Comparison of Two Different WeedGuardPlus Paper Mulches and Black Plastic Mulch on the Production of Onions and Broccoli

Dr. Frank Stonaker, Colorado State University Department of Horticulture and Landscape Architecture, Assistant Professor and Coordinator of Specialty Crops Program.

Dr. Whitney Cranshaw, Colorado State University Department of Bioagricultural Sciences and Pest Management, Professor and Extension Specialist of Entomology.

Dan Goldhamer Colorado State University Department of Horticulture and Landscape Architecture, Research Associate.

Introduction

The objective of this study was to compare the effect of two WeedGuardPlus products, a non-degradable plastic mulch, and a bare ground control on the production of both broccoli and onions. Additionally, we explored the effect the mulch type on insect populations on both crops. Previous work on straw mulches demonstrated a degree of control on the population of thrips and our objective was to discover if the paper mulches would provide similar protection.

Materials and Methods

Trials were conducted at the Colorado State University Horticulture Field Research Center in northeast Fort Collins, Colorado. In order to evaluate the effect of the mulches on broccoli and onion production, 4 total treatments were utilized. Plot design was a randomized complete block with four replications. The 4 treatments were:

- WeedGuardPlus heavy weight with pre-punched holes
- Shredded WeedGuardPlus
- Black plastic
- Bare ground control

The tested crops were broccoli (cv. “Arcadia”) and onion (cv. “Vega”), which were chosen because of their reliable infestation at the site with insect pests (e.g., crucifer flea beetles, onion thrips). All plots were established by transplanting with broccoli spaced at 18-inch in three staggered rows/bed and onions at 5-inch spacing in five rows. Planting occurred on June 1st 2011. Individual plots consisted of single beds, 15-ft in length, irrigated with two parallel lines of drip irrigation tubing running under the mulch treatments.

Evaluations of insects were made on multiple dates. Counts of flea beetles on broccoli were made by counting all beetles on 6 plants in the center of each plot. Thrips on onions were counted by examining the neck area and counting all thrips on ten plants in the center of each plot.

Evaluations were also made 14 July of weeds present on plots. Counts of individual weed plants were made initially in the center of each plot, with weed species present enumerated (kochia, lambsquarters, redroot pigweed, purslane, hairy nightshade, wild lettuce, prostrate spurge, Canada thistle, field bindweed, annuals grasses). The weeds were then harvested and weighed (fresh weight).

Soil and air temperature sensors were installed in each onion plot on July 29th. The sensors used were Sensitech Temp Tale 4. The soil temperature probe was inserted at a depth of 4" while the ambient air temperature monitor was installed 6" above the soil surface. Temperature was collected hourly.

Harvest occurred on 10/18/2011 for the onions and 10/20/2011 for the broccoli. Harvest was carried out by hand and all bulbs and broccoli crowns were included in the analysis. Statistical analysis was perfumed using SAS 9.2.

Results

Broccoli plant performance

There was no statistical difference between the treatments for average yield per plant (Figure 1.) ($p=0.634$), average number of fruit per plant (Figure 2.) ($p=0.921$), and average crown weight (Figure 3) ($p=0.257$). There was a statistical difference between transplant survival rates (Figure 4). The plastic mulch was observed having the lowest transplant survival rate and being different from the other treatments. There was no difference in transplant survival rate between the WeedGuardPlus treatments and the bare ground control plot. There was a statistical difference when observing total plot yield (Figure 5). The punched paper and bare treatments yielded more per plot then the black plastic treatments. There was no statistical difference between the shredded WeedGuardPlus treatment any of the other treatments.

