

The relative effect of three mulches on rainbow silver beet chard yields

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Abstract Mulches are a sustainable alternative to herbicides. This study looked at the relative effect of newspaper mulch, subterranean clover mulch, coffee residue mulch and bare ground control on rainbow silver beet chard yields, with the mulches and control having been left unweeded for three months prior to planting. Newspaper mulch and coffee mulch were expected to harbor the highest chard yields while the control was expected to harbor the lowest yields. The field is located in Albany, CA. There were four replicates per mulch type and control. Each replicate measured 3.5 by 2.5m. The mulches were laid down and left unweeded. After three months % weed cover was visually estimated per plot and rainbow silver beet chard crops were transplanted into the mulches. Eight chard crops per plot were harvested one month after transplanting. The chard crops were weighed together per plot. One-way ANOVA was used on the crop weights and % weed cover. The ANOVA test came out with a P-value of 0.0318 for the chard weights and a P-value of <0.0001 for % weed cover. The only significant difference between chard weights was between the newspaper mulch and the clover mulch. Newspaper mulch had higher chard weights than clover mulch. Percent weed control was significantly different between all combinations of mulch treatments and control. The control plots had the highest % weed cover, followed by clover mulch, then coffee mulch, and newspaper mulch had the lowest % weed cover. The results show that newspaper mulch supports higher yields than subterranean clover mulch if chard crops are planted three months after laying down the mulch and leaving it unweeded. The chard crops were probably in the ground too short to see significant differences in yields. Also a eucalyptus tree probably released allelopathic chemicals in two plots, which probably confounded the results. This study implies that newspaper mulch should be used rather than subterranean clover mulch if chard is planted into mulch that has been left unweeded for 3 months prior to planting.

Introduction

Herbicides have a negative effect on the life of birds and beneficial insects (Freemark and Boutin 1995). They leach into groundwater and drift off to kill plants in the neighboring ecosystem (Radosevich 1997). Thus, in order to avoid the harm that herbicides do to the environment, alternatives have been sought that sustain human and environmental health.

A mulch is a material or legume that covers the ground in between crop rows that is used as a form of weed control, to maintain soil moisture, to maintain a steady temperature within the soil, and to keep fruits from spoiling if they touch the ground (Pierce 1998). Mulches can be inorganic, organic, or living. The inorganic form usually consists of clear or black plastic sheets tucked into the ground. This form Organic forms include straw, leaves, compost, newspaper, used coffee grounds, sawdust, tree bark, and various others. Living mulches are usually patches of various species of clover or vetch, and all tend to be nitrogen-fixing.

Mulches can affect crop yields by influencing weed cover, soil moisture, nutrients, and pH (Gliessman 1998). By reducing weed cover, mulches can have a positive impact on crop yields. Organic mulches can conserve soil moisture, which allows crops to withstand longer drought periods. Organic mulches can add nutrients to the soil and living mulches can remove nutrients from the soil. Some organic mulches, such as coffee residues, can affect the acidity of the soil, which may affect crop yields positively or negatively depending on specific crop pH tolerance ranges (Nogueira and Flores 1987).

In this study I am going to evaluate the relative effect of newspaper mulch, coffee residues as mulch, and subterranean clover (*Trifolium subterraneum* L.) mulch, left unweeded, on the yields of Silver Beet Chard.

Some farmers do not have labor or capital inputs to keep their land weed free. This study takes these farmers into account by examining how the three mulches will affect chard yields if they are to be left unweeded for a period of time.

We have chosen newspaper and used coffee grounds as organic mulch material because they are a cheap, easily available material that would otherwise be on its way to the landfill. Thus, using these mulch materials is a way of reuse and a benefit for the environment.

Previous studies have looked at the effects of various organic and living mulches on crop yields most showing that mulches have a positive effect on crop yields (Kamara, Akobundu, Sanginga and Jutzi 2000; Carter et al. 1992; Brandsaeter et al. 1998; and others). Three studies

examined the effects of newspaper and subterranean clover on crop yields but without comparing the two mulches. Monks *et al.* (1997) stated that chopped newspaper and shredded newspaper provided yields in tomato similar to the area treated by two herbicides. A study done on subterranean clover as a living mulch indicated that subterranean clover is great in reducing weed biomass but has no effect on crop yield (on corn, sweet corn, cabbage, snap peas and tomato) (Ilnicki and Enache 1992). Another study on subterranean clover found that grape yields were higher in synthetically fertilized plots than ones with the clover (Favretto *et al.* 1992).

However, no study compared the effects of subterranean clover, newspaper, and coffee residue mulches on crop yields. Without such a study a farmer does not know which mulch has the best impact on crop yields.

