While evaluating the impact of various mulches on insects associated with fresh market tomatoes, *Lycopersicon esculentum* Mill., we found fewer beet leafhopper, *Circulifer tenellus* (Baker), and a lower incidence of beet curly top hybrigeminivirus in plants growing over straw mulch than in plants growing over bare soil (CGS, JJS, JPM unpublished). Wheat straw has also been shown to significantly reduce the incidence of aphids, aphid-borne viruses and whiteflies in cucurbits (Summers et al. 2003b).

This paper reports the results of a trial conducted to determine if wheat straw mulch is effective in reducing population of corn leafhopper and ultimately in reducing the incidence of corn stunt disease.

Materials and Methods

Location. Trials were conducted at the University of California Kearney Research and Extension Center, Parlier CA.

Corn Leafhopper Infestation. In order to insure a large population of corn leafhoppers, we planted 12 rows (30 inch centers, 220 feet in length) of silage corn dubbed "the nursery field" on 17 June 2002. Beginning in July, we collected leafhoppers on a weekly basis from silage fields in Kings and Tulare counties and released them in the nursery field.

Plot Preparation. Raised planting beds were formed with a tractor drawn bed shaper-tiller (B. W. Implement Co., Buttonwillow, CA). The distance between bed centers was 30 inches. Granular fertilizer (15-15-15) at 800 pound per acre was applied using a 'Vicon' applicator. Dual Magnum herbicide (Syngenta, Greensboro, NC) at 1.33 pints per acre, was applied to the beds in 50 gal of water per ha with an FMC hydraulic sprayer, Model DP20 3PT (FMC, Jonesboro, AR) equipped with 'Tee Jet 8004' (Spraying Systems Co., Bellwood, IL) nozzles. Both fertilizer and herbicide were incorporated to a depth of 6 inches with a second pass of the bed shaper, after which the beds were ring-rolled.

Plot Layout, Experimental Design, Planting and Mulch Application. Treatments (straw mulch or bare soil) were arranged in a randomized complete block design with six replications. Each plot consisted for four (4) rows, 30 feet long. There was a 10-foot walkway between each plot and two unplanted rows (ca. 5 feet), the full length of the field, between each set of plots. The blank rows provided easy access sampling without disturbing the plots. Plots were planted on 3 September 2002 using a tractor drawn John Deere planter. Corn seed (Asgrow RX913) was planted approximately 1.5 inches deep and 4-5 inches apart within the row. All plots were furrow irrigated the following day to facilitate germination and activate the soil applied insecticides. Wheat straw, cv Bonus, was spread over the designated plots at an equivalent rate of 10,000-12,000 pounds per acre, an amount consistent with a harvested wheat field. The straw was applied just as the coleoptile was beginning to emerge.

Movement of Leafhoppers from Nursery Corn. To facilitate the movement of the corn leafhoppers from the nursery corn to the trial corn, the former was cut, using a sickle bar mower, on 20 September 2002. Although some leafhoppers had already moved from the nursery to the trial field, this is considered as the infestation date. The corn was allowed to "dry" for one week allowing all of the adult leafhoppers to move to the newly emerged trial corn. The nursery corn was then shredded, forcing any remaining leafhoppers into the trial corn.

Leafhopper Sampling. Leafhopper populations were sampled by taking D-vac suction samples from 1 meter (39 inches) of row in one of the two center rows.

Corn Stunt Determination. Plants were visually inspected on 21 November 2002 for the presence of red leaves and shortened internodes, both symptoms of corn stunt.

Determination of S. kunkelii in leafhoppers. Five lots of five leafhoppers each, taken at random from the nursery field prior to cutting were tested for the presence of *S. kunkelii* using PCR techniques. Specific primers were developed to the Spiralin genes of the corn stunt spiroplasma. The most reliable set of primers "CSSF1" and "CSSR1" were used to develop a reliable assay for use in our diagnostic situation. Initially the samples were prepared according to the methods of Barros et al. (2001) but were later modified to use a Fast Prep total DNA extraction method.

