Forage Legume Bee Project

UNIVERSITY OF VERMONT EXTENSION

CULTIVATING HEALTHY COMMUNITIES

Research Project Final Report

Enhancing Nectar Production with Clover

–

Innovative Methods to Utilize Alsike and White Clover in Vermont Hay Fields

2013 – 2015

Support for this project was provided by a USDA NE SARE (Northeast Sustainable Agriculture Research and Education Program) Partnership Grant, Project ONE13-175.

NORTHEAST SARE Sustainable Agriculture Research & Education

The UNIVERSITY of VERMONT

Plant and Soil Science

Northeast SARE Partnership Project:

Enhancing Nectar Production with Clover – Innovative Methods to Utilize Alsike and White Clover in Vermont Hay Fields

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Introduction

A decline in honeybee populations in Vermont over the past few decades has been attributed to many factors including Varroa mites, disease, pesticide exposure, and a loss of nectar and pollen resources. Many beekeepers in Vermont believe that the lack of food during mid-to-late summer is an important stressor on honeybees in Vermont. Historically, an important food resource for honeybees in Vermont has been from forage legumes such as alfalfa, clovers and birdsfoot trefoil. This resource has declined over the past two to three decades due in part to 1) a decline in acreage of legume hay crops, particularly alfalfa, and 2) an increase in intensity of harvest by dairy farmers in order to optimize feed quality resulting in very little bloom periods.

The goal of this project was to increase the acreage of flowering clovers that provide sustained nectar flows during this critical summer period. In Vermont, the best clovers for honeybees are white clover and Alsike clover since their florets are small and accessible. Although not a true clover, Birdsfoot trefoil is also highly regarded by bee keepers for its nectar and pollen. Red clover has larger florets more suited for larger pollinators such as bumblebees.

With this project, UVM Extension in collaboration with The Vermont Beekeepers Association has set an initiative to promote the use of more pollinator plants that would enhance food resources for honeybees and other wild pollinators. As part of this initiative, the VBA would like to promote hay and pasture crops that are more 'bee friendly' without sacrificing forage quality that dairy and other livestock farmers are dependent upon. However, there is a need to conduct field research to determine the feasibility of various mixtures and management practices that would enhance forage legume bloom in mid-to-late summer while dairy livestock farmers still meet their feed goals of high quality forage.

Research Objectives

The overall goal was to test the feasibility of using clovers in hay systems to enhance nectar production during the mid to late summer periods. The first study objective was to test the feasibility of improving nectar flow for honeybees by introducing Dutch white clover into grass hay cropping systems and assess its impact on flower production and foraging honeybees. The second study objective was to test the feasibility of growing mixtures of flowering clovers with alfalfa managed for hay and assess its impact on flower production, forage yield and forage quality.

Objective 1: Utilizing Dutch White Clover in Grass Hay Fields

The first objective was to test the feasibility of improving nectar flow for honeybees by introducing Dutch white clover into grass hay cropping systems and assess its impact on flower production and foraging honeybees. There are three general types of white clover based on size - large, intermediate and short. The 'Dutch' white clover are of the shortest types and are often found in lawns and other intensely defoliated areas. *Our hypothesis is based on the observation that there can sometimes be a flush of white clover bloom in between cuttings of grass hay.* The success rate of overseeding white clover into an existing grass hay field can vary greatly depending on time of seeding, environmental conditions, soil type, amount of thatch and competition from existing vegetation. Secondly, even if the clover is in flower between cuttings, we really don't know the extent of nectar production from these flowers. Weather conditions as well as competition for light and water from the grasses in the hay mixture can greatly influence flower formation and nectar production.

In April 2013, a strip trial was planted into an existing grass hay field at the Duclos-Thompson Farm in Weybridge, Vermont with the assistance of Mr. Tom Duclos. Treatments included a no-treatment control plus four different seeding scenarios using Dutch white clover: two seeding rates (2 vs. 4 lbs./acre) using two methods of seeding: (no-till planted with a Haybuster 107C drill or broadcast seeding with a spinner-spreader (Figures 1 and 2). Strips were 50 feet wide and 150 feet long. There were two replications.

Fig. 1. No-till drill used in study

Fig. 2. Broadcast seeding white clover

Stands were monitored for clover germination (Figure 3) and clover head counts were made throughout the season (Figure 4). On each day that clover heads were counted, ten 20” x 20” quadrat counts were made per treatment strip and used to estimate clover head populations.

Results – Objective 1

Within a month after planting, there was a higher number of white clover seedlings at the 4 lb./a compared to the 2 lb./a seeding rate regardless of seeding method (data not shown); however, by the middle of the summer, the actual flower head populations were similar across treatments (Figure 5). Only during the second growth period were the seeded treatments higher in flower counts compared to the control; however, the control plots had a large number of white clover flowers indicating that there was already a large seedbank that existed on this field. It is likely that flower population did not differ between seeding rates because white clover flower numbers are more affected by stolon population

rather than actual plant population. In addition, it is likely that existing white clover seed already present in the soil may have germinated and contributed to the stand in 2013.

