ANNUAL REPORT COMPREHENSIVERESEARCH ON RICE
January 1, 2016 – December 31, 2016

PROJECT TITLE
Understanding the effects of rice herbicide drift on walnut in the Sacramento Valley.

PROJECT LEADER
Brad Hanson, UC Davis Cooperative Extension Weed Specialist
Univ. of California, Davis Department of Plant Sciences, MS-4 One Shields Ave
Davis, CA 95616
bhanson@ucdavis.edu

PRINCIPAL UC INVESTIGATORS
Mariano Galla, UC Davis PhD student
Kassim Al-Khatib, UC Professor of weed science
Bruce Lampinen, UC Davis Cooperative Extension Pomology Specialist
Bruce Linquist, UC Davis Cooperative Extension Rice Specialist

LEVEL OF 2016 FUNDING
$ 30,000

OBJECTIVES AND EXPERIMENTS CONDUCTED, BY LOCATION, TO ACCOMPLISH OBJECTIVES

The overall objective of this work is to determine the effects of rice herbicide drift on walnuts, an issue that appears to becoming more widespread as walnut acreage increases in the Sacramento Valley and as new, low use-rate rice herbicide enter the market.

Particularly, the aim is to:

- Evaluate the symptoms and growth effects of simulated herbicide drift on young walnut trees in a field study
- Compare symptoms and growth response of young walnuts exposed to single or multiple exposures to simulated herbicide drift
- Determine the effect of herbicide droplet application on walnut leaves and flower buds
- Evaluate the effects of simulated herbicide drift on walnut quality and yield
- Determine the residue persistence of bispyribac in walnut leaves and the minimum herbicide concentration required to cause visible injury to walnut leaves

SUMMARY OF 2016 RESEARCH (major accomplishments), BY OBJECTIVE:

1. Evaluate the symptoms and growth effects of simulated herbicide drift on young walnut trees in a field study

The first run of these studies was conducted during 2015 in an experimental walnut orchard planted in winter 2014 at UC Davis. In June 2016, validation experiments (2nd run) were conducted on another walnut orchard block planted in 2015.

The herbicides tested were: bispyribac sodium, bensulfuron and propanil. Each herbicide was applied at four rates resembling a plausible drift rate: 0.5%, 1%, 3% and 10% of the high product use rate in rice (44.8, 70.2, and 6725.1 g ai/ha for bispyribac sodium, bensulfuron and propanil, respectively).

The trial was established as a randomized complete block with four replicates, experimental units were single trees. Herbicides were applied from the ground, to one side of the canopy, using a hand held, CO_2-pressurized boom at a volume of 93 L/ha with a fine spray quality. Crop oil concentrate (0.5% v/v) was added to all treatments.

Typically, in the Sacramento Valley the majority of rice herbicides are applied between late May and early July. Therefore, in order to conduct the field experiment under the right environmental conditions and at the most applicable walnut growth stage, treatments were applied on May 31, 2016.

Injury estimates and SPAD values were collected one, two, three, four and eight week after herbicide application. Injury estimates were obtained using the following procedure: at each assessment, two injured leaflet per tree were collected and scanned using a desktop scanner. Injured areas of the leaf were separated from the green area using picture thresholding software and the percentage of injured area was calculated.

Prior to treatment application three actively growing shoots per tree were marked and the number of leaves per shoot was counted. Leaf counts were subsequently made four, eight and twelve weeks after treatments were applied.

In October 2016, yield was harvested from trees treated in 2015, while in October 2017 yield will be collected from trees treated in 2016.

All herbicides caused significant damage and delayed growth of the young walnut leaves and shoots. Symptoms were first noticed three days after application and became more evident seven days after treatment. Although recovery was noted at 28 DAT, chlorotic spotting and distorted shoot growth caused by ALS inhibitor herbicides was apparent four months after treatment in both experiments. Data indicate that rice herbicide drift may slow the growth of young walnuts in the next year. However, the effect of these symptoms on the next year nut production is still not clear and need to be established in further studies.