Newspaper mulch decomposes slowly and provides a physical barrier for weed growth, thus providing great weed control (Kamara, Akobundu, Chikoye and Jutzi 2000; Vasilikiotis 2000, pers. comm.). This would result in minimal competition from weeds on crops. Coffee residues were reported to increase sweet potato yields and act as a great fertilizer (D'Souza and Bourke 1986). Organic mulches retain soil moisture, allowing crops to have good yields during drought periods (Gliessman 1998). Subterranean clover competes with crops for water and nutrients but not as intensely as most weeds since clover fixes nitrogen and thus competes less for that nutrient (Brandsaeter *et. al.* 1998, Vasilikiotis 2000, pers. comm.). Unmulched ground allows plenty of weeds to grow and compete with crops, resulting in low yields (Vasilikiotis 2000, pers. comm.). Thus, my hypothesis is that Silver Beet Chards planted in newspaper mulch and coffee mulch result in the highest yields while those planted in unmulched control result in the lowest yields.

Descriptions of Study Subjects The study site is located at Gill Tract in Albany, California. It is located outdoors in an area protected from wind on one side by a trailer. The field is twenty meters by seven meters in area; it is divided into sixteen plots measuring 3.5 meters by 2.5 meters. Two plots in one corner of the field are shaded by a large Eucalyptus tree. This tree drops leaf litter on these plots.

Methods

Three mulch treatments consisting of subterranean clover mulch, newspapers covered by straw, and used coffee grounds and a bare ground control were evenly spaced out on the plot to minimize confounding due to microclimate and soil fertility effects (Orr 2000, pers. comm.). Mulches were randomly assigned to each set of plots. The field was tilled before planting or laying down the mulches on November 15, 2000.

Rakes were used to even out the surface of the plots (Vasilikiotis 2000, pers. comm.). Clover seeds covered with rhizobium inoculant were broadcast evenly in their plots three days after tilling. A rake was used to scrape the ground so the seeds were covered. Then the seeds were pressed in the ground with a piece of board. All the plots were watered with a hose three times over with the hose head facing up. All the plots received water either by rain or by hose at least every three days for two weeks. After that watering was at least every ten days except for a period of four weeks three weeks after the clover was sown when the clover got no water.

A twelve to eighteen sheet thick newspaper layer was laid down in the appropriate plots, with the sheets overlapping ten days after sowing the clover (Vasilikiotis 2000, pers. comm.). The layer was sprinkled with water. Dry straw was placed on top of the newspaper to keep the newspaper from flying away. The straw was 9-12 cm thick. The rest of the field was watered.

Used coffee grounds were put down evenly on the appropriate plots to a thickness of ≈ 1 cm (Vasilikiotis 2000, pers. comm.). Another layer of coffee grounds was put two weeks later to a thickness of 3-6 cm. The coffee grounds were smoothed out with a rake to make an even surface.

Percent weed cover was visually estimated eleven weeks after laying down all the coffee mulch. A scale of 0 to 10 was used with 0 standing for 0% weed cover and 10 for 100% weed cover (Monks et al 1997). The plots that were planted with clover were mowed to ≈ 1 -2 cm height a day later (Vasilikiotis 2001, pers. comm.). The plant residues were left on the plots.

UC Davis potting soil mix was placed in a total of 1,024 containers of a volume of 3cm by 3cm by 4 cm (height) five days after mowing clover. Chard seeds were planted \approx 1 cm deep in each container (golden gate). The containers were placed in a greenhouse and watered every day. The containers were placed in a lath house three weeks after planting the seeds.

Twenty-four circular clearings of bare ground were made of 10-15 cm diameter in each in each plot 24 days after planting chard in the greenhouse (Vasilikiotis 2001, pers. comm.). These clearings were in four rows in each plot that were \approx 45 cm apart measured from center to center of each clearing. The clearings were \approx 30 cm apart within the rows. The rows were lying parallel to the 2.5 m border of each plot. The rows lay \approx 90 cm from the 2.5 m edge of the plots and \approx 45 cm from the 3.5 m edge of the plots.

Chard was transplanted into the clearings in each plot 15 days after placing them in the lath house (. Roots were minimally disturbed during transplanting. The chard crops received water at least every three days for one week and then received no water for 10 days; after that they received water at least once every 5 days (Vasilikiotis 2001, pers. comm.).

The part of the chard above ground was harvested 4 weeks after transplanting. Eight crops in the center of each plot were harvested. All crops on the outer rows of each plot and on the ends of each row were not harvested. The crops in each plot were grouped together and weighed, such that there was one total weight per plot.

One-way ANOVA was done on the resulting chard weights and on the visually estimated percent weed cover of each plot, followed by the Tukey-Kramer post-hoc test.

Results

The one-way ANOVA for the weights of chard crops per plot gave a statistically significant result of P-value = 0.0318. The Tukey-Kramer post-hoc test showed that the only two mulch treatments that had a statistically significant difference in weight of chard crops were newspaper and subterranean clover mulch (Table 1). The newspaper mulch had higher chard weights than subterranean clover (Fig. 1). The differences between the weights of chard crops between the other combinations of mulch treatments and control were statistically insignificant (i.e. between newspaper mulch and control, coffee mulch and newspaper mulch, etc.).

