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The effect of an irrigated buckwheat cover crop on grape vine productivity, and beneficial insect and grape pest abundance in southern California

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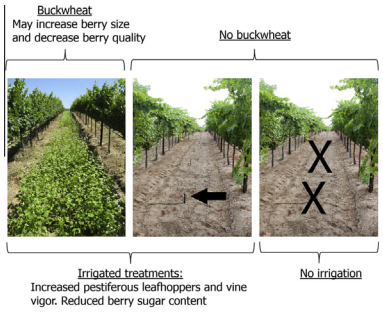
HIGHLIGHTS

- Treatments: irrigated buckwheat (BW); irrigation, no BW; control, no irrigation or BW.
- Irrigated BW cover crop may enhance the abundance of predatory thrips and predators.
- Pestiferous leafhoppers were 129–240% higher in irrigated BW and irrigated plots.
- Vine vigor was increased and berry sugar reduced in both irrigated treatments.
- Irrigated BW may increase berry size, decrease berry quality and lead to penalties for excess water use.

GRAPHICAL ABSTRACT



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ABSTRACT

The effect of an irrigated buckwheat cover crop on populations of beneficial insects and grape pests, vine growth, grape yield, and berry quality was investigated over 1 year in a commercial organic vineyard in southern California, USA. Buckwheat was grown in the spring and summer with additional irrigation that supplemented prevailing vine watering regimens. Treatments replicated four, three and six times respectively were: (1) buckwheat cover crop with supplemental irrigation between vine rows; (2) supplemental irrigation with no buckwheat cover crop; and (3) control plots with no buckwheat cover crop or supplemental irrigation. Flowering buckwheat was extremely attractive to beneficial insects at the beginning of the trial, resulting in 27 times more insects captured from shake sampling, compared with grape foliage in control plots. Results from sticky trap and visual count data indicated that buckwheat may enhance the abundance of generalist predators at certain times. However, densities of pestiferous leafhoppers on grape leaves in August was significantly higher (129–240% greater) in irrigated buckwheat and irrigated plots lacking buckwheat when compared with control plots. This increase in leafhopper density may be attributed to these pests preferring well-irrigated, vigorously growing vines. Mean cane weight was 222% and 170% greater for vines in irrigated buckwheat and irrigated plots lacking buckwheat, respectively, compared with controls indicating that vine vigor increased with supplemental irrigation. An irrigated buckwheat cover crop increased berry size, on average, by 0.67 mm for berries harvested on the side of the row that contained buckwheat, and reduced sugar content of berries by 3.2° Brix, compared with non-irrigated controls. Additionally, the buckwheat cover crop was associated with reduced berry quality because of insect feeding damage.

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Under drought conditions and water shortages, supplemental irrigation to support cover crops may result in water use penalties. Irrigated cover cropping during summer months may not be a viable pest management option for grape growers in southern California.

1. Introduction

Predatory and parasitic invertebrates can benefit from plant-based resources such as nectar and pollen, alternative hosts/prey, shelter, and mating sites (Gurr et al., 2004; Heimpel and Jervis, 2005). Floral and extrafloral nectar can maximize the longevity, fecundity, searching activity and parasitism/predation rates of most natural enemies, and beneficial insect sex ratios may become female biased as a result of these resources (Berndt and Wratten, 2005; Kost and Heil, 2005; Irvin et al., 2006; Hogg et al., 2011). Incorporating nectar producing cover crops in orchards and vineyards is potentially one way to enhance populations of beneficial insects in agricultural systems with the intention of improving pest control by providing natural enemies with nutritive resources (Gurr et al., 2004). Cover crops have been shown to enhance populations of natural enemies of vineyard pests which in turn reduced spider mite and leafhopper populations infesting grapes (Hanna et al., 1996; Nicholls et al., 2000; English-Loeb et al., 2003). Over a 4 year period in juice and table grape vineyards, Costello and Daane (1998) demonstrated that densities of third generation leafhopper nymphs were significantly lower in cover cropped plots compared to control plots. In some years, natural enemies maintained pest densities in cover crop plots below economic thresholds. Cover crops are recommended for soil management by the Californian wine industry which promotes sustainable practices through the Code of Sustainable Winegrowing Workbook (CSWW) because they can maintain soil quality, reduce erosion, and suppress weed growth (CSWA, Wine Institute, and CAWG, 2012).