Fig. 3 White clover seedlings three weeks after seeding.

Fig. 4 Counting clover heads.

In 2014, the study was dominated by volunteer red clover. It is likely the seedbank was quite high in red clover and conditions in early 2014 encourage germination. Due to this domination, there was significantly less white clover across all treatments and no measurements were made that year.

In 2015, flower head data was collected after the first harvest to see if there was any residual effects of the 2013 seeding treatments. Due to the extremely wet month of June, the first cut was not made until the first of July. An extended dry period followed and the second harvest was not made until mid-August. Overall, there were no significant differences amongst the treatments (Figure 5). There was

Figure 5. White clover flower head populations in the seeding year during the second and third growth periods in 2013 and during the second growth period in 2015 of a mixed grass/clover hay field, Duclos Farm, Weybridge, VT.

no way to distinguish between any Dutch white flower heads from any other cultivar or ecotype that may have already been in the soil seedbank at this site. Clover populations were lower in 2015 than 2013 at this site. This may reflect the year to year variation observed in clover abundance in pastures and hay fields due to variation and extremes in rainfall, dry periods and temperature patterns.

Objective 2: Enhancing Summer Nectar Production with Alfalfa-Clover Mixtures

Our second objective was to test the feasibility of improving nectar flow by growing mixtures of various early maturing clovers with alfalfa managed for hay and assess its impact on flower production, honeybee activity, forage yield and forage quality. *Our hypothesis was that white clover and/or alsike clover would bloom before the alfalfa was ready to cut and sustain a bloom until the stand was cut.*

To test this hypothesis, two trials were implemented in 2013 (Table 1). The first one was a replicated strip trial planted at the Huestis farm in Bridport, VT on a Vergennes moderately well-drained clay. Mr. Art Huestis had managed this site for over 40 years successfully growing alfalfa for his dairy herd. The sites was tested for soil nutrients and received recommended rates of phosphorus and potassium.

The study included seven treatments (Table 1) replicated four times, including two seeding rates of three clovers. Each plot was 30 by 180 feet. Mr. Huestis planted the whole area on May 3, 2013 with a single seeding rate of alfalfa at 10 lbs. per acre and one bushel of oats. Clover treatments were broadcast planted the same day within each respective plot using a hand spinner spreader. The clovers included 'Pinnacle' and 'Crusade" white clover and 'common' alsike clover seeded at two seeding rates, 2 and 4 lbs. per acre, respectively. There was also a non-clover control consisting of alfalfa only.

After planting the site, there was a month of record rainfall which kept the site saturated with water. Due to the inclement weather, there was only one cutting made in early August. An assessment of the stand early September showed that the percentage of alfalfa in the stands ranged from 47 to 55 percent in the clover mixture plots and 71% in the alfalfa-only control plots. The clovers ranged from 21% to 41% of their respective stands depending on clover variety and seeding rate. The alfalfa-only control had about 10% clover reflecting what was in the soil seedbank prior to planting.

A second small plot, replicated study was seeded August 22, 2013 at the UVM Horticultural Research Farm on a well-drained, Deerfield fine sandy loan. The clover treatments were the same as those at the Huestis farm, but the seeding rates were 3 lbs. and 5 lbs. per acre, respectively, and the alfalfa seeding rate varied (see Table 1). In addition, this study also included a mixture of alfalfa with all three clovers combined seeded at two different seeding rates. The site was slow to establish due to a dry August and September. However, the stand was in adequate shape by spring of 2014 although it had to be hand weeded.

Clover head populations were collected from each plot every one to two weeks starting in June after the first harvest was made and ending in early September. For each strip plot at the Huestis farm, counts were made from ten 20" x 20" quadrats run diagonally across the strip. At the Hort farm, three quadrat counts were made per plot. White clover and alsike clover heads were recorded separately per plot.

Table 1. Treatment description of alfalfa/clover studies at two sites in Vermont.

Heustis Farm Study

Treatments		Sd Rate
Trt No	Trt Mix	*lb/a*
1	Alfalfa	10
2	Alfalfa	10
	'Crusade' White Clover	2
3	Alfalfa	10
	'Crusade' White Clover	4
4	Alfalfa	10
	'Pinnacle' White Clover	2
5	Alfalfa	10
	'Pinnacle' White Clover	4
6	Alfalfa	10
	Alsike Clover	2
7	Alfalfa	10
	Alsike Clover	4

Hort Farm Study

Treatments		Sd Rate
Trt No	Trt Mix	*lb/a*
1	Alfalfa	20
2	Alfalfa	15
	'Crusade' White Clover	3
3	Alfalfa	12
	'Crusade' White Clover	5
4	Alfalfa	15
	'Pinnacle' White Clover	3
5	Alfalfa	12
	'Pinnacle' White Clover	5
6	Alfalfa	15
	Alsike Clover	3
7	Alfalfa	12
	Alsike Clover	5
8	Alfalfa	15
	All three clovers	1 lb each
9	Alfalfa	12
	All three clovers	2 lb each

At the Huestis site, yields of the 2nd and 3rd harvest were determined using a falling plate method (Rayburn, 1997). Ten falling plate heights were collected per strip one day before the second and third harvest, respectively. The falling plate was calibrated by clipping 12 to 16 quadrats associated with a falling plate height measurement. At the Hort Farm site, yields were determined for each cutting using a Carter small plot harvester by weighing a harvested sample cut from a 3' by 16' strip out of the center of each plot. Hand sub-samples were then collected from each plot, bagged, weighed, dried at 60°C, and reweighed to determine dry matter content.