Figure 1. Bispyribac-related yellow spotting, interveinal chlorosis and shoot distorted growth

Figure 2 Bensulfuron-related yellow spotting, interveinal chlorosis and shoot distorted growth

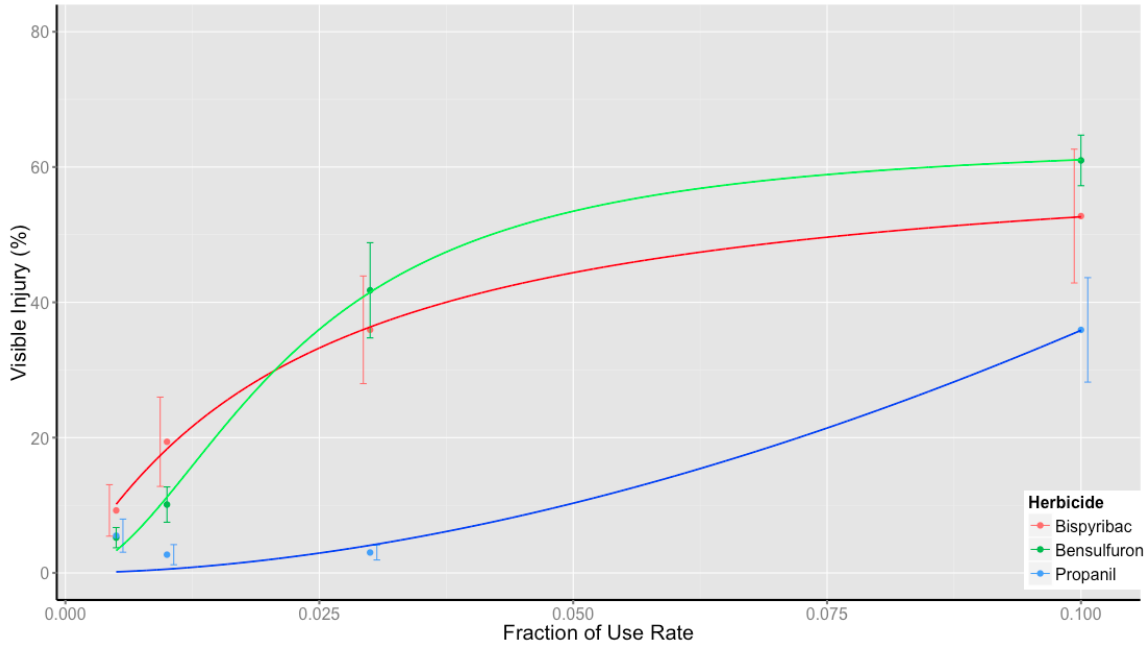

Figure 3. Effect of herbicide drift rate on visual injury to walnut leaves (two years of data)

