Did the Deer Persevere? 2023 Evaluation of Clover Cover Crops as a Living Mulch for Pepper Production in Eastern South Dakota

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Introduction

South Dakota vegetable farmers have expressed interest in incorporating cover crops into their farm systems to reduce single-use plastic and increase soil health benefits. Perennial legume cover crops provide nutrients to soil prior to vegetable planting and may overwinter to establish living mulches for future growing seasons (Vollmer et al. 2010). During the growing season, clover cover crops that are grown as living mulch may suppress weeds, contribute nitrogen after establishment and prevent soil erosion. Although clovers are a natural alternative to plastic mulch, they may be inviting to nearby deer and gopher populations. Additionally, previous research has shown that using clovers as a living mulch or living pathway between planting rows can compete with cash crops and result in lower vegetable yields (Bruce et al. 2022). The objective of our research was to analyze the relationship between four different clover species and four different soil management practices and their effects on pepper growth and yield as well as weed suppression.

Materials and Methods

Field research was conducted April through September in 2023 at the Specialty Crop Research Field in Brookings, South Dakota. The cash crop chosen was a 'Red Knight' bell pepper *(C. annuum)* which was selected for its beautiful red color and marketability factors noticed in previous research (Fig. 1) (Pfeiffer et al. 2016). Clover cultivars trialed were 'Domino' white clover *(T. repens)*, 'Aberlasting' White x Kura clover *(T. repens x ambiguum)*, and 'Dynamite' red clover *(T. pratense)* and a fourth treatment was a bare ground control.

Figure 1. Marketable Red Knight bell pepper plant harvested on September 26, 2022. (Courtesy: Alexis Barnes)

Field Design

The clovers were planted in a split plot design replicated across four blocks. Within each whole plot of clover, four soil management treatments (subplots) were randomized. The soil management treatments were: No-till + fabric (NTF), no-till without fabric (NT), tilled + fabric (TF) and tilled without fabric (T). Details of the soil management treatments are explained below.

Table 1. Actual seeding rates for clover planted in 2023 for the Specialty Crop Research Field in Brookings, SD. All seeds were provided by GoSeed (Salem, OR).

GoSeed Clover	Germ. Rate	Seeds per pound	SARE Cover Crop Guide Rate lb./A	Estimated Plants per Sq. Foot	Actual Planting Rate (lbs./A)
Aberlasting White x Kura Clover	85%	403,242	NA	75	11.9
Domino White Clover	85%	632,916	5-9	75	7.6
Dynamite Red Clover	85%	275,329	10-12	53	12.3

Field Preparation and Broccoli Planting

On June 27, soil management strips were tilled with two passes with a BCS walk-behind tiller (30-inch) to a depth of approximately six inches. Black woven landscape fabric was 36-inches wide and had planting holes cauterized with a butane burner before installation. All management rows were 12 feet long. The fabric was installed with 6" landscape staples every 2 feet with a rubber mallet to prevent fabric from blowing away due to high South Dakota winds.

Table 2. Field activities and data collection events that occurred throughout the 2023 season for pepper production at the SDSU Specialty Crop Research Field, Brookings, SD.

Activity	Dates
Seeded Oats and Clovers	27-Apr
Seeded Transplants in Greenhouse	21-Mar, 25-May
Mowed CC, Tilled, Pinned Fabric, Installed Drip Tape	22-Jun
Peppers Planted in the Field	7-Jul
Fertigated	14-Jul, 26-Jul, 10-Aug, 26-Aug, 2-Sep, 9-Sep
Installed Soil Moisture Sensors	24-Jul
Collected Whole plot Clover Biomass	1-Jun, 26-Jun, 19-Jul, 14-Aug, 25-Sep
Mowed CC / Weeded Subplots	1-Jun, 12-Jun, 26-Jun, 19-Jul, 14-Aug, 5-Sep
Collected SPAD Readings	10-Aug, 26-Sep
Mid-Season Plant Height and Canopy Width	10-Aug
Peppers Stand Counts	27-Sep
Liquid Fence Application	8-Aug, 15-Aug

Peppers were seeded in a greenhouse on the SDSU campus March 28 and reseeded on May 25 due to pepper frost damage in the holding area. Peppers were moved outside on May 15 to harden-off prior to planting. On July 7, Peppers were transplanted into the Specialty Crop Research Field in Brookings, South Dakota (Fig. 2). Within each 12-foot plot, twenty pepper transplants were hand planted in staggered, double rows, 18 inches apart from each other with 12 inches between plants within each row. The time required to transplant peppers were recorded in two out of the four research blocks to analyze labor needed for planting in different clover and soil management treatments.