In 2014 at the Hort Farm, samples from selected treatments were collected during the 3rd harvest to determine crude protein, neutral detergent fiber, and digestibility. Botanical separations between alfalfa, clover, and weeds were made at the same time.

Results – Objective 2

Forage Yield and Stand Persistence – At the Heustis site in 2014, there were no significant differences in yield of either the second or the third harvest for any of the clover mixture treatments nor the pure alfalfa (data not shown). Our observation was that the clover was most prevalent in the areas of the field with the thinnest alfalfa. This was particularly true for the alsike clover and somewhat for the 'Crusade' white clover. 'Pinnacle' white clover tended to be better dispersed across the strips as determined by clover flower head counts. Unfortunately, the complete stand at this site was killed out during the winter of 2014/2015 so we only got data from the 2014 year. It was a very frigid winter with

variable snow cover in the Champlain Valley region resulting in a high amount of alfalfa winter injury or winter kill across the region.

At the UVM Hort Farm location, total seasonal yields were generally not affected by most single-clover treatments (Table 2). Only the high seeding rate of three-way clover seeding (Treatment #9) had consistently lower yields in both 2014 and 2015. The combination of all three clovers and the high clover seeding rate may have created too much competition for the alfalfa in the seeding year resulting in a lower density of alfalfa plants. Observations showed that the majority of the clovers in this treatment were white clover.

Table 2. Forage yield of alfalfa/clover treatments in 2014 and 2015 at the Horticultural Research Farm, South Burlington, VT. Botanical composition was made from hand separations.

Treatments			Total Seasonal Dry Matter Yields		Botanical Composition (8/17/2014)			Botanical Composition (8/14/2015)		
Mixture Number	Species/Varieties	Seeding Rate	2014	2015	Alfalfa	Clover	Weeds	Alfalfa	Clover	Weeds
		lb/a	*tons DM/acre*		*% or cover*			*% or total dry matter*		
1	Alfalfa	*20*	3.7 *ab*	4.2 *a*	86%	0%	14%	93%	0%	7%
2	Alfalfa 'Crusade' White Clover	*15* *3*	3.1 *bc*	3.6 *ab*	47%	39%	15%	78%	4%	17%
3	Alfalfa 'Crusade' White Clover	*12* *5*	3.2 *abc*	3.8 *ab*	14%	69%	17%	61%	6%	33%
4	Alfalfa 'Pinnacle' White Clover	*15* *3*	4.0 *a*	4.1 *a*	64%	27%	10%	77%	9%	14%
5	Alfalfa 'Pinnacle' White Clover	*12* *5*	3.4 *abc*	3.7 *ab*	30%	62%	8%	66%	14%	20%
6	Alfalfa Alsike Clover	*15* *3*	3.7 *ab*	4.2 *a*	62%	8%	30%	74%	5%	16%
7	Alfalfa Alsike Clover	*12* *5*	3.8 *ab*	3.8 *ab*	53%	16%	31%	69%	3%	16%
8	Alfalfa Three-way mix	*15* *3*	3.2 *bc*	4.2 *a*	60%	16%	23%	85%	4%	7%
9	Alfalfa Three-way mix	*12* *6*	2.9 *c*	3.2 *b*	25%	66%	10%	35%	26%	39%

*Yield means with the same letter are not significantly different (P<0.05)

In 2014, the higher proportions of weeds in the alsike clover treatments (#6 and #7) most likely offset potentially lower alfalfa-clover yields for those treatments in 2014. There was also a lower amount of clover in the alsike treatments compared to the other clover-alfalfa treatments. Weed content was lower in the other treatments indicated a more dense stand of alfalfa and clover. The white clover cultivars made a significant contribution to the mixture, especially at the 5 lb. seeding rate (#3 and #5).

Overall clover content was significantly lower in 2015 compared to 2014, most likely due to the harsh winter of 2014/15. This was particularly the case for alsike clover and ‘Crusade’ white clover. ‘Pinnacle’ white clover was also reduced not as much. Alfalfa did not appear to be affected by winter injury at this location. Other than treatment #9, the alfalfa tended to have a significant increase in content in 2015 compared to the 2014 levels in their respective treatments. The dry weather from July through September most likely favored the alfalfa over the other species and was the most dominant species by the time the botanical separations were made on August 14. There were generally more

weeds in 2015 in the higher clover seeding rate plots due to the lower density of alfalfa caused by the clover competition in the seeding year.