Yield Determinations. Yields were taken on 25 November 2002 by cutting all of the plants in the two center rows approximately 3 inches from the soil surface. Weights were determined in the field.

Statistical Analysis. The leafhopper population, percent stunt, and yields were evaluated by analysis of variance and the means separated with Fishers LSD (Statistix 7 2000). Percent stunt was transformed to arcsine $\sqrt{x}$ before analysis and then back transformed for presentation.

Results and Discussion

Seedlings emerged on 8 September and were almost immediately infested by corn leafhopper adults. Plants growing over the wheat straw had significantly ($P < 0.05$) lower number of adult corn leafhoppers for almost a month following emergence (Fig. 1). Leafhopper populations were nearly 5x lower in plants growing over wheat straw compared to those growing over bare soil for the first three weeks following emergence. By the time leafhopper numbers in the straw mulch plots were equal to those in plants growing over bare soil, leafhoppers were on the decline. The results agree with previous studies of the effect of straw mulch in reducing the incidence of certain insects (Summers et al. 2003b) and give the first indication that straw mulch may be used to repel leafhoppers as well as aphids and whiteflies.

The percentage of plants showing corn stunt symptom was three times greater in plants growing over bare soil than in those growing over wheat straw (Table 1). Caution is advised in the interpretation of these data since symptomology is not the best method to use in determining disease infection. Because of the lateness of the season and the cool temperatures, attempts at determining the rate of infection using ELISA were not successful (Summers et al. 2003a). The rate of infection based on symptoms, however, provides some clues as to the possible effects of wheat straw in reducing the incidence of disease. Yields were approximately 25% higher in plots growing over wheat straw compared to bare soil (Table 1).

These studies are preliminary, but they do offer the possibility of another tool in the management of corn leafhopper. More and more growers are using conservation tillage in growing corn by planting corn directly into stubble following winter forage or a grain crop. We will be working with a number of such growers this season to evaluate the level of corn leafhopper control in such a production system.

Acknowledgments

We appreciate the assistance of Dan Mulligan and Rudy Gonzales in conducting the trial. Dan Opgenorth, California Department of Food and Agriculture, conducted the PCR on the leafhoppers.

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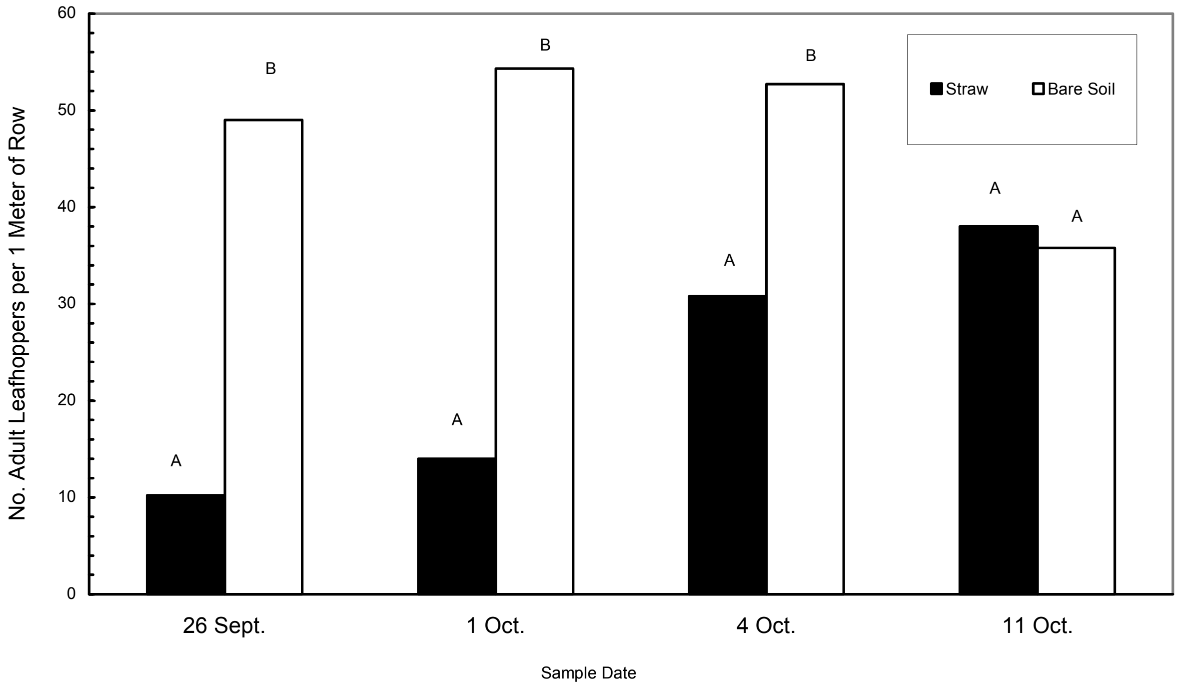