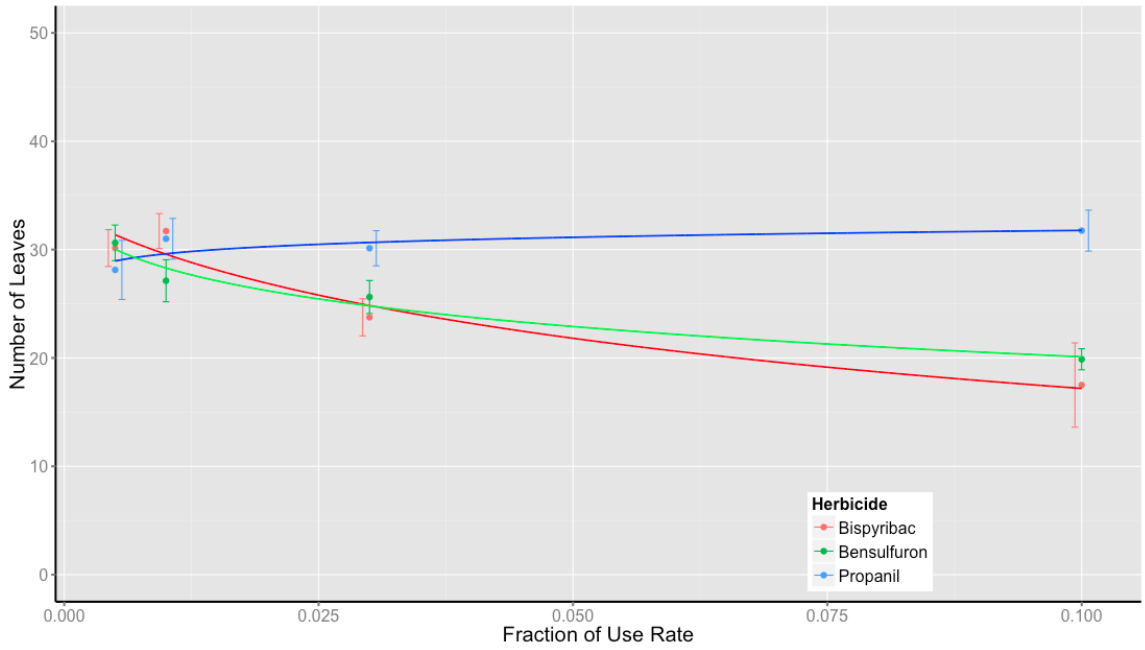

Figure 4. Effect of herbicide drift rate on leaf production on young shoot growth (two years of data).

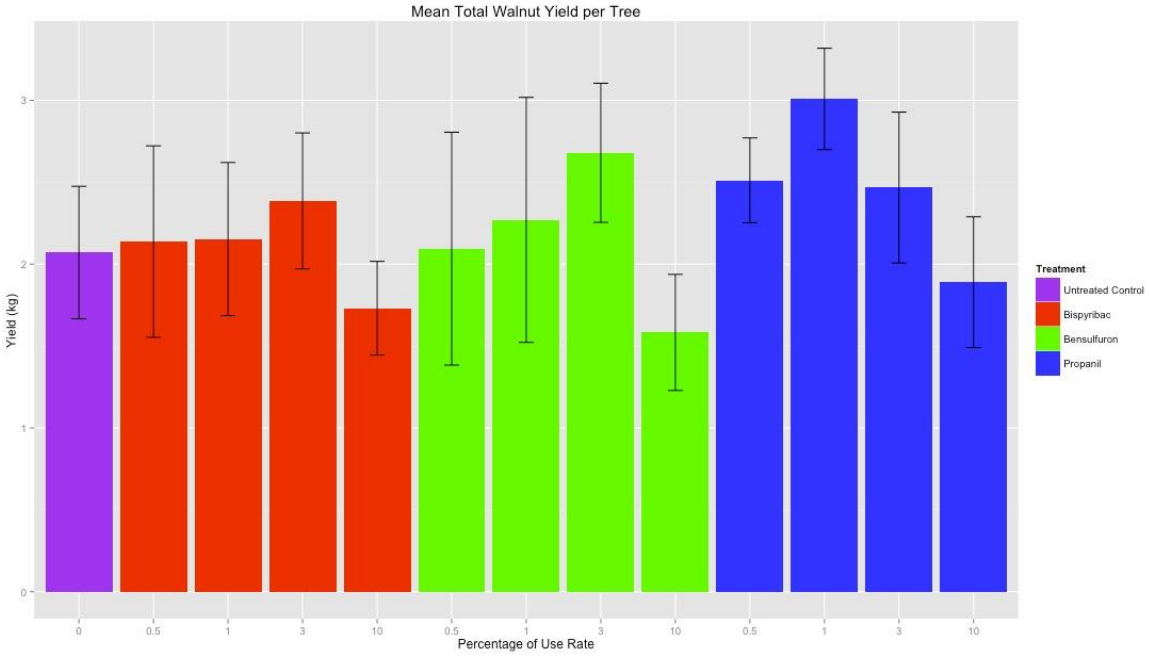

Figure 5. Mean walnut yield per tree. Walnuts were harvested in October 2016 from trees treated in June 2015