Forage Quality –Only selected treatments were assessed for quality during third harvest in 2014. The samples were hand separated, weighed and re-composited for analysis (Table 3). Our hypothesis was that white clover would have little or no negative impact on the mixture since most of its biomass is made up of leaf material and some petiole. This turned out to be the case. There was no significant difference in crude protein, acid detergent fiber or neutral detergent fiber amongst the alfalfa-clover mixtures compared to the pure stand of alfalfa. However, NDF digestibility was significantly higher in the two white clover mixtures compared to pure alfalfa or the alsike mixture, with a strong relationship between clover content in the mixture and NDF digestibility (Fig. 6). The alsike clover made such a small contribution to the mixture and was essentially the same as the pure stand of alfalfa.

Forage quality of selected clover/alfalfa treatments collected on 8/20/2014 at the Horticultural Research Farm

Treatments			Forage Quality Parameters				Botanical Composition	
Mixture Number	Species/Varieties	Seeding Rate	CP	ADF	NDF	$NDFD_{48}$	Alfalfa	Clover
		lb/a	*% of dm*	*% of dm*	*% of dm*	*% of NDF*	*% or total dry matter*	
1	Alfalfa	*20*	21.5	29.4	38.7	41.4 *c*	100%	0%
2	Alfalfa Crusade White Clover	*15* *3*	22.2	27.1	35.5	45.9 *ab*	76%	24%
4	Alfalfa Pinnacle White Clover	*15* *3*	21.9	27.4	35.5	47.7 *a*	69%	31%
6	Alfalfa Alsike Clover	*15* *3*	21.0	29.3	38.8	42.3 *bc*	95%	5%
Significance*			n.s.	n.s.	n.s.	**		

*n.s. - not significantly different (P<0.05); ** - significanly different (P<0.01); means with the same letter are not different (P<0.05)

CP - crude protein, **ADF** - acid detergent fiber, **NDF** - neutral detergent fiber, **$NDFD_{48}$** - NDF digestibility with 48 hour incubation

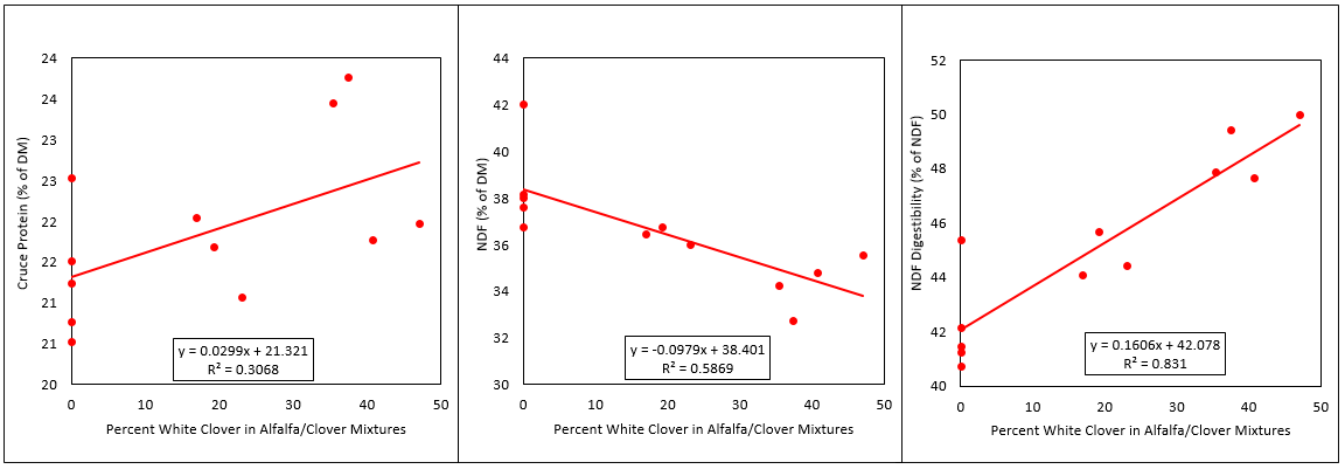

Figure 6. Relationship of crude protein, neutral detergent fiber (NDF) and NDF digestibility with percentage of white clover in an alfalfa/clover mixture, Horticultural Research Farm, 8/20/2014

Clover Flower Abundance and Distribution – White and alsike clover flower populations from the two research sites in 2014 are shown in Figures 7, 8 and 9. White clover was much more prolific at producing flowers compared to alsike clover. After each harvest, white clover would produce bloom within the first week to 10 days after regrowth and would continue to bloom until the next harvest. On the other hand, alsike clover flowers took longer to develop than white clover and would not have a significant number of flower heads until at least two to three weeks into regrowth. Most of the bloom from alsike clover was in June with less bloom in the later part of the season; however, the response of alsike clover was quite different between locations. At the Heustis site (Figure 7), there was hardly any alsike clover heads; whereas at the UVM site (Figure 8), there were a significant amount of alsike clover flowers in 2014 in both the June and July growth period. There were differences in white clover cultivars. 'Pinnacle' white clover had the most abundant flowers and the most widely distributed throughout the season (Figure 7, 8 and 9). Mid-summer 'Pinnacle' flower populations reached 250 to 300 thousand heads per acres at both locations. 'Crusade' white clover, had its most flower production in June but tapered off in July and August.