In northern California, winter vegetation dries early in the grape growing season (i.e., by May) or is mowed or plowed under around June (Altieri et al., 2010). This weed management practice results in vineyards becoming large grape monocultures that lack diverse flora during summer months (i.e., July–September). Therefore, habitat management practices have been developed in Napa and Sonoma counties in northern California which involve intercropping five plant species to ensure flowering cover crops bloom in sequence throughout the season, of which buckwheat (Fagopyrum esculentum Moench [Caryophyllales: Polgonaceae]), is one (Altieri et al., 2010). These cover crop plantings are associated with decreasing pest densities when good establishment of flowering ground cover occurs (Altieri et al., 2010). Supplemental irrigation may be needed to keep buckwheat flowering (Altieri, Pers. Commun.). It is unknown whether this additional irrigation to maintain the cover crop effects vine vigor, grape yield, or berry quality.

In southern California, arid conditions during spring (i.e., March–May) also cause resident winter vegetation to die thereby limiting resources for beneficial insects in vineyards. Maintaining a 'nectar cover crop' in southern California vineyards throughout the spring and summer through additional irrigation may enhance populations of beneficial insects, thereby resulting in lower pest densities. Beneficial insects that may be present in vineyards and enhanced through nectar cover cropping include parasitoids (e.g., *Gonatocerus* spp., parasitoids of sharpshooter eggs, and *Anagrus erythroneurae* Triapitzyn and Chiappini, a parasitoid of leafhopper eggs; both are mymarids) and generalist predators (e.g., anthocorids, coccinellids, chrysopoids and arachnids) (Van Driesche et al., 2008). Key pests of grapes in California include leafhoppers (Hemiptera: Cicadellidae), mites (Acari: Tetranychidae) and thrips (Thysanoptera: Thripidae) (CSWA, Wine Institute, and CAWG, 2012). Sharpshooters (Hemiptera: Cicadellidae) are significant pests of grape in California due to their ability to vector Xylella fastidiosa Wells et al., a xylem-dwelling plant pathogenic bacterium that causes Pierce's Disease, a lethal malady of grapes (Freitag et al., 1952; Kaloostian et al., 1962; Blua et al., 1999). Other herbivore pests such as honeydew producing hemipterans like mealybugs (Hemiptera: Pseudococcidae), psyllids (Hemiptera: Psyllidae) and aphids (Hemiptera: Aphididae) can be pestiferous in vineyards (Bettiga, 2013), especially if they develop mutualisms with ants which disrupt biological control (Serra et al., 2006; Vanek and Potter, 2010; Navarrete et al., 2013).

Flowering cover crops may be attractive to pest species (Nilsson et al., 2011) or result in increased fitness of pest herbivores (Baggen et al., 1999; Begum et al., 2006; Lavandero et al., 2006; Nilsson et al., 2011). If cover crops are to be used in vineyards in southern California to enhance beneficial insect activity, it is important to select plant species that will support natural enemies while simultaneously having no detrimental effects on pest abundance, vine growth, yield, or grape quality. One potentially beneficial cover crop is buckwheat, which has been shown to enhance natural enemy reproduction and efficacy (Nicholls et al., 2000; Berndt et al., 2002; English-Loeb et al., 2003; Irvin et al., 2014). Other attributes favoring the selection of buckwheat are inexpensive seed that is readily available and germinates easily, it tolerates poor growing conditions and has a short sowing to flowering time (Angus et al., 1982; Bowie et al., 1995). Additionally, field trials resulted in the recommendation of buckwheat as a cover crop plant for enhancing beneficial insects in crops grown in arid soils in the southwestern USA (Grasswitz, 2013).

The studies reported here investigated the use of buckwheat as an irrigated spring and summer cover crop in a commercial organic vineyard in southern California. The effect of cover cropping on populations of beneficial insects and grape pests, vine growth, grape yield, and berry quality was determined.

2. Materials and methods

2.1. Experimental set up and design

In 2008, thirteen plots (28.7 m × 6 m [2 rows], with at least 36 m spacing between replicates) were selected in four blocks of Cabernet Sauvignon grapes in an organically-certified vineyard in Temecula, California (CA) USA (GPS coordinates: 33° 33′26.18″N × 117° 00′52.12″W; elevation: 499 m) (Fig. 1). Cover crop and control plots were randomly allocated per block, for a total of seven cover crop plots and six control plots. An additional treatment was incorporated as described below due to poor establishment of cover crops. Control plots consisted of six plots maintained under prevailing vineyard practices, which included machine and hand cultivation between rows to remove unwanted weeds, drip irrigation, and no fertilizer or pest control. On 1 May 2008, one side of each cover crop plot was sown with buckwheat (obtained from Outsidepride, Salem, OR) and the second side of the plot was sown on 11 June, 2008. Staggered seeding was done to produce a consistent supply of flowers. In 2009, treatments were re-randomized using the same thirteen plots outlined above and