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Evaluation of Drought Tolerant Cover Crops for California's Central Valley at the Lockeford PMC in 2015

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ABSTRACT

Farmers in California's Central Valley grow winter cover crops infrequently, with water availability a significant limiting factor. This trial is in the second year of a study to assess selected cover crops for drought tolerance and adaptability to the Central Valley. The increased implementation of cover cropping by farmers is a necessity for increasing soil health and water holding capacity. 'Triticale' is commonly grown due to its drought tolerance and above ground to below ground biomass ratio. 'Cucamonga' brome and 'Braco' white mustard are commercially available, and perform well under drought conditions as seen at the Lockeford Plant Matereials Center (PMC) in 2014. Hairy vetch is a legume known for high levels of spring residue production, mineralized nitrogen contribution, and weed suppression. The cover crops were planted on January 28, 2015. The experimental design was a randomized block with four replications. There were nine treatments: a high biomass cover control, triticale (T), 'Cucamonga' brome (C), hairy vetch (HV), and 'Braco' white mustard (B) as single species plantings; two component mixes of each grass and legume (THV & CHV); and three component mixes of each grass with the legume and the mustard (TBHV & CBHV). Canopy cover was recorded every two weeks after planting and biomass samples were collected at termination, 105 days after planting (DAP). 'Cucamonga' brome had consistently higher percentages of total planted canopy cover for the entirety of the trial. Hairy vetch plots had the highest total biomass for all treatments, and hairy vetch mixes had consistently higher biomass than 'Triticale' and 'Cucamonga' brome alone; however, no significant differences were found in total planted biomass between treatments. Soil moisture levels fell between 30 and 45 days but then stabilized around 12% until 90 DAP.

INTRODUCTION

Cover crops are increasingly used in US agriculture due to their benefits, which include: improved soil quality, increased soil organic matter, and enhanced nutrients (Liu et al., 2005; Magdoff et al., 2000), reduced soil compaction, increased water infiltration, and water holding capacity (Chen & Weil, 2010); increased presence of arbuscular mycorrhizae (Lehman, et al., 2012); competitive suppression of weeds and fewer insect pests (Clark, 2007). Consequent crops may have lower requirements for fertilizer, herbicides, pesticides, and greater drought tolerance.

In the Mediterranean climate of California, the potential requirement for irrigation during a dry year serves as a barrier to increased implementation of cover crops. California farmers who

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grow summer crops such as tomatoes, peppers, cotton, and corn frequently leave fields fallow over the winter instead of planting to cover crops. Producers of perennial crops such as almonds, walnuts, and vineyards may also avoid planting cover crops due to the perception that these will utilize water and nutrients that would otherwise be available to the crops. Aguilera et al. (2012), in a meta-analysis of management practices under Mediterranean cropping systems, showed that cover cropping increased carbon sequestration, soil organic matter, and water holding capacity, although, treatments in conjunction with conservation tillage and organic amendments were most effective.

The Lockeford Plant Materials Center (PMC) is located in San Joaquin County in the Central Valley. This is a Mediterranean climate, with hot and dry summers and precipitation during the fall, winter, and spring varies greatly from year to year. This study is the second to assess drought tolerance of cover crop species. The first year study in 2013-2014 included five species: triticale, 'Cucamonga' California brome (*Bromus carinatus*), Soft brome (*Bromus hordeaceus* ssp. *hordeaceus,* 'Scimitar' Spineless Burr Medic (*Medicago polymorpha*). 'Braco' white mustard (*Sinapsis alba).* 'Blando' brome and 'Scimitar' burr medic exhibited poor growth and contributed nominal biomass as well and were omitted for the 2015 trial, which included the following:

- '888' Triticale (T), a wheat/rye hybrid, frequently planted as a cover crop in California's Central Valley because it performs well under drought conditions. The variety used was selected because of its early lateral growth, and the seed was collected at the PMC.
- 'Cucamonga' California brome (*Bromus carinatus*) (C) a native annual grass release from the California Plant Materials Program in 1949 and extensively used for critical area plantings and as a cover crop in vineyards and orchards (USDA-NRCS, 2012).
- Hairy vetch (*Vicia villosa*) (HV) was a substitute for 'Scimitar' burr medic in the 2014 trial which performed poorly. It produces nitrogen and grow vigorously and also has proven to be hardy during the winter months. Additionally, hairy vetch provides water recharge in the root zone over winter and produces substantial residue in the spring.
- 'Braco' white mustard (*Sinapsis alba)* (B) has been selected for its drought tolerance, quick growth progression, weed suppression, and its ability to control diseases and suppress plant parasitic nematodes in soil.
- A high biomass cover control (faba, peas, oats, vetch), was planted for comparison of moisture levels in soil, but not the plant biometric data.

This study evaluates soil water content, canopy cover, and biomass production of four different species of cover crop and several mixes of those four species. Information gathered in this study will help us determine the effectiveness of these cover crop species in California's Central Valley during a time of drought.

MATERIALS AND METHODS

The treatment area was prepped by disking and cultipacking. Heavy rains in early December postponed the planting, which occurred on January 28, 2015, using a Truax range drill with a planting rate of 50 seeds/ft^2 for all treatments. No irrigation was applied to the trial through the course of the study. Triticale and 'Cucamonga' brome seed were sourced from PMC production, while 'Braco' mustard and hairy vetch were obtained from Kamprath Seed in Manteca, CA. In addition to the high biomass cover control, there were eight seed treatments in all: triticale (T), 'Cucamonga' brome (C), hairy vetch (HV) and 'Braco' white mustard (B) as single species plantings; two component mixes of each grass and legume (THV & CHV); and three component mixes of each grass with the legume and the mustard (TBHV & CBHV). The field was cultipacked again after planting to ensure good soil-to-seed contact, but no irrigation was applied to these plots following planting.

The experimental design was a randomized block design with four replications. Volumetric water content (VWC) was measured utilizing the Hydrometer II (Campbell Scientific, Logan, UT). Moisture readings were taken at three locations in each plot every 15 days, beginning 30 days after seeding. A photographic record of individual plots was also taken at this time. Biomass samples were taken immediately prior to termination from randomly chosen 0.5 m^2 sample plots. These samples were sorted into their respective plant categories, including a single weeds category where all non-planted species found in the sample were combined, and then dried to constant weight. Data sorting was performed utilizing Microsoft Excel and statistical analysis was carried out on Statistix 8.0; one-way ANOVA and Tukey HSD comparison tests were performed.

RESULTS AND DISCUSSION

The Drought Tolerant Cover Crop Study planted on January 28 was harvested after 105 days of growth. No irrigation was applied to the study and the total rainfall over the period was 2.83 inches. Data was collected for canopy cover, biomass at termination, and soil moisture readings.