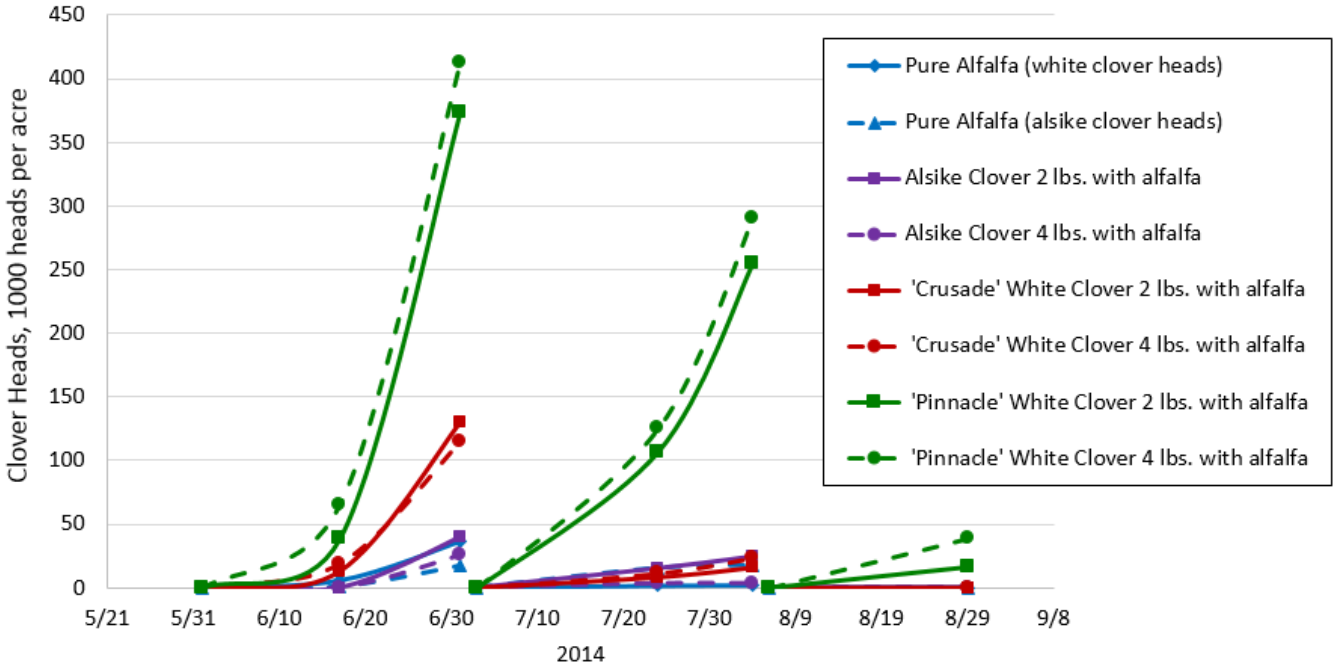

Figure 7. White and alsike clover flower head populations of various clover and seeding rate treatments when grown with alfalfa for hay, 2014, Heustis Farm, Bridport, VT. Only flower heads with 80 percent or more open florets were counted on any given date.

Seeding rate did not appear to have much effect on clover flower head populations at the Huestis Farm (Figure 7), whereas, the higher seeding rate did result in more flower heads at the Hort Farm location in 2014, particularly during the June growth period (Figure 8). However, yields were slightly depressed at the higher seeding rates (discussed in earlier section). Overall, a seeding rate of 2 to 3 lbs./acre seems satisfactory to for white or alsike clover when mixed with alfalfa.

The Hort Farm location also included a treatment that combined all three clovers with the alfalfa at two seeding rates (Treatments #8 and #9 in Table 1). We found most of the clover heads to be white clover (data not shown) and the overall populations (white and alsike clover heads combined) were still

less than the 'Pinnacle' white clover treatments at their respective seeding rates (Figure 8). There appeared to be no advantage of having the diverse mixture treatment in this study under these conditions.