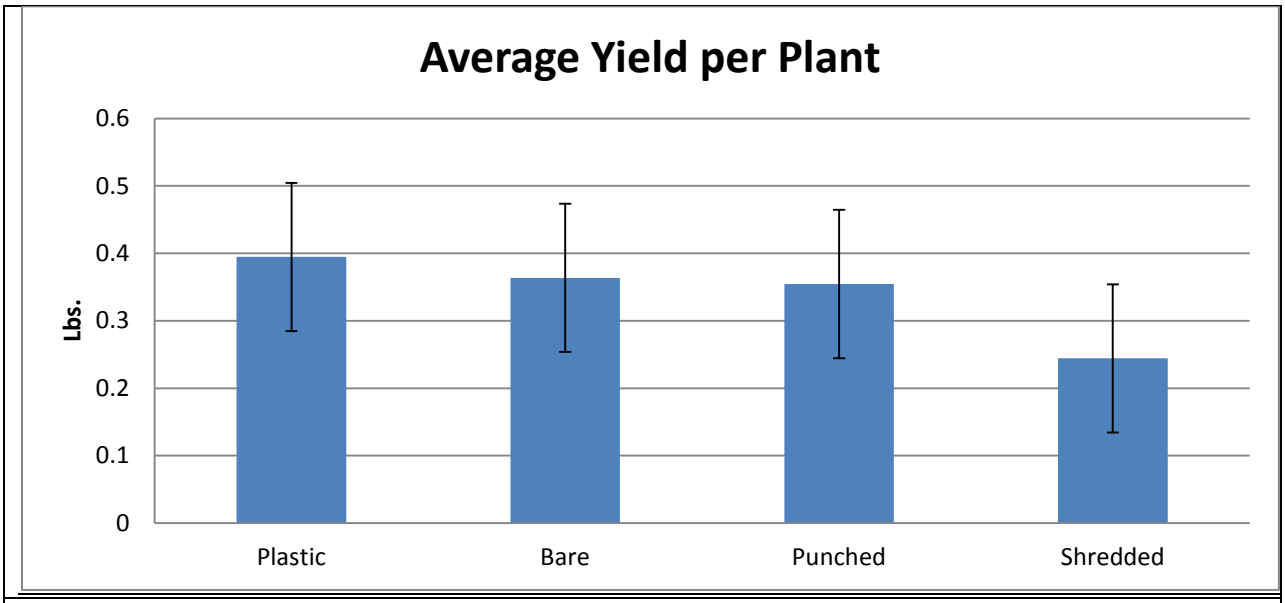

Figure 1. The average yield per broccoli plant. No statistical difference between treatments was observed.

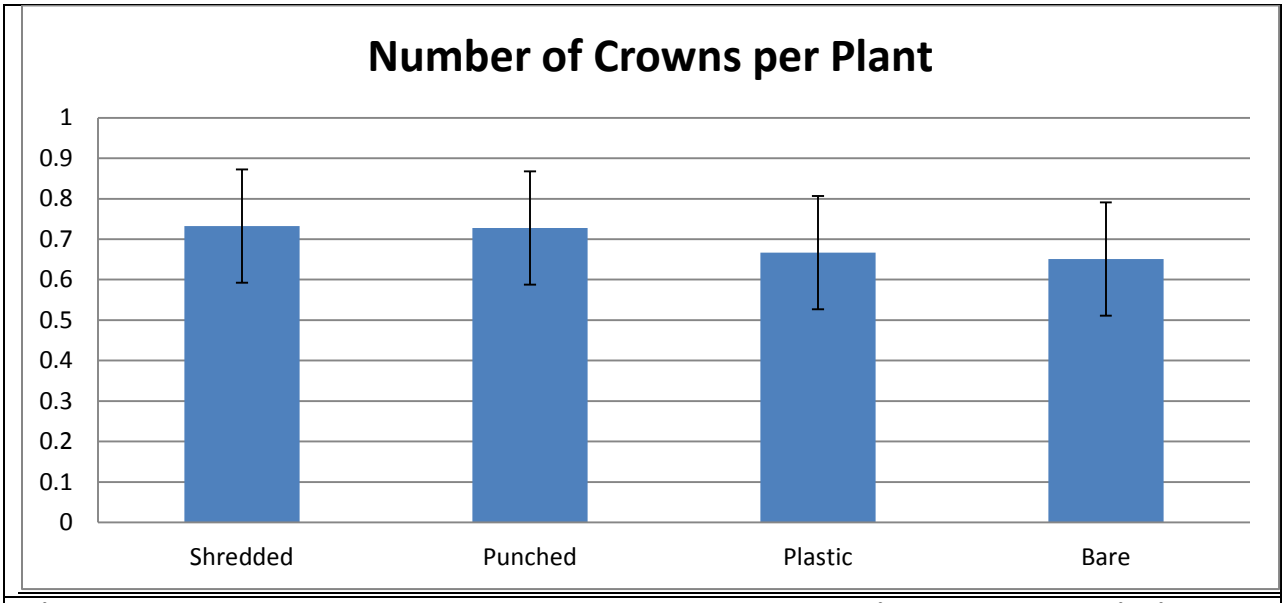

Figure 2. The average number of crowns per broccoli plant. No statistical difference between treatments was observed.