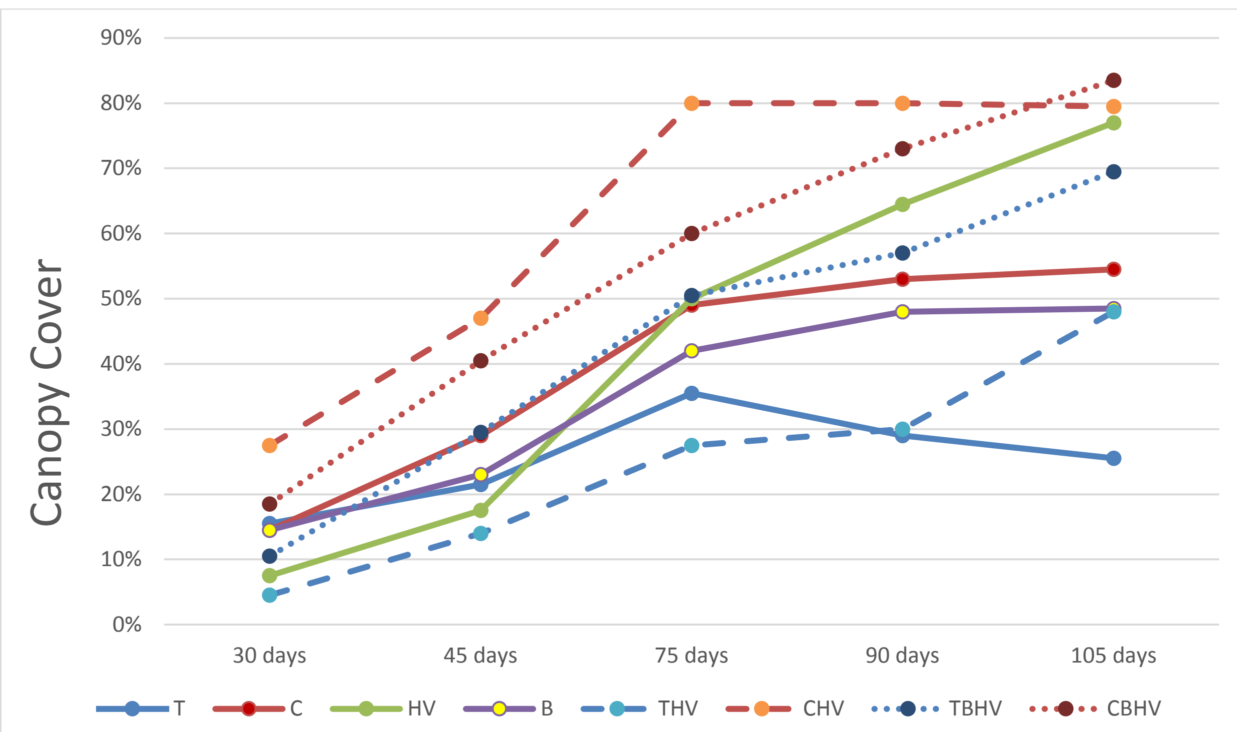

Figure 1. Average total planted cover (%) for each treatment from 30 days after planting to 105 days after planting; no data was taken at 60 days post-planting.

Canopy cover:

The variations in canopy cover over time are shown in Figure 1. The greatest increase in canopy cover from 30 days to 105 day was HV with a ~70% increase. Followed by CBHV ~65%, TBHV ~60%, CHV ~50%, THV ~45%, C ~40%, B ~35%, and T ~20%. The three and two component mixes exhibited more cover than the single mixes with the exception of hairy vetch, showing the importance of increased diversity with 'Braco' mustard included into the mix. 'Cucamonga' brome out performed the triticale, singly and in the two and three component mixes.