Figure 1. Number of corn leafhopper adults from one meter of row determined by D-vac suction samples. Means sharing a common letter are not significantly different at *P* = 0.05. Fishers LSD.

Table 1. Yield and percent corn stunt infected plants in silage corn grown over wheat straw mulch and bare soil.

Treatment	**Yield -Tons per Acre** [a]	**Percent Corn Stunt** [b]
Wheat Straw	25.1a	1.4a
Bare Soil	18.0b	4.6b

[a] Means followed by the same letter are not significantly different at *P* = 0.05. Fishers LSD. Yields are below those expected in normal silage production because the harvest was made prior to tassel formation. However, the relative differences are significant.

[b] Means followed by the same letter are not significantly different at *P* = 0.10. Fishers LSD.

SURROUND USE IN CITRUS INCREASES CALIFORNIA RED SCALE

Beth Grafton-Cardwell and Chris Reagan, University of California, Riverside, and UC Kearney Agricultural Center

Surround® Crop Protectant (Engelhard Corporation, Iselin NJ) is a kaolin clay particle film material applied to the foliage of crops to create a physical barrier that repels insects and modifies canopy temperature (Glenn et al. 1999). It has been used extensively in apples and pears in the Pacific Northwest to protect against pear psylla *Cacopsylla pyricola* (Puterka et al. 2000) and codling moth *Cydia pomonella* (Unruh et al. 2000), and to reduce fruit sunburn (Glenn et al. 2002). In California, one of the most significant uses of this material is in grapes where it is used to repel glassy-winged sharpshooter, *Homalodisca coagulata* (Bentley et al. 2002). Glassy-winged sharpshooter is a vector of the bacterium *Xyllela fastidiosa* that causes Pierce's Disease in grapes. Because there are no resistant grape varieties available, the only management tactics for the disease are to rogue out infected vines and prevent the sharpshooters from feeding on grape plants. Surround has become an important component of the grape program because it repels sharpshooters and inhibits feeding, thereby reducing the rate of disease transmission.

Citrus is a significant egg-laying host for glassy-winged sharpshooter and a large number of San Joaquin Valley citrus groves are adjacent to vineyards. Citrus growers are asked to treat for sharpshooters to reduce the movement of sharpshooters into neighboring grapes and to prevent infestation of harvested citrus fruit that is to be moved to uninfested areas of the state. Occasionally, citrus growers apply Surround and these treatments may cover the entire orchard or only the 2-4 rows of citrus adjacent to the grapes.

