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FINAL STUDY REPORT
Lockeford PMC, Lockeford, CA

Evaluation of Drought Tolerant Cover Crops for California's Central Valley

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ABSTRACT

Winter cover crops are grown infrequently by farmers in California's Central Valley because dry seasons are common over the winter. The potential requirement for irrigation during a dry year serves as a barrier to increased implementation of cover crops and growers frequently leave fields fallow. This study was conducted at the USDA Natural Resources Conservation Service, Lockeford Plant Materials Center (PMC) with the objective to evaluate cover crop species as alternatives and additions to the standard triticale. There were 12 seed treatments in all: triticale (T), 'Blando' soft brome (B), 'Cucamonga' California brome (C), 'Scimitar' burr-clover (S) and 'Bracco' white mustard (M) as single species plantings, two component mixes of the grass and legume TS, BS. CS and three component mixes TSM, BSM, and CSM. The experimental design was a randomized block with 3 replications. The study was planted into a Columbia fine sandy loam soil on November 26, 2013. There was no irrigation and rainfall over the planting period was 0.43 in during December zero in January and 5.65 inches during February and March. Germination of T, B, C and M was observed by December 31, 2013, no germination was observed in the legume S plots. At termination the highest biomass producers were C and M although these were not significantly different from the T control, B had significantly lower yields, while germination and growth of S was poor in all treatments.

INTRODUCTION

Cover crops are increasingly used in US agriculture due to the 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), competitive suppression of weeds and fewer insect pests (Clark, 2007). Consequent crops may have lower requirements for fertilizer, herbicides, pesticides and greater drought tolerance.

Even with these benefits, winter cover crops are grown infrequently by farmers in California's Central Valley. In this Mediterranean climate, summers are hot and dry and rainfall during the fall, winter and spring, varies greatly from year to year. Dry seasons are common over the winter. California farmers who grow summer crops such as tomatoes, peppers, cotton and corn frequently leave fields fallow over the winter instead of planting to cover crops. The potential requirement for irrigation during a dry year serves as a barrier to increased implementation of cover crops. Aguilera et al. (2012) in a meta-analysis of management practices under Mediterranean cropping systems found that cover cropping in combination with conservation tillage and organic amendments showed good performance in carbon sequestration, increasing soil organic matter.

Five species were included in this preliminary study. Triticale (T), a wheat/rye hybrid is frequently planted as a cover crop in California's Central Valley because it performs well under the drought conditions and was selected as the standard control. 'Cucamonga' California brome (*Bromus carinatus*) (C) is a release from the California Plant Materials Program in 1949. The release has been

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extensively used for critical area plantings and as a cover crop in vineyards and tree crops (USDA-NRCS, 2012). Soft brome (*Bromus hordeaceus* ssp. *hordeaceus)* (B) is an introduced species naturalized through the western states of the US. 'Blando' soft brome was collected from San Ramon in Contra Costa County in 1940 and released in 1954 (USDA-NRCS, 2014). 'Blando' brome is widely used for rangeland improvement, and as a cover crop in orchards and vineyards for erosion control.'Scimitar' Spineless Burr Medic (*Medicago polymorpha*) (S) was developed in western Australia as a drought tolerant legume. It is reported to perform well under drought conditions. This cultivar has been grown previously at the Lockeford PMC. 'Bracco' white mustard (*Sinapsis alba)* (M) was selected for its drought tolerance, good early growth, weed suppression, and its ability to control diseases and suppress plant parasitic nematodes in soil. This cultivar has been grown previously at the Lockeford PMC.

Identification of additional cover crops that will function well under drought conditions in California is the reason to undertake this study. The objective of this preliminary trial was to evaluate performance of these cover crop plants under drought conditions alone and as mixtures compared to the triticale control. This study falls within the stated mission of the PMC to address issues related to the resource concerns of soil health and water quality.