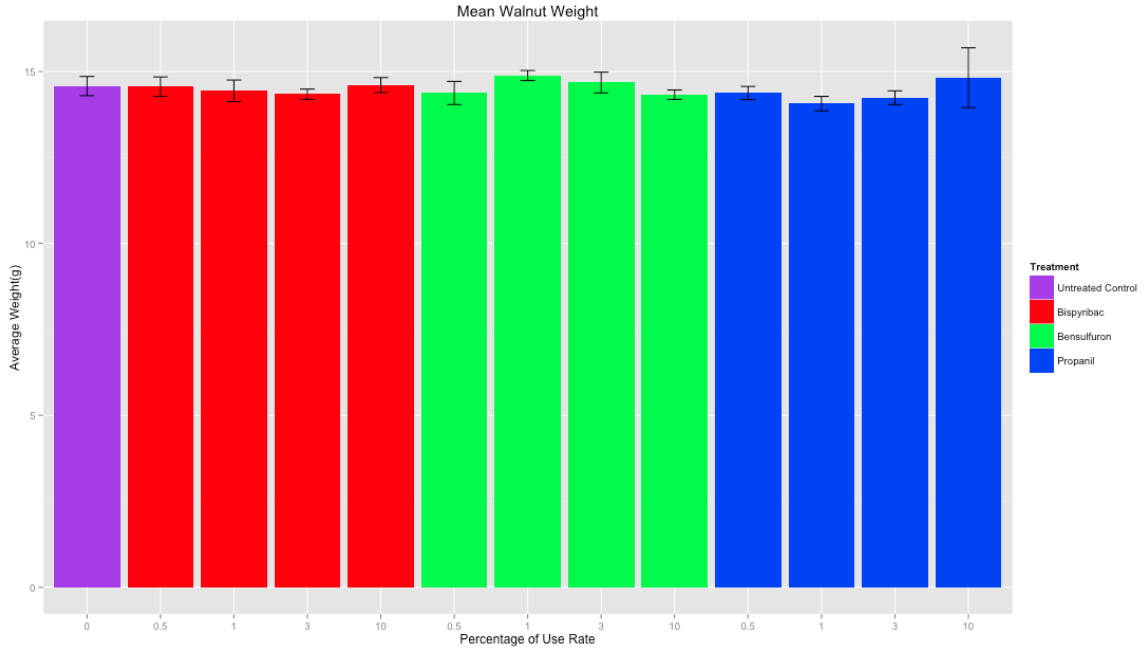

Figure 6. Mean walnut weights. Walnuts were harvested in October 2016 from trees treated in June 2015

2. Compare symptoms and growth response of young walnuts exposed to single or multiple exposures to simulated herbicide drift

A field trial was established in a two year-old chandler walnut orchard at the UC Davis experimental station. In this case, the objective was to simulate a scenario in which a walnut orchard is exposed multiple times in a season to herbicide drift. The first run of these studies was conducted during 2015 in an experimental walnut orchard planted in winter 2014. In June 2016, validation experiments (2^{nd} run) were conducted on another walnut orchard block planted in 2015.

Bispyribac sodium was applied four times at weekly intervals at two different rates: 0.5% and 3% of the rice use rate (44.8 g ai/ha). The first application was made on June 1, 2016.

The trial was established as a randomized complete block with four replicates and experimental units were single trees. Herbicides were applied from the ground, to one side of the canopy, with a hand held, CO2-pressurized boom at a volume of 93 L/ha with a fine spray quality. Crop oil concentrate (0.5% v/v) was added to all treatments. Injury estimates and SPAD values were collected at each treatment application and one, two, three, four and seven weeks after the last application.

Prior to the first treatment application three actively growing shoots per tree were marked and the number of leaves per shoot was counted. Leaf counts were conducted at each assessment time.

Multiple exposures to bispyribac caused significant damage and delayed growth of young walnut leaves and shoots. The symptoms observed were similar to the ones observed in the single drift exposure trial but more pronounced. In particular, the maximum level of injury caused by four applications of bispyribac at 3% of the rice use rate was similar to that caused by one application of bispyribac at 10% of the rice use rate in the single exposure study.

A trend toward reduced shoot growth after multiple drift exposure was also observed. The number of leaves counted in the shoots treated with bispyribac at 3% of the use rate was smaller than the number of leaves counted in the untreated shoots.