A well-known tenet of San Joaquin Valley citrus integrated pest management (IPM) is that in order to maximize biological control, citrus growers must minimize dust, fertilizers, whitewash and other contaminants of leaves, twigs, and fruit. Parasitic wasps and predators have difficulty gaining access to their hosts and prey through such barriers. One of the most important examples of the significance of this concept is the case of California red scale, *Aonidiella aurantii*. California red scale populations tend to be higher in trees that are next to dusty roads or where whitewash or manure has been applied because these treatments prevent the parasitic wasps *Aphytis melinus* and *Comperiella bifasciata* from gaining access to their California red scale hosts. Growers often apply water to dusty roads to keep the trees free of dust. Growers who release *Aphytis* wasps for red scale control generally wait to apply products such as hydrated lime until the late fall months to avoid disturbing fall populations of *A. melinus*.

We became concerned that in-season Surround applications for glassy-winged sharpshooter repellency would reduce parasite activity. In citrus, Surround treatments could be applied any time from the beginning of sharpshooter activity in February or March through the summer. Treatments applied during this period are likely to disrupt red scale parasites *A. melinus* and *C. comperiella* that are active from March until November.

In 2002, we conducted a trial to determine the impact of Surround on a population of California red scale in a 'Fisher' navel orange block at the Lindcove Research and Extension Center. There were three treatments: 1) untreated, 2) Surround applied once on 12 July 2002, 3) Surround applied twice on 12 July 2002 and 12 September 2002. We applied 50 lbs of Surround in 500 gallons of water per acre (FMC 1093 air blast sprayer) to 4 rows of citrus trees per plot (18 trees per row) and replicated the plots 3 times (a total of 1.6 acres per treatment). The experiment was blocked based on pretreatment scale densities by sampling 5 twigs per tree from 5 trees in the center of each plot on 20 June (a total of 15 trees per treatment). We sampled 5 fruit per tree in 5 trees from the center of each plot in August and November. The number of live 1st and 2nd instar male and female scales as well as 3rd instar and mature females, were counted on each fruit. The percentage parasitism by *A. melinus* and *C. bifasciata* of 2nd instar, 3rd instar and mature female scales were recorded. The mean number of scale per twig or fruit was compared for the three treatments on each sample date using ANOVA followed by the Least Significant Difference (LSD) mean separation test.

Total fruit per tree from each of 5 trees per replication (15 trees per treatment) was individually harvested on 26 Feb 2003. The fruit were examined and the number of fruit that were infested as well as the number that were infested with a heavy population of CRS (> 10 scale per fruit) were recorded. The data for the mean percentage fruit infested and fruit with >10 scale were transformed using arcsine [proportion] ½ transformation before ANOVA and followed by the LSD mean separation test. Evaluation of parasitism by *A. melinus* and *C. bifasciata* was conducted on 4 Dec 2002 by examining under a dissection microscope approximately 3,000 2nd instar, 3rd instar, and mature female scale from each of the treatments. A scale individual was considered parasitized if it had evidence of an external live stage of *A. melinus* (egg, larva, or pupa) or an internal live stage of *C. bifasciata* (larva or pupa). The data for the mean percentage parasitism [parasitized scale/(healthy+parasitized scale)] were transformed using arcsine [proportion] ½ transformation before ANOVA. Means were separated using the LSD mean separation test.

In August, the first treatment of Surround had been applied to both the single and double treatment areas and these areas exhibited elevated numbers of scale on the fruit (Fig. 1). The areas that ultimately received one application of Surround had significantly ($F = 4.85$; df = 2; $p = 0.013$) more scale than the other treatments. In November, after the second application had been applied to the double treatment and the red scale population had developed further, both single and double-treated areas had significantly higher densities of scale on fruit, compared to the untreated control ($F = 6.64$; df = 2; $p = 0.003$). The trees treated twice with Surround had numerically, but not statistically higher densities than those treated once.

We found that both the percentage of fruit that were infested with scale ($F = 3.99$; df = 2; $p = 0.026$) and the percentage of heavily infested fruit ($F = 3.43$; df = 2; $p = 0.042$) were significantly higher in the two Surround treatments compared to the untreated areas (Table 1). Single and double applications of Surround resulted in similar levels of red scale infestation of fruit.