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MATERIALS AND METHODS

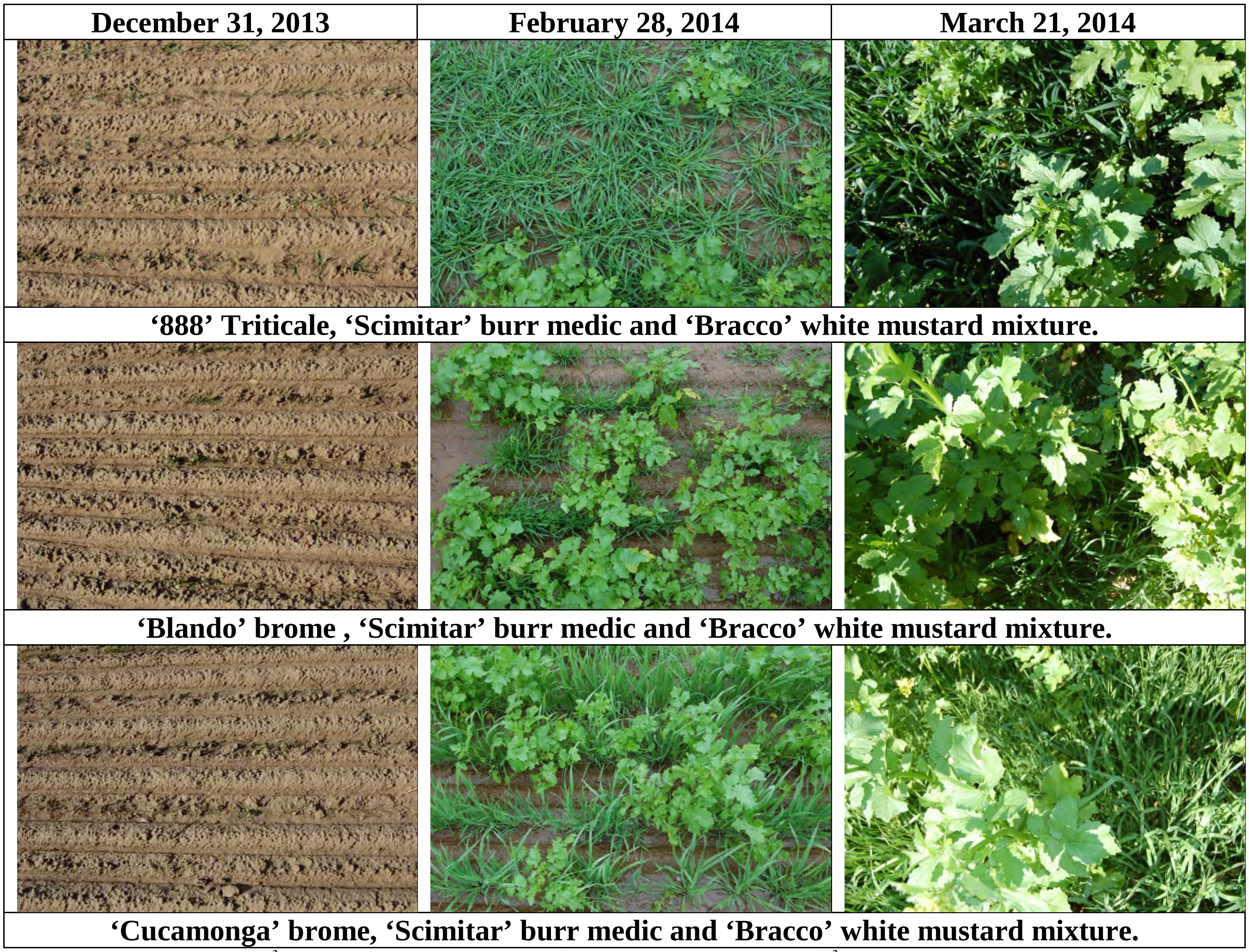
The study was planted into a Columbia fine sandy loam soil at the Lockeford Plant Materials Center. Prior to planting the area was prepped by disking and cultipacking. Irrigation was applied by wheel line in stages during October with 2 x 1 inch applications to germinate surface weed seeds that were then treated with glyphosate to ensure a clean seed bed. Seed of '888' triticale, 'Blando' and 'Cucamonga' bromes were grown at the PMC while 'Bracco' mustard and 'Scimitar' burr medic were obtained from Kamprath Seed, Manteca, CA. There were 12 seed treatments in all: triticale (T), 'Blando' (B), 'Cucamonga' (C), 'Scimitar' (S) and 'Bracco' (M) as single species plantings, two component mixes of the grass and legume TS, BS. CS and three component mixes TSM, BSM, and CSM. The experimental design was a randomized block with 3 replications. Individual plots were 5 x 400 feet (the width of the drill x length of the field). Planting occurred on November 26, 2013, using a Truax range drill (Truax Co Inc, New Hope MN) with a seeding rate of 50 seeds/ft^2 for all treatments (Figure 1). The field was cultipacked again after planting to ensure good soil to seed contact.