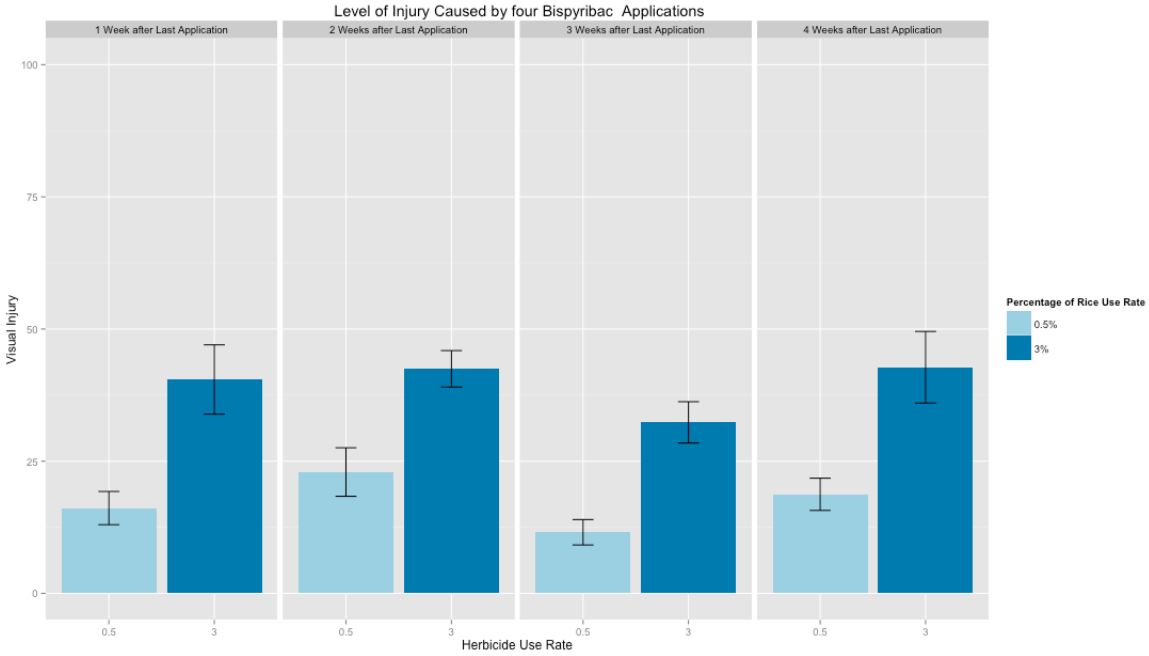

Figure 7 Level of walnut injury (±SE) caused by four, weekly exposures to simulated drift of bispyribac sodium in a young walnut orchard at UC Davis (two years of data).

3. Determine the effect of herbicide droplet application on walnut leaves and buds

The objective of this study is to evaluate the direct impact of micro-droplet application of bispyribac on walnut and compare the effects caused by leaf application with those caused by bud application.

In July 2016, a field study was initiated in a four-year old walnut orchard and replicated in a different location at the UC Davis experimental station. The trial was established as a randomized complete block with four replicates and experimental units were single branches. Flower formation and shoot development on the treated branches will be monitored in summer 2017.

Effect of droplet application on leaves. The herbicide was applied at three rates: 1, 3 and 5 one-microliter droplets of rice label aerial rate (0.8 oz/ac at 5 gal/ac volume) solution of bispyribac. In each branch, 10 leaves were selected and the treatment was applied to a maximum of 5 leaflets per leaf.

Effect of droplet application on axillary buds. Spray drift is a dynamic process due to evaporative losses of water in spray droplet as the droplet is carried off target. Water loss would increase the concentration of the herbicide within the droplet. In this experiment, bisypyribac was applied as a 1-microliter droplet directly on the axillary buds of walnut at three different concentrations:

1. 0.8 oz/ac at 5 gal/ac volume (typical aerial application rate)
2. 0.8 oz/ac at 3 gal/ac volume
3. 0.8 oz/ac at 1gal/ac volume

4. Evaluate the effects of simulated herbicide drift on walnut quality

A pilot study was initiated in summer 2016 to evaluate the effects of herbicide drift on walnut quality. In this case, in order to obtain a higher yield and reduce variability between trees, treatments were applied to three-year-old walnuts (in the orchard planted in winter 2014).

Walnuts were harvested in October 2016 and will be tested for quality, with particular attention given to kernel color and fatty acid content.

5. Determination of bispyribac residue persistence in walnut leaves and minimum herbicide concentration required to cause visible injury to walnut leaves

Using analytical methods provided by the manufacturer of bispyribac, a series of pilot studies to determine analytical detection limits of the herbicide in walnut leaves will be conducted.