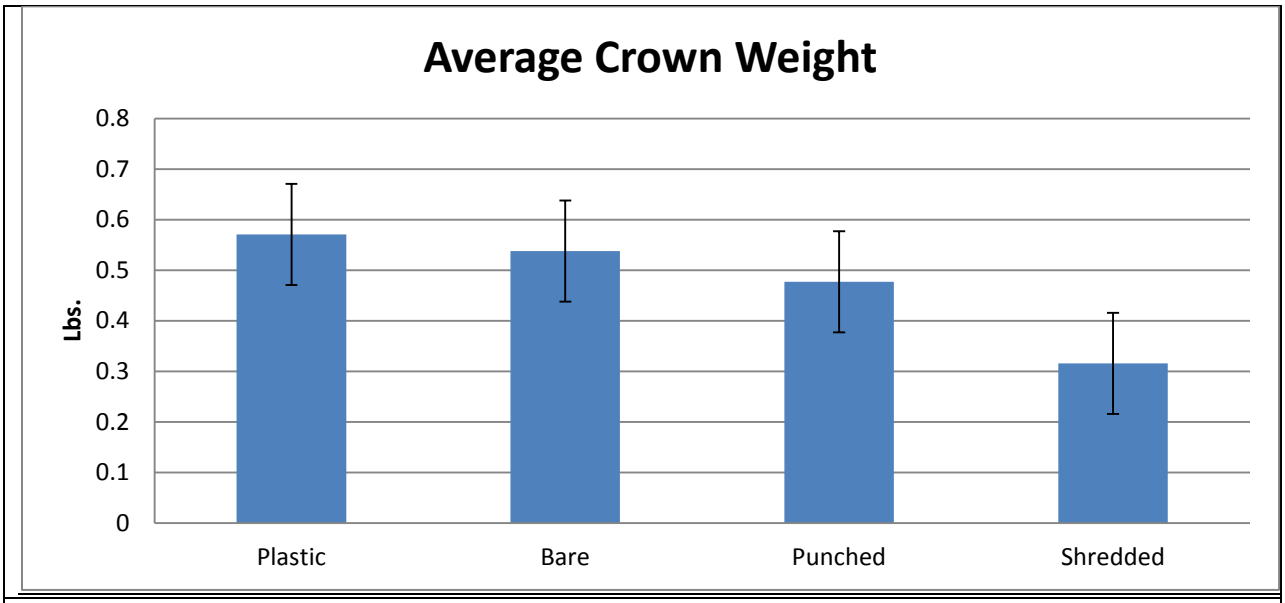

Figure 3. The average broccoli crown weight. No statistical difference between treatments was observed.

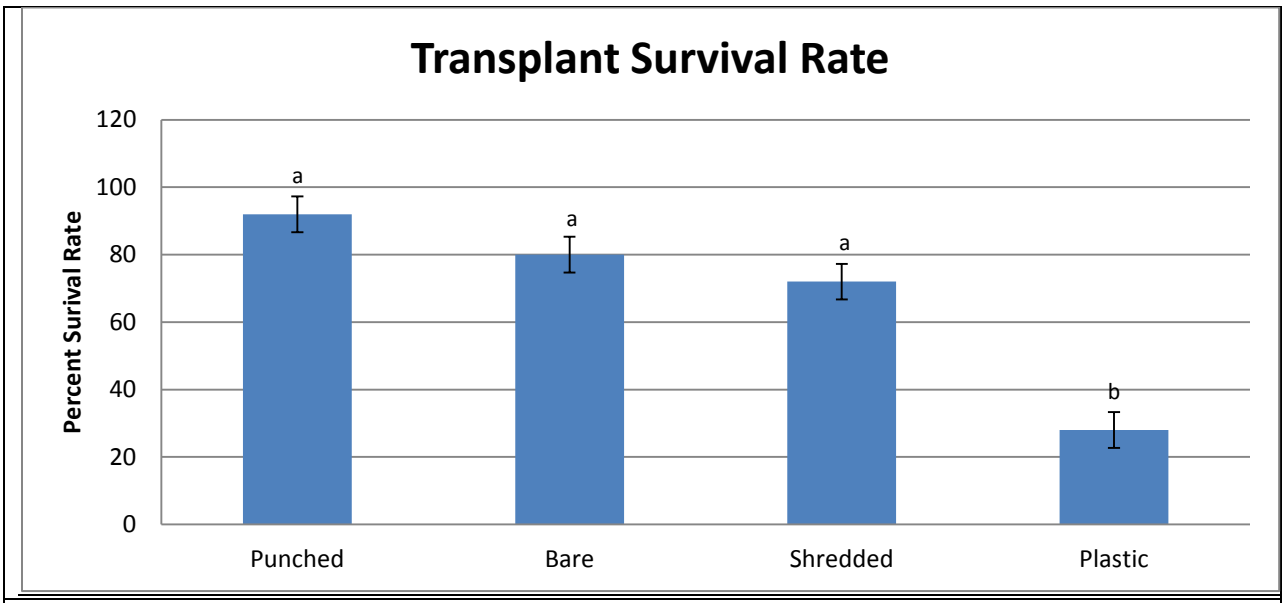

Figure 4. Average broccoli transplant survival rate. Differing letters signify statistical differences at p=0.05 according to least square means utilizing the Tukey adjustment.