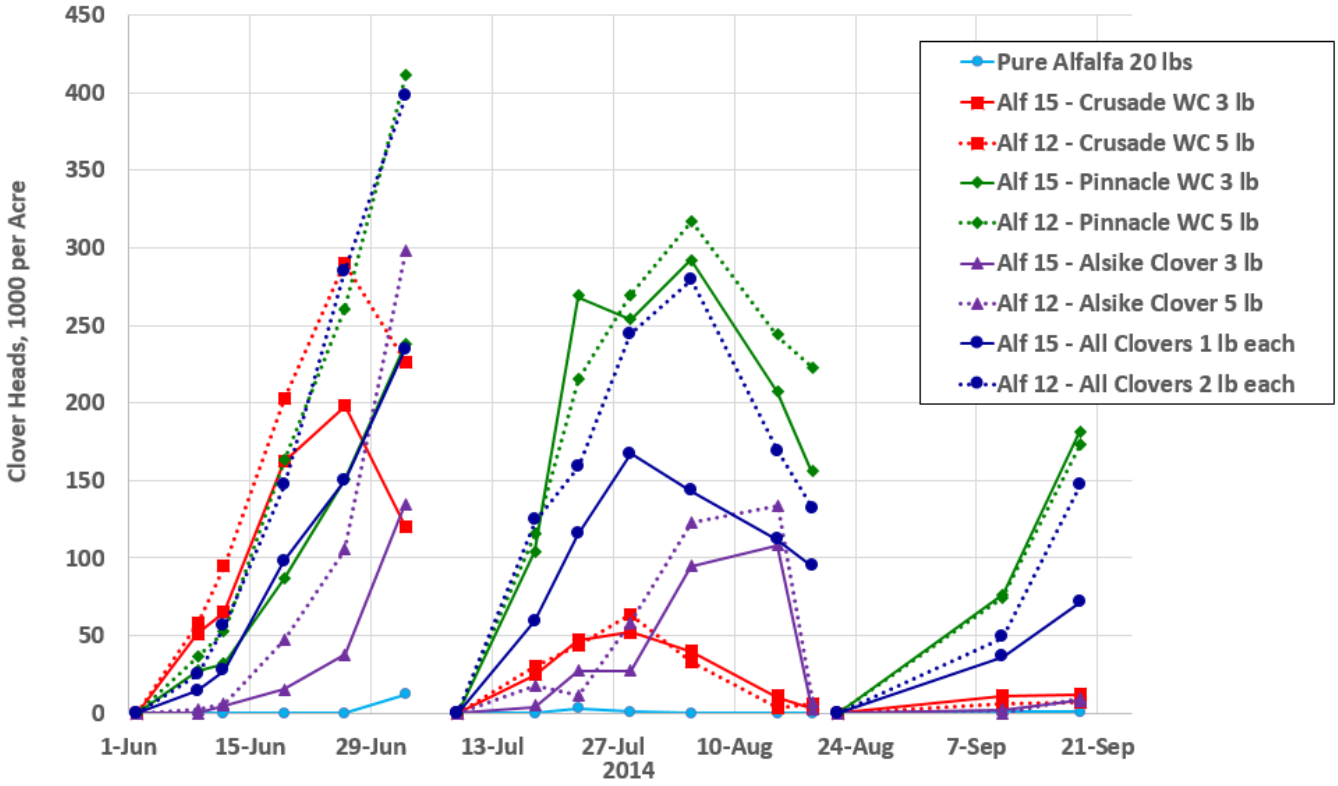

Figure 8. White and alsike clover flower head populations of various clover and seeding rate treatments when grown with alfalfa for hay, 2014, Horticultural Research Farm, South Burlington, VT. Only flower heads with 80 percent or more open florets were counted on any given date.

Figure 9. Generally, 'Crusade' white clover on the left had far fewer flower heads as compared to the 'Pinnacle' white clover on the right as depicted in the photograph taken on 8/29/14 at the Heustis farm site.

The most likely reason that the white clover cultivars differed in floral abundance and seasonal distribution was due to their genetic response to day length. When looking at the 2014 Hort farm data during the June growth period, flower head populations were somewhat similar between the two cultivars in the study; however, as days shortened in July and August, 'Crusade' white clover produced far fewer flower heads than 'Pinnacle' white clover. This occurred whether each of the cultivars were grown in mix with alfalfa or when grown alone (Figure 10). On the other hand, alsike clover had similar populations during the June and July/August growth periods only falling off in September. The competition of the alfalfa may have played a role since all the clovers had fewer flower heads in the mixed stands compared to the pure clover stands. However, the relative differences in clover flower head populations between the pure stands and the mixed stands for each respective clover treatment was not that different; therefore, we cannot conclude that the reduction in late season flowers of the 'Crusade' white clover and alsike clover treatments was due to competition alone.