Figure 2. Pepper Plants a few days after pepper planting taken on July 15. (Courtesy: Alexis Barnes)

Data Collection Procedures

Clover whole plot (pathway) Biomass Accumulation.

Clover performance was assessed five times during the growing season. A 25 x 25-centimeter quadrat was randomly tossed three times within each clover whole plot pathway (between crop rows) and two times in each in-row clover x management subplot (within planting row) to analyze the relationship between weeds and clover species (Puka-Beals and Gramig, 2021; Tarrant et al. 2020). The tallest clover, weed and oat in each quadrat were measured from the base of the stem to the tallest leaf point. All oats, clovers and weeds present in the quadrat were cut at the base of the stem and kept in a brown paper sample bag for biomass drying. Samples were then dried for approximately four days at 110° F. Dried samples were weighed to the nearest 0.1 grams to determine plant biomass.

After data was collected, clover and weeds were mowed in the three clover species whole plots and weeds were hand cultivated in the bare ground treatments; time spent for these events was recorded for two out of the four block replications. Timed weeding events occurred for in-row (subplot) weed management events and consisted of hand pulling and using a stirrup hoe when appropriate. The mowing height was set at approximately three inches from the ground using a push-mower.

Pepper Plant Health Data Collection

Eight pepper plants per row were measured for height, canopy width and chlorophyll content (SPAD meter) in the middle of the season. SPAD readings are an indirect measurement of chlorophyll and can help farmers and researchers make soil fertility decisions.

Pepper stand counts were taken at the end of the season in September (Table 2). The number of plants alive per plot were counted as well as the number of plants affected by deer and rodent damage (Table 3).

Table 3. Average number of pepper plants per clover whole plot and average number of damaged pepper plants from deer and rodents.

Plot	Clover	Pepper plants per plot	Damaged Pepper Plants
101	WC[z]	19	19
102	KC	18	18
103	BG	20	20
104	RC	18	18
301	BG	20	20
302	WC	18	18
303	RC	18	18
304	KC	18	18
501	KC	18	18
502	RC	18	18
503	WC	20	20
504	BG	20	20
701	RC	18	10
702	BG	20	5
703	KC	18	12
704	WC	19	6

[z]Clovers include: BG = Bare ground, WC = White clover, RC = Red clover, KC = White x Kura clover.

Results

Whole Plot Oats, Clover and Weed Biomass

Clover Biomass. Clover biomass resulted in similar growing potential among treatments (Fig. 3). Red clover (RC), white clover (WC) and White x Kura clover (KC) treatments following similar growing trends until August. KC biomass plateaued in August and began to increase into September (Fig. 3). RC was slow growing in the beginning of the season and became linear in July, but was still less than KC and WC treatments (Fig. 3). WC biomass reacted similarly to RC plots, however resulted in the greatest amount of biomass compared to RC and KC treatments (Fig. 3).

Weed Biomass. Weed populations showed similar growth potential among the clover treatments throughout the season (Fig. 4). KC, WC and bare ground (BG) weed populations grew throughout the season and began to plateau in August (Fig. 4). RC weed biomass was consistent throughout the season and resulted in linear growth (Fig. 4). Interestingly, BG biomass was lower in June compared to RC, KC and WC plots, but began to increase until August (Fig. 4). Overall, total weed populations were comparable to total clover populations by the end of the 2023 season (Figs. 3 & 4).