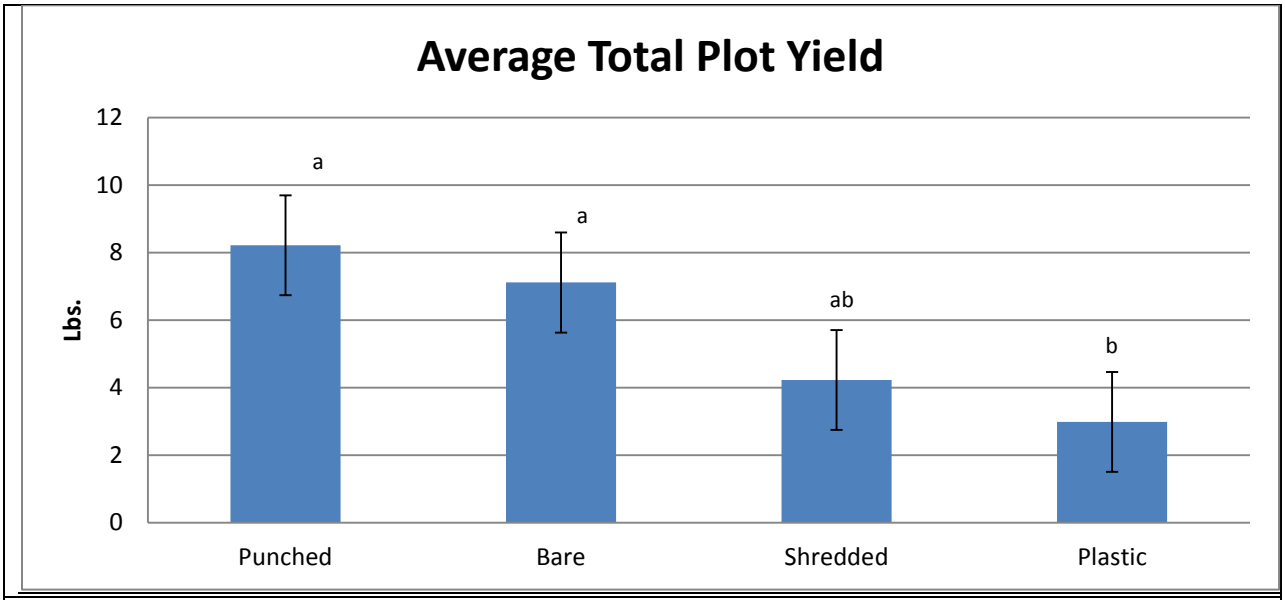

Figure 5. Average total plot yield for broccoli. Differing letters signify statistical differences at p=0.05 according to least square means utilizing the Tukey adjustment.

Insect Evaluation on Broccoli

Moderate levels of flea beetles were present on broccoli plants (Table 1). No treatment differences between mulch treatments were observed on two dates; an increase in flea beetles/plant were noted on the paper roll mulch treatment on the second evaluation date (30 June).

Table 1. Crucifer flea beetles on broccoli plants ("Arcadia") grown with use of different mulch treatments. Colorado State University Horticulture Field Research Center, Fort Collins, Colorado, 2011.

	Flea Beetles/6 plants		
Treatment	17 June[a]	30 June[b]	14 July
Untreated Check	6.8 a	5.8 b	11.0 a
Black Plastic Mulch	7.3 a	8.5 b	20.8 a
Paper Roll Mulch	11.0 a	26.0 a	22.5 a
Shredded Paper Mulch	9.3 a	6.5 b	10.5 a

Numbers followed by the same letter are not significantly different (P = 0.05) by SNK.
[a]DF 3; F=0.66; Pr > F 0.5951
[b]DF 3; F=4.83; Pr > F 0.0286
[c]DF 3; F=0.70; Pr > F 0.5286

Onion plant performance

There was a statistical difference between the treatments for average yield per plot of onions (Figure 6). The punched WeedGuardPlus treatment plots yielded statistically more than the shredded WeedGuardPlus plots while there was difference between the plastic, bare, and shredded plots. There was also a difference between the treatments in terms of number of onion bulbs harvested per plot (Figure 6). The punched WeedGuardPlus and the bare ground treatments contained more onion plant that survived compared to the shredded treatment while there was no difference between the plastic treatment and the shredded treatment. There was also no difference between the bare treatment and the plastic treatment. There was no statistical difference between the treatments for the average onion bulb weight (Figure 8) (p=0.411). Image 1 displays the total of yield of onions from all the plots and treatments.