Figure 1. Planting Drought Tolerant Cover Crop Study on November 27, 2013, planted plots are in foreground with planting carried out using a Truax range drill. ©Lockeford PMC.

Moisture readings were taken using a Hydrosense II monitoring unit at three locations in each plot on a 15 day schedule after seeding. No irrigation was applied to these plots following planting. A photographic record of individual plots was taken at 30 day intervals after planting. Biomass readings were to be taken from 3 x 1 ft^2 samples at random areas in the upper middle and lower areas and from the central rows from each treatment plot. The biomass samples were sorted into different plant categories and weeds and dried to constant weight. Data was analyzed using the Statistix 8 software.

RESULTS AND DISCUSSION

Germination and Growth Germination of triticale, ‘Blando’brome, ‘Cucamonga’ California brome and ‘Bracco’ mustard occurred by December 31, 2013, with no germination observed in the legume S plots. Growth was slow for all treatments during January with cold temperatures and no rain. Unfortunately photos of growth at 60 days (Jan 31) were lost. By ninety days, good soil cover occurred for plots containing triticale and ‘Cucamonga’ brome (Figure 2). ‘Blando’ was not as vigorous or as effective a ground cover as the grasses ‘Cucamonga’ and triticale. Only patchy and sparse germination of ‘Scimitar’ was observed.



Total seeding rate was 50 seeds/ft^2, therefore the actual seeding rates for each species were 16.6 seeds/ft^2.

Figure 2. Growth and coverage of the Grass, Legume and Mustard cover crops over the 2013-2014 growing season at the Lockeford Plant Materials Center. ©Lockeford PMC.

Soil Moisture Precipitation over the entire growing season was 6.28 inches. The fall and winter were very dry, with 0.43 inches of precipitation on December 6 and 7, followed by no more rainfall until Jan 30, 2014. Following this seven week dry spell, rainfall normal for the Lockeford area occurred in February and March (Figure 4).

Soil moisture levels at that start of the trial did not vary significantly from each other and continued to decline until February 5 (Table 1). 'Scimitar' burr medic (S) exhibited poor growth and little biomass and had the highest moisture levels, significantly different from T, TS, TSM, BSM and CSM which were the driest.

Figure 3. Standing water on unvegetated 'Scimitar' burr medic plot compared to vegetated BM treatment on February 28, 2014.

Following rainfall on February 6-9, standing water was present on the 'Scimitar' planted plots, and infiltration occurred on the vegetated plots (Figure 3). Soil moisture levels on February 19 were lowest for the S and BSM treatments at 11.7% and 11.9% respectively, and significantly different from T at 14.7% moisture (Table 1). The tritical treatment also had the highest moisture levels on 4/14/14 (Figure 5).

The role of cover crops to provide increased water infiltration into soil is well known (Chen & Weil, 2010; Clark, 2007; and Ingels et al., 2002). Our results indicated that '888' triticale was particularly effective in increasing water infiltration after precipitation events. Triticale is currently widely used as a cover crop in the Central Valley. '888' triticale is a late maturing cultivar with lateral leaf growth and it would be interesting to see if other triticale cultivars showed similar increases in infiltration. The 'Scimitar' burr medic due to the poor growth was essentially a bare ground control treatment, with least increase in soil moisture.

Table 1. Soil moisture (%) as an average of three treatment plots over the 2013-2014 growing season at the Lockeford Plant Materials Center.

	Soil Moisture %							
Treatments	**12/12**	**12/26**	**1/9**	**1/27**	**2/5**	**2/19**	**3/5**	**4/4**
T	**11 a**	**8.2 a**	**6.5 a**	**4.5 a**	**4.5 b**	**14.7 a**	**8.2 a**	**23.5 a**
B	**9.9 a**	**7.7 a**	**6.8 a**	**4.7a**	**5.6 ab**	**12.8 ab**	**7.7 a**	**19.4 abc**
C	**11.3 a**	**8.1 a**	**7.3 a**	**4.4 a**	**5.5 ab**	**13.7 ab**	**8.1 a**	**20.5 abc**
S	**10.7 a**	**7.9 a**	**6.8 a**	**5.2 a**	**6.1 a**	**11.7 b**	**7.9 a**	**21.8 abc**
M	**10.5 a**	**7.6 a**	**6.7 a**	**5.0 a**	**4.9 ab**	**13.3 ab**	**7.6 a**	**19.9 abc**
TS	**10.5 a**	**7.9 a**	**6.8 a**	**5.3 a**	**4.6 b**	**14.2 ab**	**7.9 a**	**22.9 ab**
BS	**10.9 a**	**7.4 a**	**6.4 a**	**5.4 a**	**5.3 ab**	**12.6 ab**	**7.4 a**	**21.1 abc**
CS	**10.4 a**	**7.7 a**	**6.5 a**	**4.9 a**	**5.5 ab**	**12.9 ab**	**7.7 a**	**21.0 abc**
SM	**10.7 a**	**7.5 a**	**6.6 a**	**4.8 a**	**5.3 ab**	**13.2 ab**	**7.5 a**	**20.0 abc**
TSM	**10.2 a**	**7.1 a**	**5.6 a**	**4.3 a**	**4.5 b**	**13.1 ab**	**7.1 a**	**19.7 abc**
BSM	**10.3 a**	**7.2 a**	**5.5 a**	**4.1 a**	**4.6 b**	**11.9 b**	**7.2 a**	**17.4 bc**
CSM	**9.9 a**	**7.4 a**	**6.0 a**	**4.6 a**	**4.4 b**	**12.4 ab**	**7.4 a**	**16.4 c**