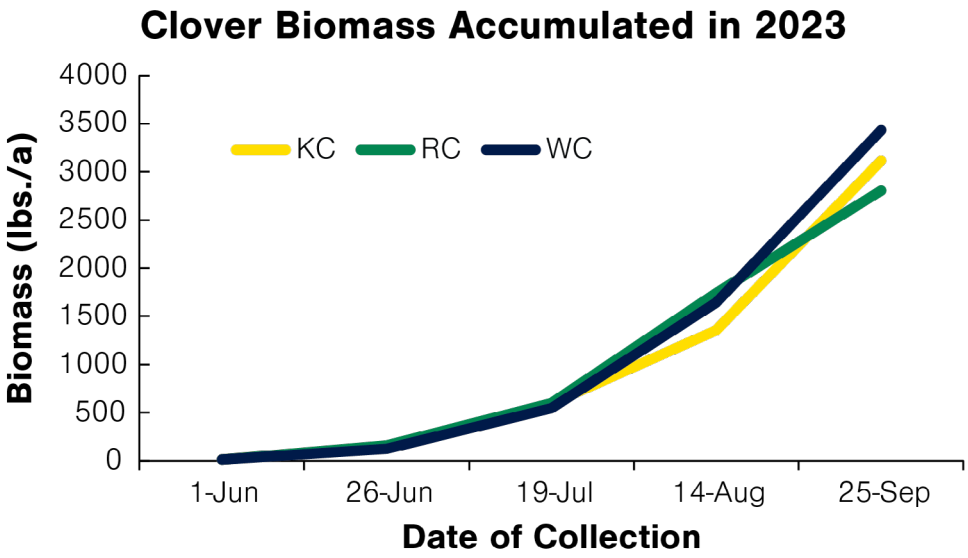

Figure 3. Pepper whole plot (walkway) clover biomass accumulated during the 2023 growing season. BG= Bare ground, KC= Kura Clover, WC= White Clover, RC= Red Clover.

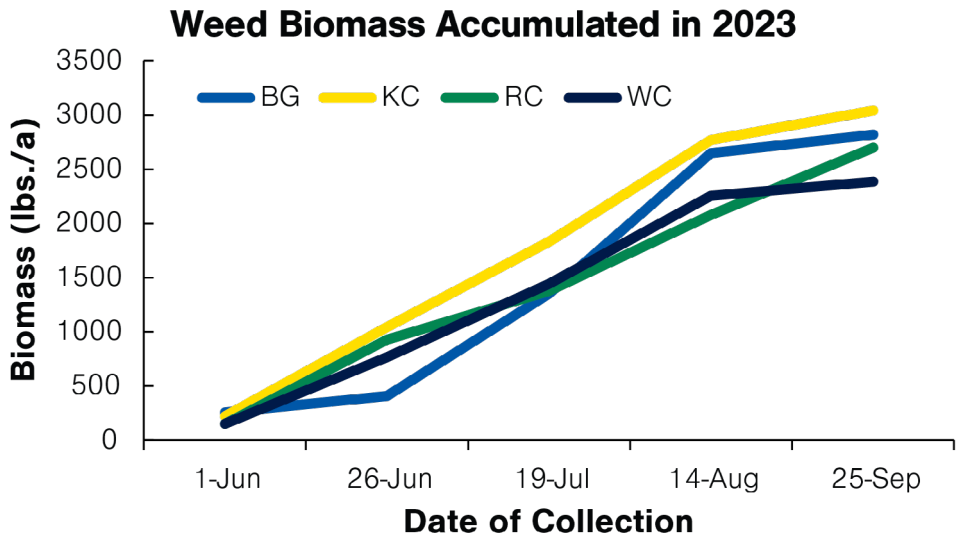

Figure 4. Pepper whole plot (walkway) weed biomass accumulated during the 2023 growing season. BG= Bare ground, KC= Kura Clover, WC= White Clover, RC= Red Clover.

Discussion

The absence of early season rainfall affected clover establishment early on and led to high weed populations early in the season. Supplemental moisture was added with overhead sprinkler irrigation for about 4-8 hours a week depending on rainfall. Clovers established well by September, but weeds were still competitive throughout the season (Figs. 3 & 4).