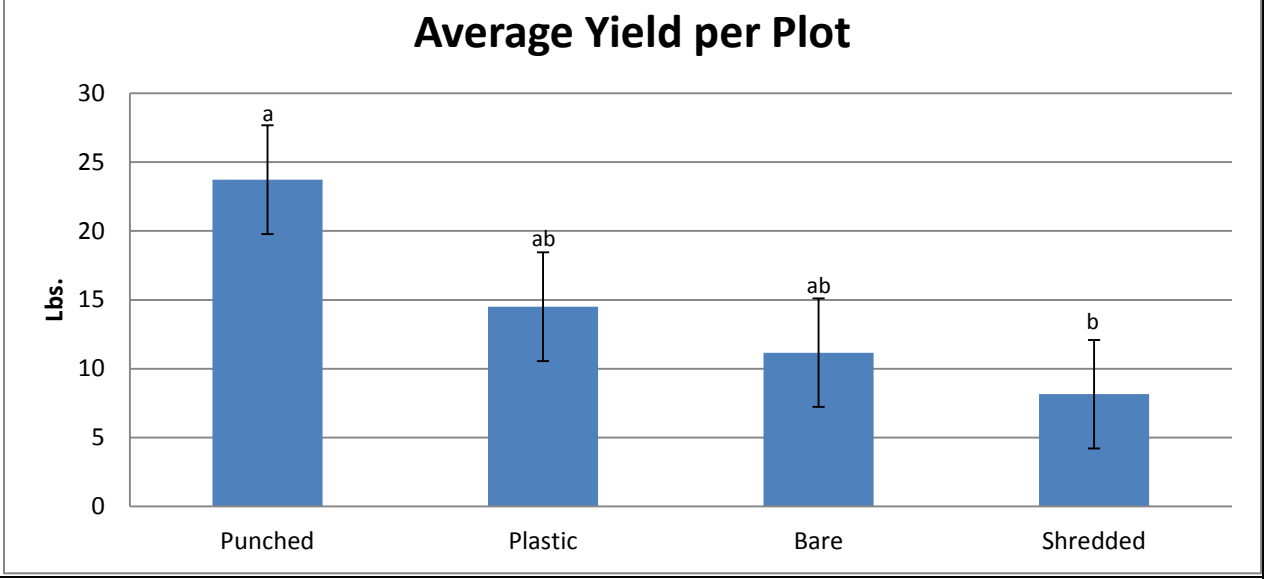

Figure 6. The average onion yield per plot. Differing letters signify statistical differences at p=0.05 according to least square means utilizing the Tukey adjustment.

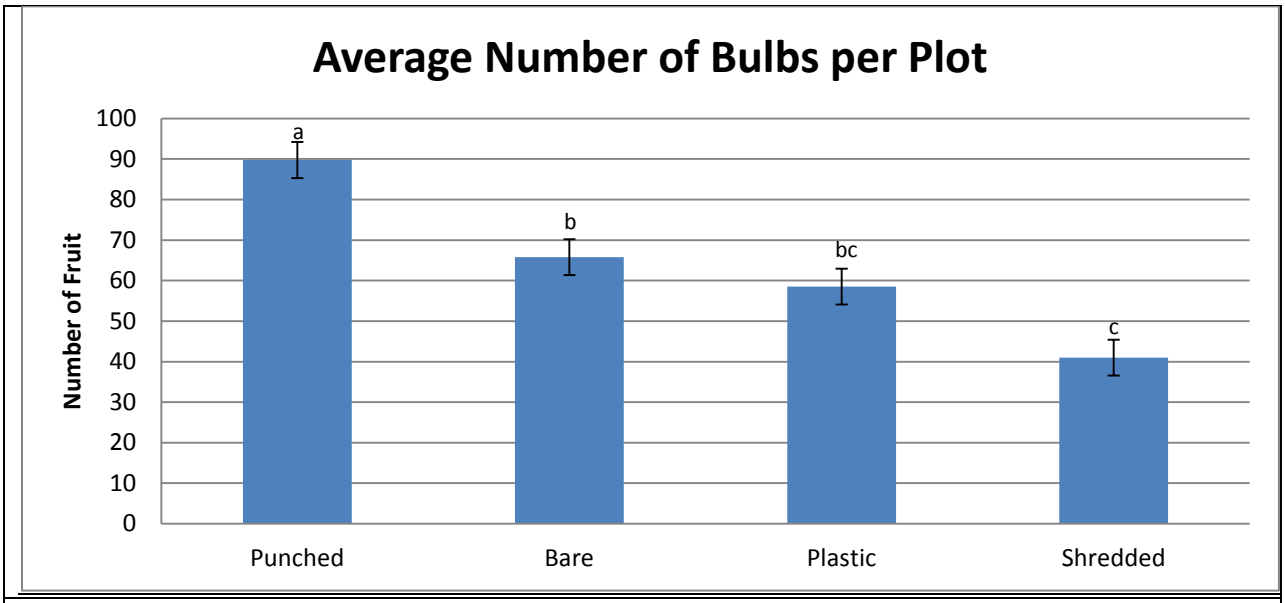

Figure 7. The Average number of onion bulbs harvested per plot. Differing letters signify statistical differences at p=0.05 according to least square means utilizing the Tukey adjustment.