Field data showed that bispyribac is able to cause injury symptoms on walnuts exposed to rates as low as 0.5% of the use rate in rice. In order to evaluate the minimum herbicide concentration required to cause injury, a greenhouse study on walnut nursery stock will be conducted.

A pilot analytical study was started at the UC Davis Orchard Park greenhouse on April 19, 2016. Bispyribac was applied using a greenhouse cabinet sprayer on walnut nursery stock at six rates: 0%, 1%, 3%, 10%, 50% and 100% of the rice use rate (44.8 g ai/ha). Leaf samples were collected 10 and 20 days after treatment application.

PUBLICATIONS OR REPORTS:

Galla, M., K. Al-Khatib, and B. Hanson. 2016. Effects of simulated rice herbicide drift rates on walnuts. Proc. California Weed Science Society. Sacramento, CA, January 14, 2016. 68:82.

Galla, M., K. Al-Khatib, and B. Hanson. 2016. Response of walnut to simulated drift of rice herbicides. Proc. Western Society of Weed Science. Albuquerque, NM, March 7, 2016. (paper #29).

Galla, M., K. Al-Khatib, and B. Hanson. 2016. Walnut response to simulated drift rates of selected herbicides. 60th Annual UC Weed Day booklet pg 3-4.

Galla, M., K. Al-Khatib, and B. Hanson. 2016. Effect of multiple exposures of simulated drift rates of rice herbicides on walnut. 60th Annual UC Weed Day booklet pg 5-6.

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS

In 2016, a preliminary greenhouse assay and four field studies were conducted. The overall objective was to determine the effect of herbicide drift on walnuts growth and yield.

In the greenhouse assay, bispyribac was applied using a greenhouse cabinet sprayer on walnut nursery stock at six rates: 0%, 1%, 3%, 10%, 50% and 100% of the rice use rate (44.8 g ai/ha). Samples were collected 10 and 20 days after application and stored in freezers. Residue analysis, following manufacturer protocol, will be conducted in winter 2017.

Up to this time, only data from the in-orchard drift simulation studies are available (objective 1 and 2). Statistical analysis of visual injury and new growth data collected in summer 2015 and summer 2016 did not show a significant year effect, so the data have been analysed together.

All herbicides caused significant damage and delayed growth of the young walnut leaves and shoots. Symptoms were first noticed three days after application and became more evident seven days after treatment. The severity of symptoms peaked 28 days after treatment (DAT) then plants started to recover. Bispyribac and bensulfuron caused similar damage to the walnuts: interveinal chlorosis, leaf deformation, stunted and distorted growth of shoots. Propanil caused significant damage only when applied at 10% of the use rate and caused leaf chlorosis, crinkling and necrosis.

Bispyribac appeared to be more active than bensulfuron when applied at rates lower than 3% of the rice use rate. At higher rates, however, bensulfuron showed more activity. Although recovery was noted at 28 DAT, chlorotic spotting and distorted shoot growth caused by ALS inhibitor herbicides was visible four months after treatment. Young shoot growth data indicate that rice herbicide drift may slow the growth of young walnut trees in the next year.

A similar trend was observed in the multiple drift exposure study. Particularly, the symptoms were similar to the ones observed in the single drift exposure trial but more pronounced. The maximum level of injury caused by four applications of bispyribac at 3% of the rice use rate was similar to that caused by one application of bispyribac at 10% of the rice use rate in the single exposure study suggesting an additive effect.

A trend toward reduced shoot growth after multiple drift exposure was also observed as the number of leaves counted in the shoots treated with bispyribac at 3% of the use rate was smaller than the number of leaves counted in the untreated shoots.

In conclusion, observing the data collected, it is possible to infer that rice herbicide drift may slow down and affect the growth of young walnuts. Yield data collected in fall 2016 indicates that the high drift rate (10% of rice label use rate) may reduce the subsequent year yield. As the walnut average weight was similar in all the treatments it is possible to infer that the lower yield is the results of lower number of walnuts in trees treated with the high drift rate.

Starting in winter 2017, results from droplet application studies, walnut quality studies and analytical studies will become available. These data will help clarifying the overall effect of rice herbicide drift in walnuts and will be used to define the next research steps.