The percentage of California red scale parasitized in untreated trees was significantly higher ($F = 7.13$; df = 2; $p = 0.002$), in fact more than double, the percentage found in either of the Surround treatments (Table 1). This is evidence that Surround disrupts the ability of parasites to find and successfully parasitize California red scale, resulting in an increase in scale per twig or fruit and a higher number of infested fruit. Fruit with >10 scale would require high pressure washing to disinfest the fruit. High pressure washing does not always result in a top grade of fruit. In addition, not all fruit can be high pressure washed, either because the packinghouse does not have a high pressure washer or because the fruit is susceptible to injury. For example, early harvested fruit cannot be high pressure washed because the rind is too tender. Thus, growers should avoid treatments or situations that aggravate California red scale and increase the infestation level of citrus fruit.

We conclude from this experiment that Surround treatments in citrus disrupt parasites and have the potential to escalate California red scale populations. Surround has also been shown to reduce natural enemies and increase populations of San Jose scale, *Diaspidiotus perniciosus*, and other pests in apples (Knight et al. 2001). P. Mauk (personal communication) found that Surround increased the level of damage to citrus leaves caused by the citrus leafminer, *Phyllocnistis citrella*. California red scale is a primary pest of citrus, that can cause both cosmetic and direct damage to trees. While Surround is an effective repellent of glassy-winged sharpshooters, citrus growers should carefully consider the potential red scale problems that a Surround treatment could cause.

Acknowledgments

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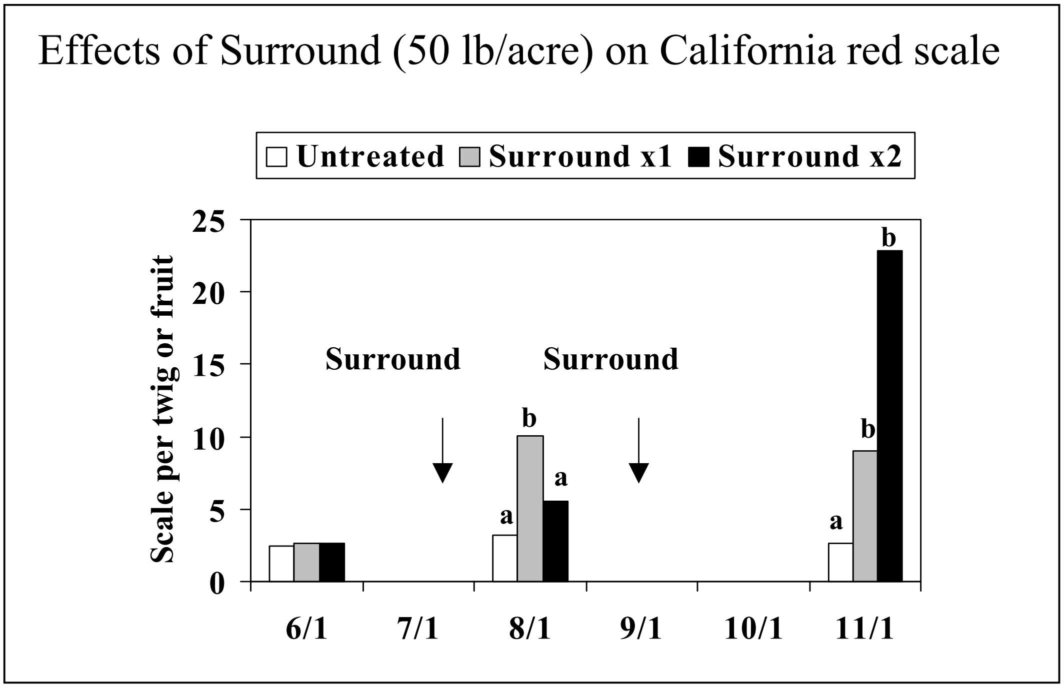

Figure 1. The number of California red scale per twig or fruit before and after treatments of Surround.