Values within the same column followed by the same letter are not significantly different in Tukey HSD means comparisons at α = 0.05.

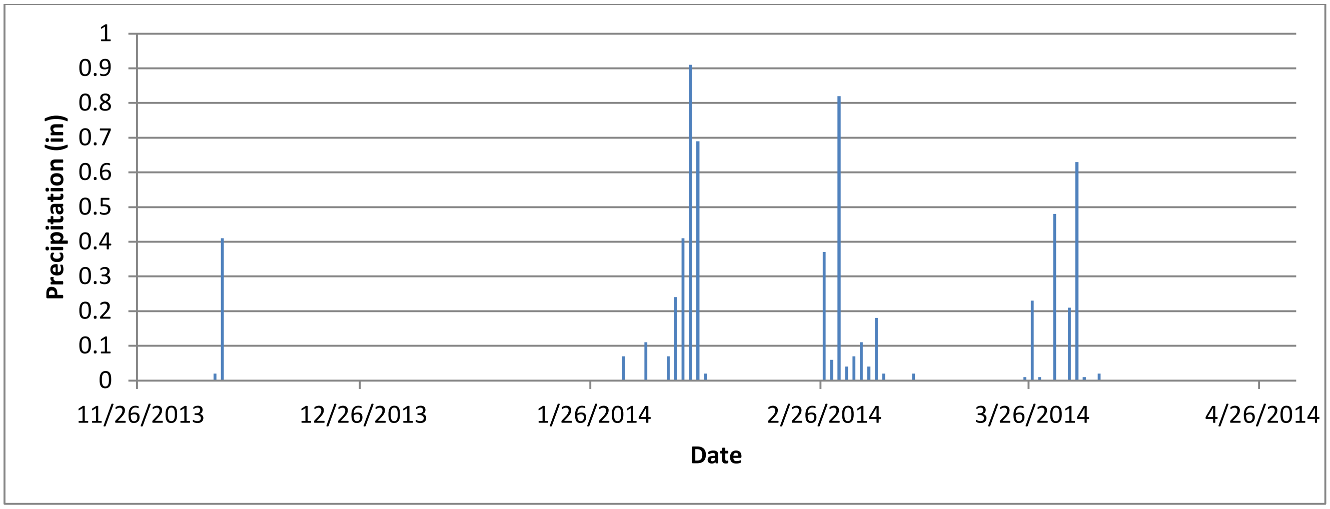


Figure 4 Precipitation during 2013 and 2014 season at the Lockeford Plant Materials Center.