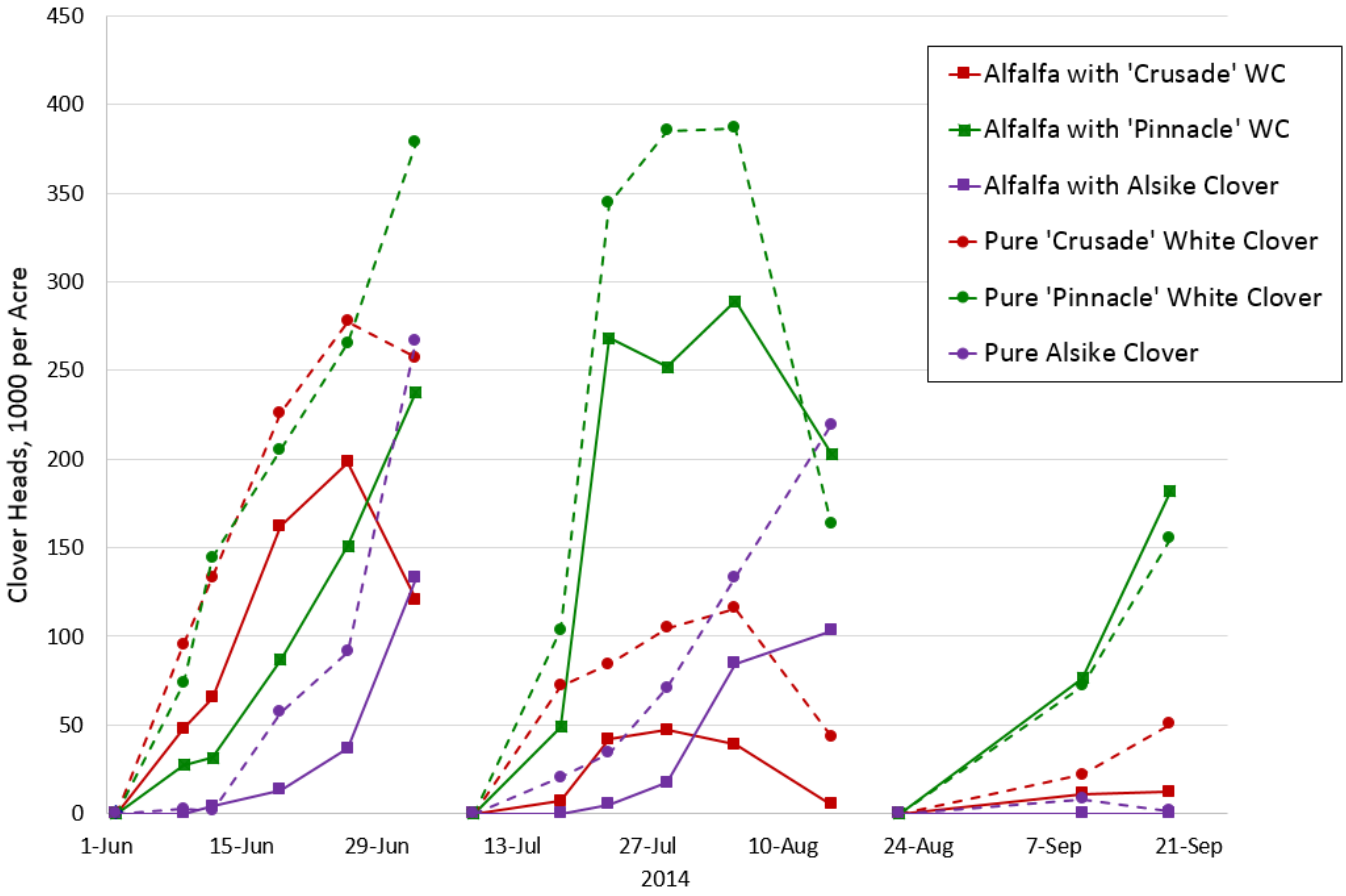

Figure 10. White and alsike clover flower head populations when grown in mixture with alfalfa (at 3 lb. clover and 15 lb. alfalfa seeding rate) or when grown in pure stands, 2014, Horticultural Research Farm, South Burlington, VT. Only flower heads with 80 percent or more open florets were counted on any given date.

Clover populations were much lower in 2015 compared to the previous year resulting in half to a third of the flower head populations (Figure 11). The only treatment that exceeded 200,000 flower heads per acre was the three way clover, high seeding rate (# 9) but that treatment resulted in lower yields and more weeds in the stand. 'Pinnacle' white clover performed best but was still far lower in floral abundance than the previous year.