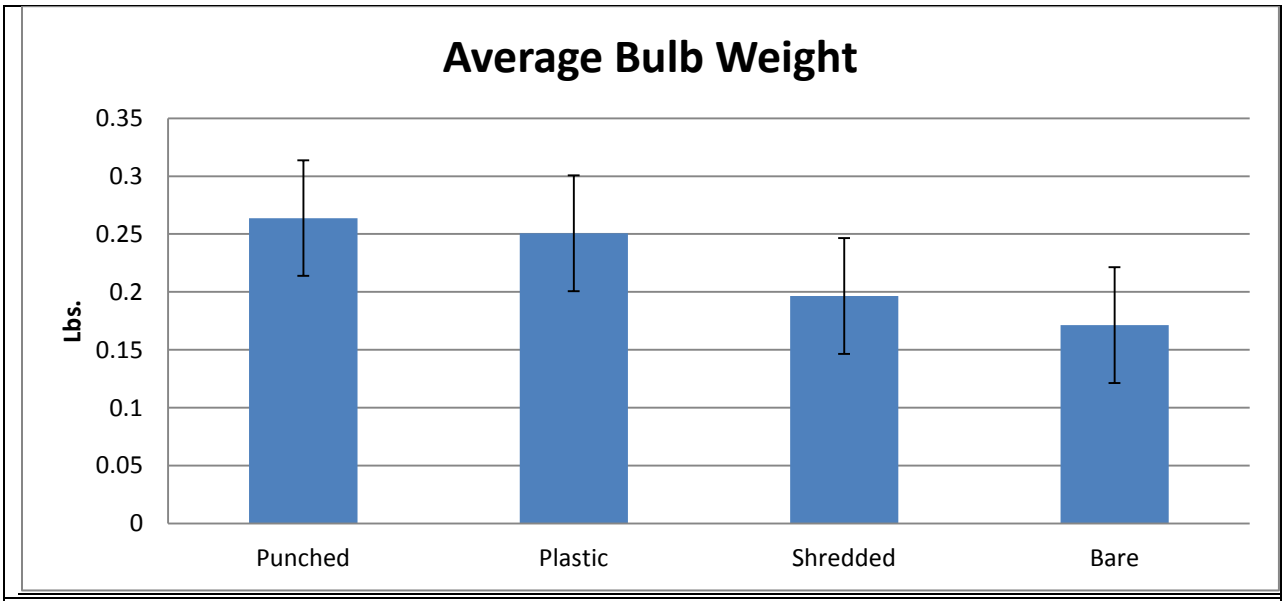

Figure 8. The average onion bulb weight. No statistical difference between treatments was observed.

Image 1. Total onion yields from all plots and treatments. In order from left to right the treatments are bare ground control, punched WGP, shredded WGP, and black plastic.

Insect Evaluation on Onion

Low levels of thrips were present across onion plots (Table 2). No differences in thrips populations were observed on plants grown under different mulch treatments.

Table 2. Onion thrips on onion plants ("Vega") grown with use of different mulch treatments. Colorado State University Horticulture Field Research Center, Fort Collins, Colorado, 2011.

	Thrips/10 plants	
Treatment	30 June[a]	14 July[b]
Untreated Check	40.8 a	81.3 a
Black Plastic Mulch	40.3 a	91.8 a
Paper Roll Mulch	31.3 a	82.5 a
Shredded Paper Mulch	49.3 a	44.3 a

Numbers followed by the same letter are not significantly different (P = 0.05) by SNK.
[a]DF 3; F=0.35; Pr > F 0.787
[b]DF 3; F=1.61; Pr > F 0.255

Weed Evaluations

Several weed species were present in plots, dominated by purslane, common lambsquarters and redroot pigweed (Table 3). All mulch treatments significantly reduced weed biomass (Table 4), with somewhat greater weed suppression from the sheet mulches (paper roll, black plastic) compared to the shredded paper mulch. The number of individual weeds counted on the shredded paper mulch plots was much higher than the other mulch treatments; however, this was largely due to purslane plants which were observed to be greatly retarded in growth compared to plants on the untreated check plots.

Table 3. Total number of individual weed plants collected from the center (area between rows 2 and 4) of broccoli and onion grown under different mulch treatments. Colorado State University Horticulture Field Research Center, Fort Collins, Colorado, 2011.

	Untreated Check	Black Plastic Mulch	Paper Roll Mulch	Shredded Paper Mulch
Purslane	566	24	92	302
Lambsquarters	52	0	13	8
Redroot Pigweed	94	5	22	36
Prostrate Spurge	15	0	1	4
Hairy Nightshade	24	4	7	20
Kochia	9	0	1	0
Wild Lettuce	1	0	0	2
Canada Thistle	0	0	0	8
Annual Grasses	10	1	0	1
Field Bindweed	1	1	2	1

Table 4. Total biomass of weeds harvested from the center (between rows 2 and 4) of broccoli and onion grown with the use of different mulch treatments. Colorado State University Horticulture Field Research Center, Fort Collins, Colorado, 2011.

	Total Weed Biomass Fresh Weight (lbs)	
Treatment	Broccoli Plot[a]	Onion Plot[b]
Untreated Check	3.99 a	5.31 a
Black Plastic Mulch	0.00 c	0.55 b
Paper Roll Mulch	0.45 c	0.40 b
Shredded Paper Mulch	1.68 a	1.14 b

Numbers followed by the same letter are not significantly different (P = 0.05) by SNK.
[a]DF 3; F=128.99; Pr > F <0.0001
[b]DF 3; F=19.20; Pr > F 0.0003

Soil and air temperature

Air temperature within the onion plots is displayed in Figure 9. There is little difference between the air temperatures of the mulch treatment plots. Soil temperatures in the onion plots are displayed in Figure 10. Soil temperature varies with treatment with the plastic mulch consistently having the highest soil temperature and the punched WeedGuardPlus treatment having the lowest. The shredded WeedGuardPlus and the bare ground control were consistently in the middle with the bare ground being slightly higher than the shredded treatment during most weeks.