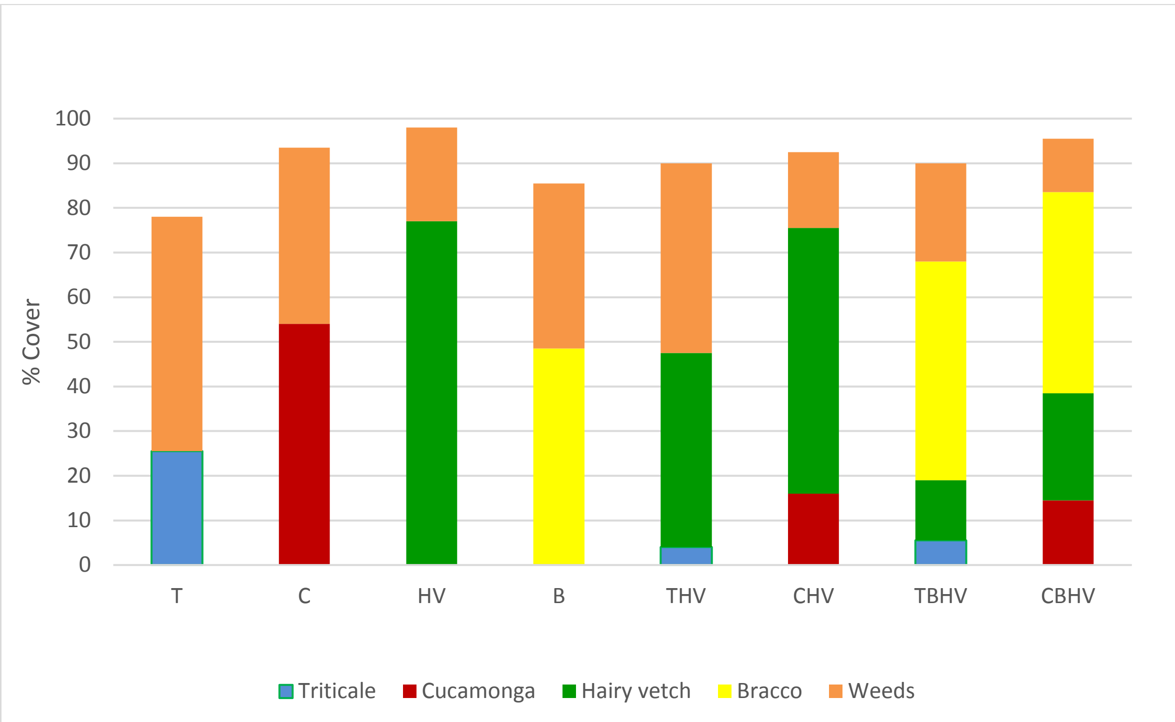

Figure 2. Species composition of canopy cover at 105 DAP in the Drought Tolerant Cover Crop study at the Lockeford PMC in 2015.

Canopy cover assessments were broken down to show the individual species contributions at 105 DAP (Figure 2). Hairy vetch was dominant as a single species, and performed well with the triticale and 'Cucamonga' brome, but did not compete as well in combination with the 'Braco' mustard. The weed contribution was lowest in the 'Cucamonga', Hairy vetch, mustard combination. The superior performance of the 'Cucamonga' over the triticale is clear and is similar to the result the previous year.

Figure 4. Drought Tolerant Cover Crop Study plots taken on 3/19/15 (50 DAP) and 4/28/15 (90DAP) at the Lockeford PMC.

Biomass at termination:

The growth in the treatments were variable as shown in Figure 4. The study was terminated at 105 DAP, with biomass data collected from randomly selected $0.5m^2$ plots. The above ground biomass was separated by species and dried to constant weight. The data is presented as yields as dry matter per m^2. There were no significant differences between treatments (Table1). The biomass for triticale was greater than 'Cucamonga' brome, in contrast to the higher incidence of Cucamonga brome in the canopy cover results. The highest biomass was with the single species hairy vetch and 'Braco' mustard.

Triticale is frequently selected for its strong root growth as well as its drought tolerance. It would be helpful to compare the root growth of 'Cucamonga' brome with triticale.

Table 1. Biomass harvested in the Drought Tolerant Cover Crop study at the Lockeford PMC in 2015.

Treatments	Biomass dry matter kg/m^2
Triticale	0.66[1]
'Cucamonga' Brome	0.53
Hairy Vetch	2.1
'Braco' White Mustard	2.0
Triticale & Hairy Vetch	1.1
'Cucamonga' & Hairy Vetch	1.3
Triticale, Hairy Vetch, & 'Braco'	1.1
'Cucamonga', Hairy Vetch, & 'Braco'	1.8

[1]No significant differences were deteced between the treatments.

Soil moisture: For the entirety of the study, from January 28 to May 12, precipitation totaled 2.83 inches; the distribution pattern is displayed in Figure 5.