Clover growth performed about the same throughout the season with some differences in September. KC plots had more weed competition which could be due to its low growing and rhizomatous structure (Figs. 3 & 4). RC plots had a consistent amount of weed pressure throughout the season which is no surprise due to deep taproot and vertical growing point (Pfieffer et al. 2016). WC plots had produced consistent weed pressures throughout the season but started to plateau in August thanks to its stoloniferous root zone which causes above ground sprawling of the clovers (Bruce et al. 2022). BG plots varied in growth throughout the season and plateaued in June and September (Figs. 3 & 4). BG plots were tilled with a BCS 749 tiller on June 19, prior to pepper planting, which could have caused less weed populations compared to the clover treatments. An additional mowing and weeding event in July and August would have been beneficial to minimize weed and clover competition.

A few weeks after pepper planting in July, deer entered the north side of the field and topped all pepper plants in blocks one and two and slowly made their way to blocks three and four (Fig. 5 and Table 3). Pepper plants persevered thanks to increased fertigation this year compared to 2022, and produced healthy leaf set and branching (Fig. 6) but were still no match for deer pressure. Gophers were in the field throughout the season and consumed the clover walkways before pepper fruiting. Liquid fence was applied to the aisle walkways two times in August, but by the time the application was applied the pepper damage was too far gone. Gophers were still noticed in the clover plots after liquid fence was applied, but clovers were not consumed beyond that point. Liquid fence applications were not effective for this project and a large 10’ fence would have been more protective. When the pepper fruit set did occur, gophers scavenged the area and took small pepper buds that were starting to form (Fig. 7).

Figure 5. Damaged pepper plants from deer, found two weeks after pepper planting on July 24. (Courtesy: Alexis Barnes)

Figure 6. Healthy peppers and foliage with limited deer damage taken on August 26. (Courtesy: Alexis Barnes)

Figure 7. Small fruit formation shown on a pepper plant in a no-till fabric treatment taken on Aug 18. (Courtesy: Alexis Barnes)

By the end of the season, the number of pepper plants affected by deer varied among clover plots. Peppers in blocks one, three and five showed 100% of plants being topped by deer (Table 3). Block seven did not have as many peppers topped compared to the other treatments, which could indicate pepper growth in blocks one, three and five from fertigation applications and deer continued to consume those plots (Fig. 8). Pepper plants that produced fruit had gopher pressures or intense sun scalding from little to no foliage from deer pressures (Fig. 7). Pepper harvest did not occur this season due to limited fruit formation and deer droppings that posed a food safety concern.

Figure 8. Topped pepper plants producing extra leaves and foliage due to deer damage and increased fertigation taken on September 20. (Courtesy: Alexis Barnes)

Protective measures should be considered moving forward to prevent deer and rodent damage to specialty crops. Fence installations should be at least 10’ tall to protect vegetable crops, especially in West River South Dakota. Nylon row covers (ProtekNet) can be applied if fencing is too costly to install. Growers that experience deer pressure may be able to fertilize and add protect field barriers after the first deer damage event and still have a crop by the end of the season. Fruit may be limited compared to no rodent or deer pressures, but there is a chance of crop survival if protective measures are implemented early enough in the season.

Conclusions and Recommendations

South Dakota specialty crop producers interested in incorporating living mulches into their farm system should be prepared for yield decreases and competition between cash crops, weeds, and clover. Low rainfall amounts can impact early season cover crop and oat establishments, especially in year one of establishment. Added irrigation may be necessary throughout the season, especially early in the season if rainfall is not significant enough for crop establishment. All clover treatments reacted relatively similarly throughout the season and growing conditions should be noted when choosing a clover cultivar. White clover seems more promising compared to red and white x clover due to its low growing and sprawling effect above ground. Weed populations were decreasing in WC treatments by the end of the season, which shows positive weed suppression. A 10' tall fence to deter deer pressures would be ideal in any open growing system. A nylon row cover may prevent deer and gopher damage if you live in open or forested areas to prevent cash crop damage. Early season deer repellent applications may prove useful to deter deer, keeping in mind produce safety and handling and overall deer deterrence effectiveness. Accurate fertilizer plans should be implemented to encourage production of foliage to prevent sun scalding. Pepper fruiting may prosper if crop protection is implemented early in the season to protect against deer damage. Pest scouting, increased fertilizer applications, increased moisture and selecting competitive cash crops may be necessary to make living mulches successful on certain farm system.

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