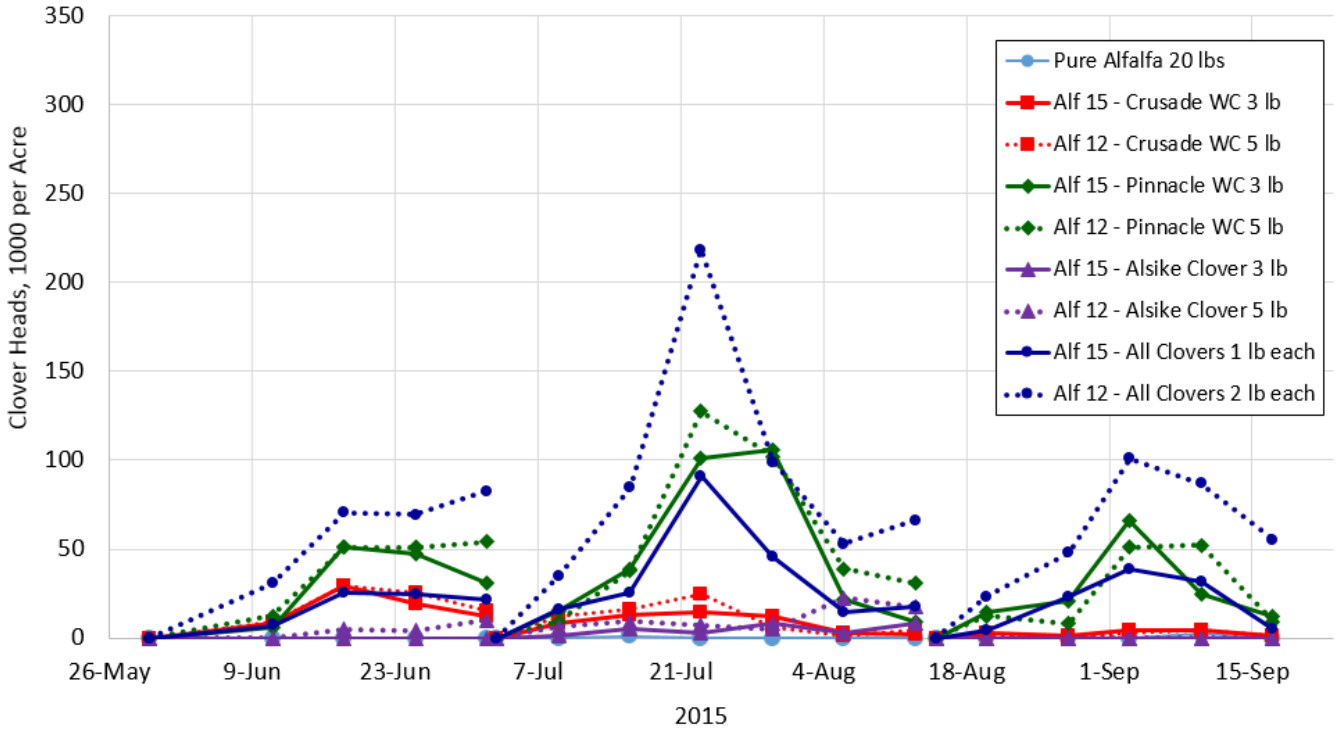

Figure 11. White and alsike clover flower head populations of various clover and seeding rate treatments when grown with alfalfa for hay, 2015, Horticultural Research Farm, South Burlington, VT. Only flower heads with 80 percent or more open florets were counted on any given date.

Floral Resources and Bee Observations

There is limited information in the literature on reported white clover flower populations and most are from seed production fields. Weaver (1965) reported an average of 17.3 seed head per square foot in a bee behavior study in Mississippi. That would extrapolate to 753,588 flower heads per acre. Goodwin et al. (2011) reported white clover flower head populations between 371,033 and 727,449 per acre in two New Zealand seed fields during peak flower. Our research showed that populations of 'Pinnacle' white clover flower heads were within the lower end of this range throughout the season in 2014, indicating that there was likely enough flower abundance to provide a critical level of nectar production for honeybees. 'Crusade' white clover had a moderate abundance in June at the Hort farm site but failed to provide sufficient flowers at the Heustis site nor in the later summer period at either location. Alsike clover was too low in abundance in most cases. The combination of all three (Treatments 8 and 9 at the Hort farm site) was also adequate but most likely was made up primarily of 'Pinnacle' white clover. At the Duclos site which consisted of mixed grasses, white and red clovers and weeds, our overall populations of white clover were much lower than in the seeded alfalfa/clover fields.

This may have been due to the competition of the other species in the mixture including many weed species particularly smooth bedstraw and dandelion.

Bee observations collected in 2014 and 2015, showed that the most predominate pollinators were honeybees (*Apis* spp.); however, we also found native bumblebees (*Bombus* spp.) and sweat bees (*Augochlora pura*) working the clover flowers. The plots were too small at the Hort farm to make any conclusions about preferences for clover type and cultivar and at the Huestis farm, there were not enough flowers from the alsike and 'Crusade' strips to make any comparisons. Overall, our limited bee observations indicated they had no discretion between the clover types.

Summary

This project demonstrated that by mixing properly selected cultivars of white clover with alfalfa, one could achieve a flower head population that could provide nectar and pollen resources for pollinating bees that could be sustained over the summer period. However, the lack sustained high populations into the second year study demonstrates the year-to-year variation that can occur due to extreme weather conditions. More research is needed to test identify other white clover cultivars that can sustain flower abundance throughout the season and test the resilience of more diverse mixtures of forage legume species and cultivars including birdsfoot trefoil and red clover.

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Acknowledgements

Special thanks to Tim Kelly, Rhianna Sommers, Darienne Chouinard, Eoin Kenny and John Bruce for their assistance in data collection during the project.

For More Information on bees and legumes, go to: http://pss.uvm.edu/beeclover/

Northeast SARE is a regional program of the nationwide SARE which offers competitive grants to projects that explore and address key issues affecting the sustainability and future economic viability of agriculture. The program is authorized under Subtitle B of Title XVI of the Food, Agriculture, Conservation, and Trade Act of 1990. Its wider mission is to advance, to the whole of American agriculture, innovations that improve profitability, stewardship, and quality of life by investing in groundbreaking research and education. For more information go to, http://www.nesare.org/

- March 2016