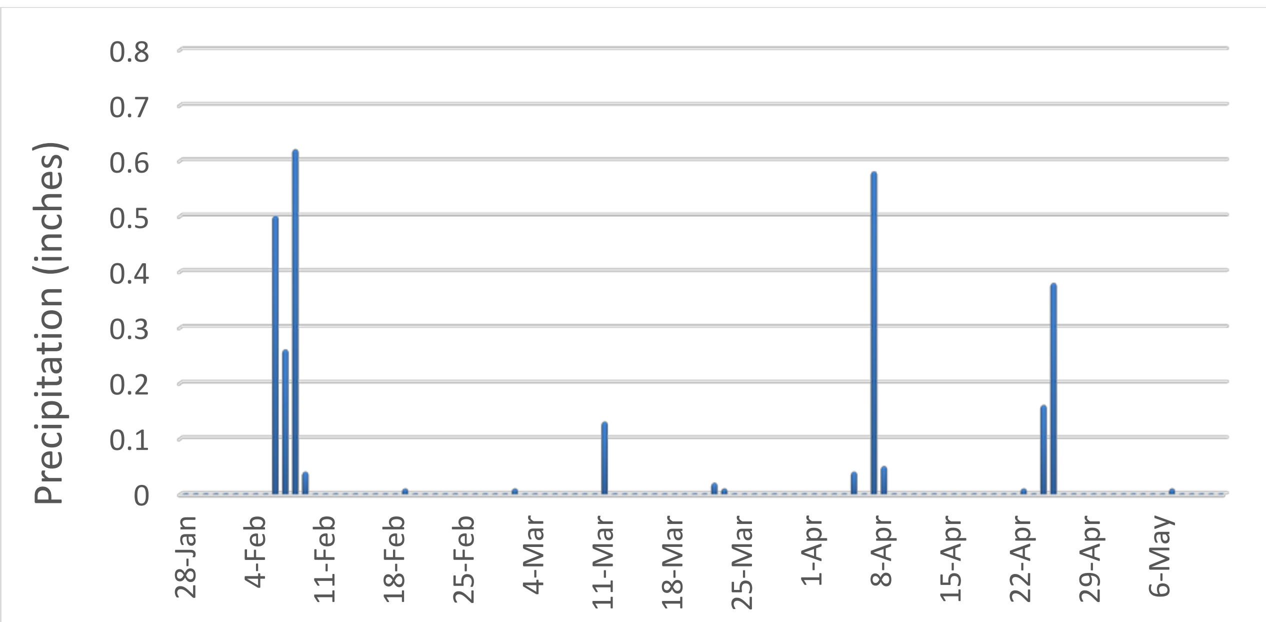

Figure 5. Precipitation over the period of the study at the Lockeford PMC in 2015.