Table 1. Percentage parasitism of California red scale evaluated 4 Dec 2002 and percentage scale infestation of fruit evaluated at harvest (26 Feb 2003).

Treatment	Rate (ai)/acre	Application date(s)	Percentage (± SEM) % Fruit infested with CRS	% Fruit infested with >10 CRS	% Parasitism[b]
Untreated	---------	----------	61.3 ± 4.8b	29.1 ± 4.6b	35.8 ± 5.3b
Surround	50.0 lb/acre	7/12/02	74.7 ± 2.3a	41.8 ± 2.6a	16.1 ± 3.1a
Surround	50.0 lb/acre	7/12 & 9/12/02	74.8 ± 3.5a	40.4 ± 4.5a	14.8 ± 2.4a

[a] Means within a column followed by the same letter are not significantly different (LSD, *p*=0.05) after arcsine [proportion] ½ transformation. Untreated means are listed.

[b] % Parasitism is determined by examining all 2nd, 3rd and mature females stages. A scale is considered parasitized if it has present a live stage of *A. melinus* or *C. bifasciata*.

NEW GUIDE & TRAINING FOR *LYGUS* IDENTIFICATION AVAILABLE

P.B. Goodell[1], S.C. Mueller[2] and C.G. Summers[1], UC Kearney Agricultural Center[1], and UCCE Fresno County[2]

Lygus bugs are key pests in many crops, including field crops, vegetables, nuts and fruits. There are 43 species of *Lygus* identified, worldwide, 34 of which are known to exist in North America (Kelton, 1975). Within the San Joaquin Valley, three species of *Lygus* have been recorded. These are *L. hesperus* (Knight), *L. elisus* (Van Duzee) and *L. lineolaris* (Palisot and de Beauvois). In addition to these species, there are other plant bugs that resemble *Lygus* and could be mistaken for them.

Proper identification of a pest organism is the first step in IPM. The appropriate strategic response and choice of insecticide is based on the correct identification. For example, *L. elisus* is much less damaging to cotton than *L. hesperus*. Basing treatment decisions on *L. elisus* overestimates the pest problem, resulting in potentially misdirected insecticide applications. Thus, associating proper biology and potential damage to the correct pest is essential before any management regime is initiated. Finally, building a history of experience must be based on knowledge of the correct organism.

Dr. Shannon Mueller, Agronomy Farm Advisor in Fresno County, used part of her sabbatical leave to develop a guide to separate the three *Lygus* species reported in the Central San Joaquin Valley. A dissecting microscope is useful when first using the guide, but once the distinguishing features are recognizable, a 10X hand lens can be used to identify them in the field. The guide is based on characteristics of the male *Lygus* bug that are easy to observe. It minimizes the use of jargon and is well illustrated to highlight the morphological features important in separating the species.

The guide is titled *A Field Key to the Most Common Lygus Species Found in Agronomic Crops of the Central San Joaquin Valley*. It is published as a UC Agriculture and Natural Resources publication (ANR Publication 8104) and is available as an electronic document. In support of the key is a companion publication that is pictorial in nature and concentrates on the most important features for separating species. It is titled *Key Features of Common Lygus Species in the Central San Joaquin Valley* (ANR Publication 8105). The publications are available at www.lygus.uckac.edu or through the ANR publications E-catalog on http://anrcatalog.ucdavis.edu/. Although primarily developed for use in field crops, the key can also be used to identify *Lygus* species found in many other cropping systems.

The UC ANR *Lygus* Management Workgroup supported this work and provided funds to print 500 copies.

These printed copies will used in conjunction with free training workshops to be held on June 26, 2003 at Kearney Ag Center and June 27, 2003 at Shafter Research and Extension Center. Both workshops will run from 10 AM until noon. If interested, please RSVP with JoAnn Coviello, 559/646-6525.

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