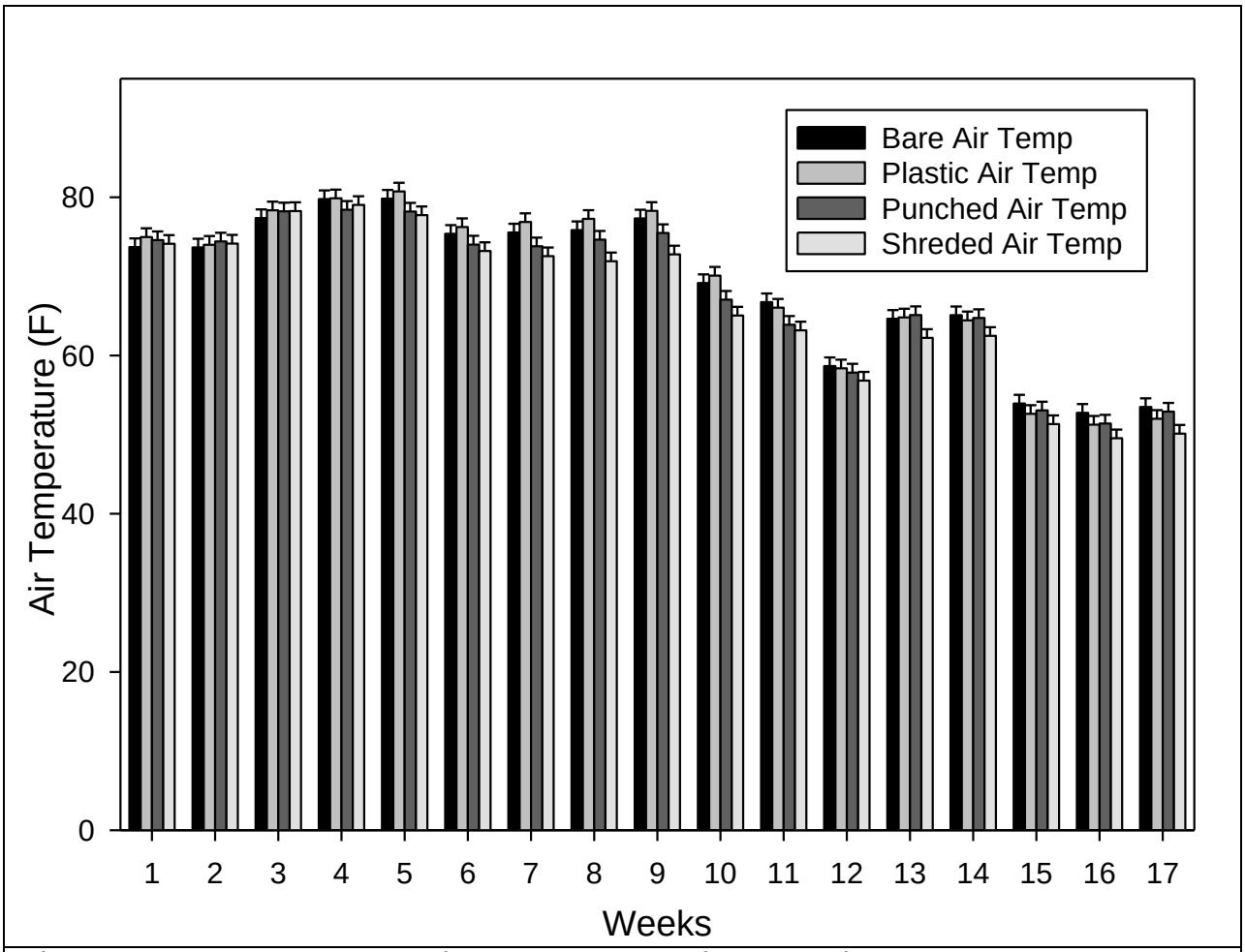

Figure 9. Average weekly air temperatures in the onion plots. Temperature data collection begins on July 29th 2011.