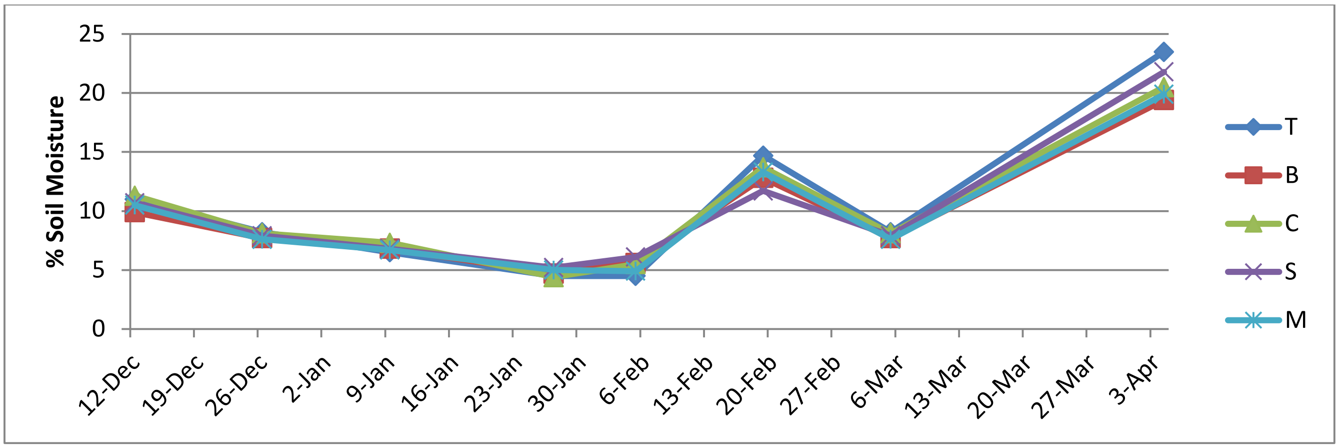
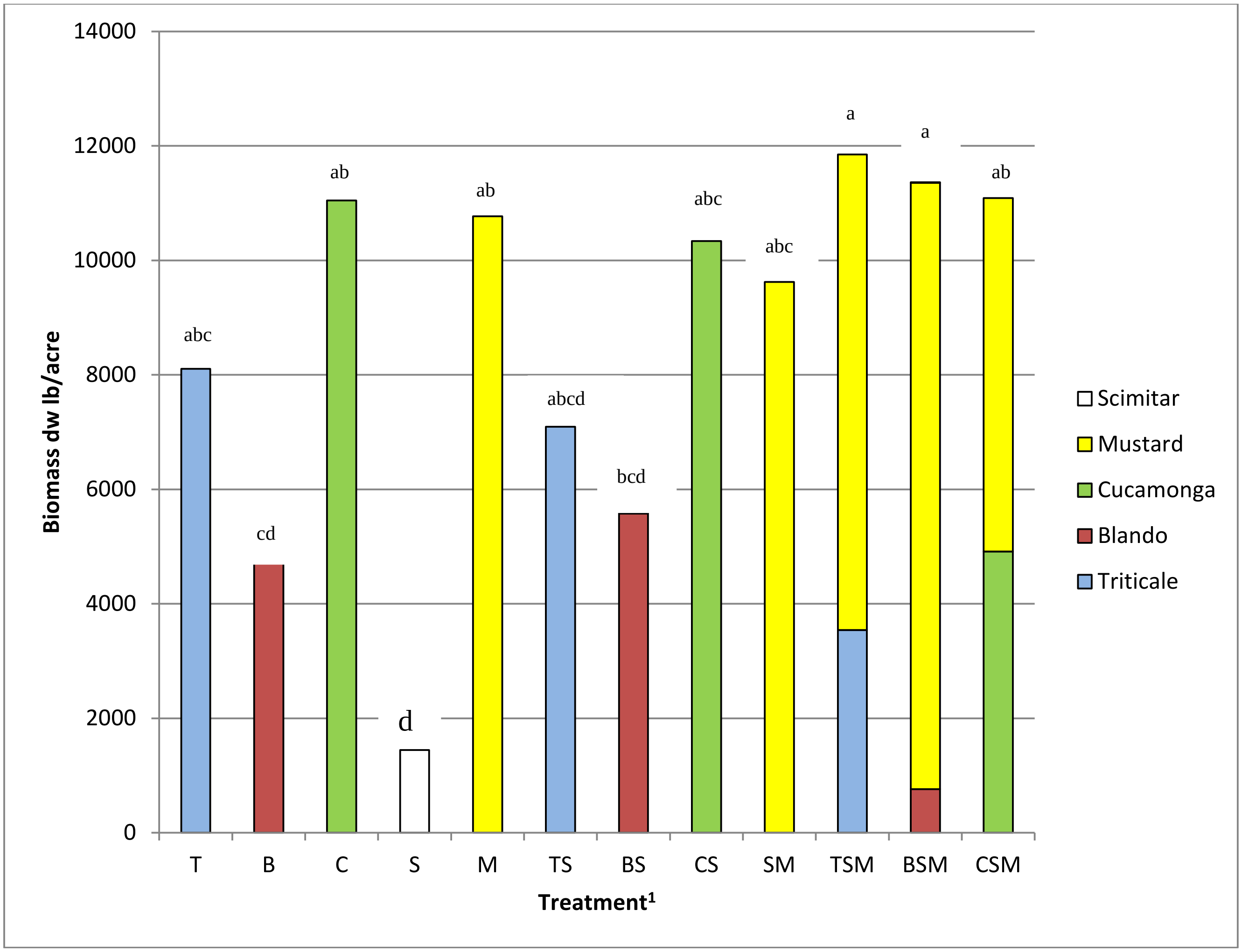


Figure 5. Average soil mositure during 2013 and 2014 for the triticale (T), 'Blando' soft brome (B), 'Cucamonga' California brome (C), 'Scimitar' burr clover (S) and 'Bracco' white mustard (M) treatments.