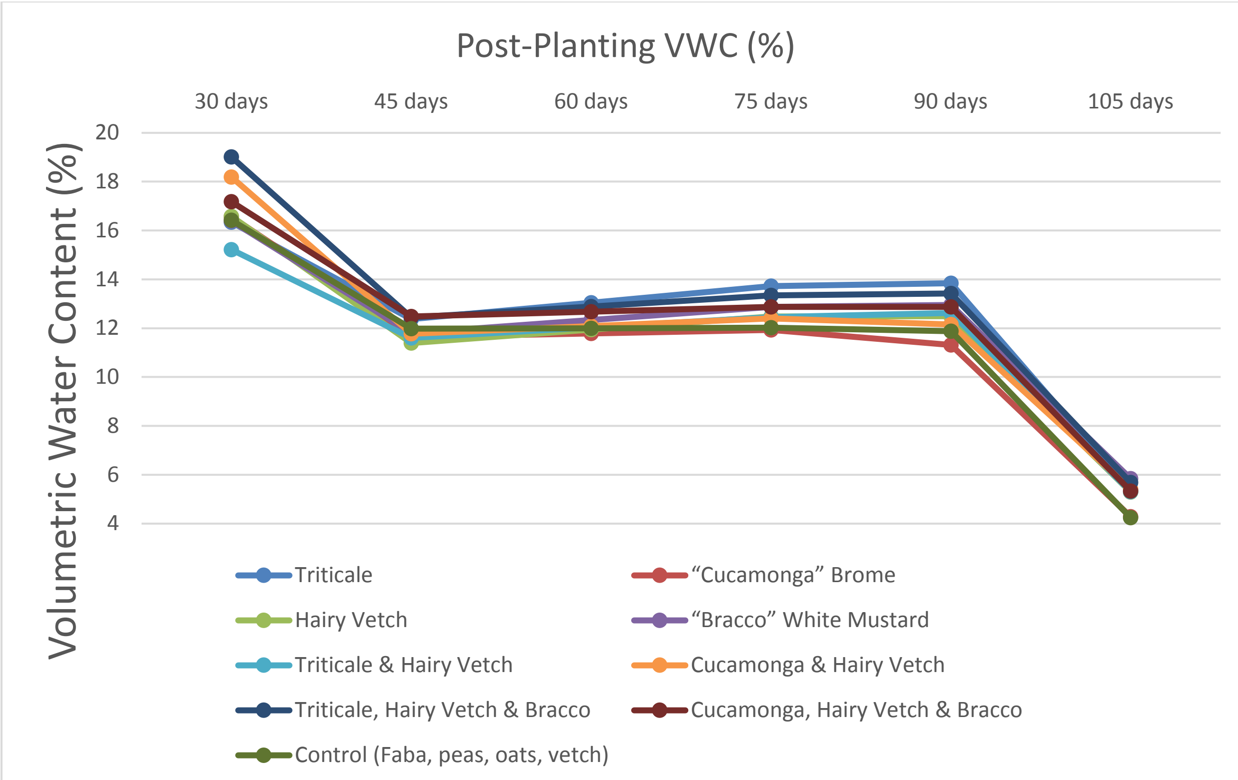

Figure 6. VWC (%) of all treatments from approximately 30 days after planting to 105 days after planting (no data was taken at 60 days post-planting, data is extrapolated).

At the beginning of the trial, soil moisture levels as measured by volumetric water content did not vary significantly between treatments, and this trend continued throughout the study (Figure 6. Table 2). The majority of moisture fell within the first 30 days of the trial. Soil moisture levels declined from 30 to 45 days but then were fairly stable around 12% moisture between 45 and 90 days after which they declined sharply. Observations of the cover crop plots at this time were that within the plantings moisture levels were high. This cannot be explained by the amount of rainfall during this period, but it appears that dew formation on the leaves of the plants likely contributed to the maintaining good moisture levels within the planting. After 90 days, air temperatures continued to rise and as plants matured water soil moisture fell rapidly.

Determinating the optimum time for termination of the cover crops is critical. These results indicate that the cover crops were not acting to deplete moisture between 45 and 90 DAP. We do not understand the environmental or plant related factors that contributed to this effect, and more studies are needed.

Table 2. Soil moisture (%), specifically volumetric water content, as an average of four treatment plots for the 2015 growing season at the Lockeford Plant Materials Center.

Treatment	**Soil Moisture (VWC%)**				
Date	**3/3**	**3/19**	**4/14**	**4/28**	**5/12**
Days after Planting	**30**	**45**	**75**	**90**	**105**
Triticale	16.34	12.37	13.73	13.84	5.36
‘Cucamonga’ Brome	16.56	11.64	11.93	11.31	4.28
Hairy Vetch	16.58	11.40	12.48	12.50	5.29
‘Braco’ White Mustard	16.39	11.80	12.88	12.95	5.84
Triticale & Hairy Vetch	15.22	11.61	12.46	12.63	5.30
‘Cucamonga’ & Hairy Vetch	18.19	11.78	12.40	12.15	5.41
Triticale, Hairy Vetch, & ‘Braco’	19.01	12.44	13.34	13.43	5.68
‘Cucamonga’, Hairy Vetch, & ‘Braco’	17.18	12.48	12.88	12.88	5.33
Control (faba, peas, oats, vetch)	16.42	11.98	12.02	11.88	4.24

All values in the same column were not significantly different in Tukey HSD means comparisons at $\alpha = 0.05$.

CONCLUSIONS

This study confirms that selected cover crops can be grown successfully athe Lockeford PMC in California’s Central Valley even under extreme drought conditions with no additional irrigation.

The most promising cover crops from 2014, ‘Cucamonga’ California brome and ‘Braco’ mustard also performed well in 2015. In addition, the legume hairy vetch performed well.

Soil moisture levels did not decrease between 45 and 90 days in the cover crop plots, indicating that the plants were not removing moisture from the soil during this time. More information is needed about soil moisture use by specific cover crops, to document the optimum time for termination.

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