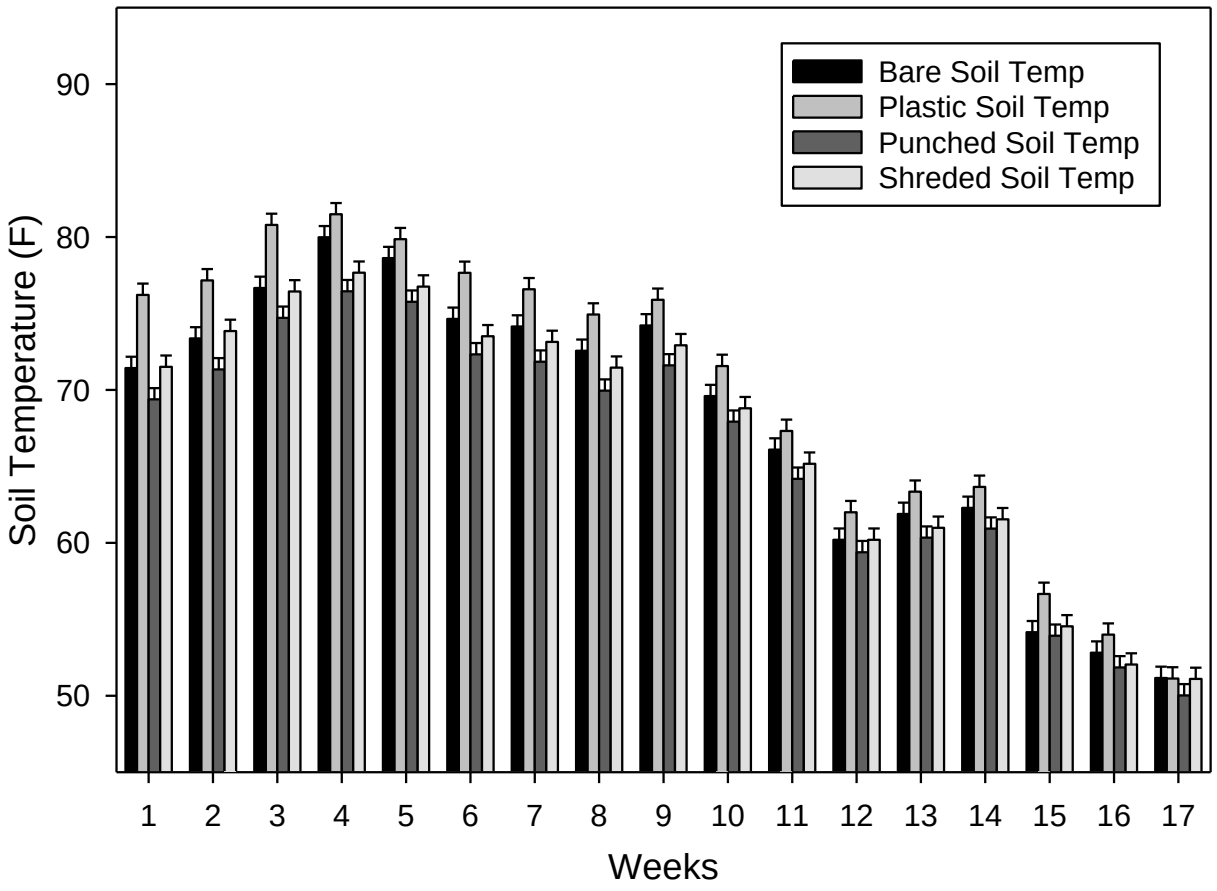

Figure 10. Average weekly soil temperatures in the onion plots. Temperature data collection begins on July 29th 2011.

Discussion

For the production of both broccoli and onion, WeedGuardPlus was as effective and in some degrees more effective than black plastic mulch. WeedGuardPlus did not increase yields for broccoli on a per plant basis or increase average bulb or crown weigh compared to the black plastic. However, the major advantage that WeedGuardPlus possessed compared to the black plastic was that for both broccoli and onions there was a great survival rate of the transplants which intern lead to higher yield on a plot or area basis. The elevated soil temperature observed in the black plastic probably contributed to lack of transplant survival. The cooler temperatures observed under the mulch treatments may have lead to a less of a transplant shock and great survival rate.

The tested mulch treatments did not affect on-plant populations of either of the insect species that were the focus of this study. Mulches that are lighter colored and reflect light have been shown to reduce numbers of both species; the mulches in this study were dark and did not provide much contrast with the soil background.

The WeedGuardPlus mulches did substantially suppress weed pressure. There was an observed reduction of weed biomass by 60% in the shredded plots and reduction of weed biomass of by 90% in the punched WeedGuardPlus compared to the bare ground check. Weed populations (particularly purslane) were less reduced by the shredded WeedGuardPlus mulch compared to the punched WeedGuardPlus. All mulch treatments held up well and remained largely intact throughout the trial.

Of note, the wet spring delayed the tractor application of the mulches. The shredded paper mulch was the most easily applied on the small plots area and matted well after the initial wetting. Thus in situations where weather could delay tractor operations and hand application is physically and economical viable, the shredded mulch provides an advantage over the rolled mulches. The other advantage of the shredded mulch is that it can be applied after transplanting and additional mulch can be applied if needed. However, the shredded mulch was not as effective at suppressing weed biomass as well as increasing total plot yields. Perhaps a higher application rate could solve some of those issues. Overall through, for a commercial operation the rolled WeedGuardPlus appears to be a better alternative solution to black plastic mulch due it is ability to be mechanically laid out and its more effective weed control.

Overall, WeedGuardPlus was well suited for the production of both onions and broccoli. The increased transplant survival rate compared to the black plastic was the most interesting finding of the study. The much cooler soil temperatures of the punched WeedGuardPlus compared to the black plastic and somewhat cooler soil temperatures compared to the bare ground is of particular interest. This could be an advantage for producers looking to establish cool season crops such as brasicas in the middle of the summer for a fall harvest. It could also extend the growing region of areas where high summer temperatures prevent effective vegetable production. To further understand the best management practices associated with WeedGuardPlus, further research should be performed on soil water dynamics underneath the mulch. Overall the WeedGuardPlus mulch should increase soil water content compared to bare ground but due to its permeable nature the degree of preservation is currently unclear. Additionally, the cooler soil temperatures under WeedGuardPlus may negatively impact warm season crops such as tomatoes and peppers. This would also be important to explore due to the widespread use of plastic mulches in field tomato production.