<u>Biomass Production</u> The highest yields in the single species plots were 'Cucamonga' brome and 'Bracco' mustard although these were not significantly different from the triticale control (Figure 6). 'Blando' brome had significantly lower yields, while germination and growth of 'Scimitar' was poor in all treatments. For the two component treatments of TS, BS,CS and SM with each component planted at 25 seeds/ft^2 the biomass yields were lower but not significantly different from the single species plantings. As growth of the legume 'Scimitar' was negligible in these treatments, plants compensated for the lower seeding rate by increased growth. The highest total biomass yields in the trial were in the three triple combination mixtures with mustard contributing the majority of the biomass. 'Cucamonga' brome was the most competitive against the mustard, while 'Blando' brome contributed the least.
Weed distribution tended to be patchy, but there were significant differences between the 'Scimitar' burr clover plots with which had the highest biomass of weeds at 3368 lbs dm/acre compared to the 'Cucamonga' brome, and 'Bracco' mustard treatment at 0 and 6 lbs dm/acre respectively.



[1]Plots with single species of (T) triticale, (B) 'Blando' brome, (C) 'Cucamonga' brome, (S) 'Scimitar' burr medic, and (M) 'Bracco' mustard were planted at 50 seeds/ft^2. The total seeding rate remained at 50 seeds/ft^2 for the combined plot treatments. Treatment values with the same letter are not significantly different in Tukey HSD means comparisons at α = 0.05.

Figure 6. Botanical composition of above Ground Biomass at Cover Crop Termination at the Lockeford PMC in 2014

Both 'Cucamonga' California brome and 'Bracco' mustard performed well during the drought conditions of 2013-2014. 'Cucamonga' brome is a native annual grass adapted to medium to coarse soils with annual precipitation of 8 inches (USDA-NRCS, 2012) and could function as a native substitute for triticale. Its performance in this trial with only 6.28 inches of rainfall indicates that it has potential to be more widely used as a cover crop. It is self-seeding and so should be terminated prior to seed set to avoid volunteer establishment. 'Bracco' mustard is appropriate alone or in combination plantings although most growth was over the last month of the trial. Brassica species with a large taproot are effective in reducing soil compaction and increasing water infiltration (Chen & Weil, 2010; Clark, 2007). In addition, mustards are excellent pollinator plants, especially for European honey bees, and this makes them especially attractive for crops depending upon pollinators, such as stone fruits, including almonds. No supplemental irrigation was supplied to the cover crop, and the average rainfall that occurred in spring contributed to the high levels of productivity of these crops 'Blando' brome performed poorly and probably will be excluded from further trials. Although 'Blando' brome is naturalized in California, and widely used for range plantings, the plant can be weedy under some circumstances (USDA-NRCS, 2014).

The poor performance of ‘Scimitar’ burr medic in this study highlights a lack of readily available drought tolerant legumes for use in California. The most common legumes used in the Central Valley are Faba or bell bean, Austrian winter pea and various species of vetch and all of these species do better with substantial fall rainfall (Ingels et al, 2002). The fall and winter were dry, and our experience with these legume species in previous years at the PMC is that these cover crops perform well when a wet fall and is followed by a dry spring. Although the results of this year’s study is promising for ‘Cucamonga’ California brome and ‘Bracco’ mustard, further studies are needed with these and other legume species.

CONCLUSION

‘Cucamonga’ California brome produced the highest levels of biomass in this trial, superior even to the standard triticale while ‘Bracco’ mustard also produced higher biomass than ‘888’ triticale. ‘Blando’ soft brome and ‘Scimitar’ white mustard performed poorly and will not be included in further studies of drought tolerant cover crops. Following rainfall, soil moisture levels increased most in the triticale plots, indicating good water infiltration. The findings from this preliminary study will be incorporated into future studies of drought tolerant plantings to enable solid recommendations for the agricultural community.

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