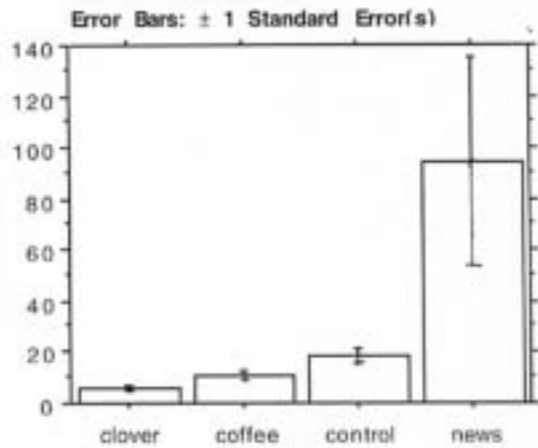


Fig. 1 Chart showing mean total weight values per mulch type with error bars. Vertical axis shows total weight values in kg.
 clover = subterranean clover mulch
 coffee = coffee mulch
 news = newspaper mulch
 control = control

Tukey/Kramer for biomass (g)
 Effect: mulch type
 Significance Level: 5 %

	Mean Diff.	Crit. Diff.	
clover, coffee	-4.700	86.396	
clover, control	-12.600	86.396	
clover, news	-88.650	86.396	S
coffee, control	-7.900	86.396	
coffee, news	-83.950	86.396	
control, news	-76.050	86.396	

Table 1. Tukey-Kramer post-hoc test results. The "S" stands for statistically significant difference.

The one-way ANOVA for visually estimated % weed cover for each plot gave a highly statistically significant result of P-value < 0.0001. The Tukey-Kramer post-hoc test showed that differences in % weed cover were statistically significant amongst all mulch treatments and control. The control had the highest % weed cover, the clover mulch had the second highest % weed cover, coffee mulch had a % weed cover lower than the clover mulch, and newspaper mulch had the lowest % weed cover (Fig. 2).

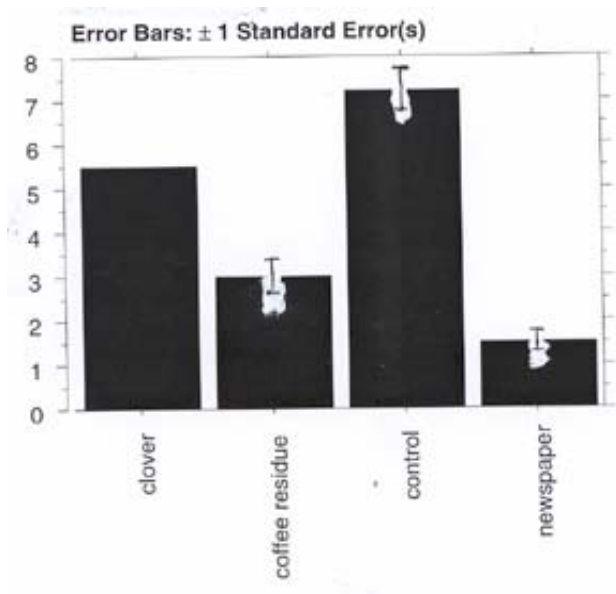


Fig. 2 Chart showing mean % weed cover values per mulch type with error bars. Vertical axis shows rating of visually estimated % weed cover with 10 = 100% weed cover and 0 = 0% weed cover.
 clover = subterranean clover mulch
 coffee residue = coffee mulch
 newspaper = newspaper mulch
 control = control

Discussion

The results show that planting into newspaper and straw mulch would result in higher yields of rainbow silver beet chard than planting the crops into subterranean clover mulch, if both mulches are laid down and left unweeded 3 months prior to planting. Planting in any of the other combinations of the mulches and bare ground control would not result in any difference in chard yields.

Planting in newspaper mulch resulted in higher yields than planting in subterranean clover probably for the following reasons. Newspaper mulch had a lower weed density than clover mulch. Also, there was a ten day period of drought that the chard had to bear. The newspaper mulch conserves soil moisture while the clover takes soil moisture away through transpiration, thus the higher availability of water in the newspaper mulch probably had a positive impact on yields. Brandsaeter et. al. showed that subterranean clover is most competitive when both the clover and the crop are small (1998). The chard was small in this study. Also, the clover

completely blocked all sunlight from the chard crops in this study as well as competing for nutrients and water.

The rainbow silver beet chards maybe were in the ground for too short of a time (1 month) to notice any significant differences. Researchers usually leave the crops for a longer time in the ground to get statistically significant differences in yields (Ibarra et. al. 2001, Easson and Fearnough 2000, Singh 2000, etc.). Unfortunately, due to time constraints of the study, leaving the chard crops in the ground for a longer time was not done.

Considering only the weed cover, chard yields should have been highest in the newspaper mulch, followed by the coffee mulch, then the clover mulch, and the control should have the lowest chard yields since more weed cover means more competition between crops and weeds which results in lower yields.

Coffee residues are highly acidic with a pH of 4.2 (Nogueira and Flores 1987). This factor could have affected chard yields negatively since chard cannot tolerate this pH level (Peirce 1998). How much the coffee residues changed the pH of the soil is not known and depends on how much coffee residues were added. It is possible that the acidity factor could have offset the factors of nutrient addition and moisture conservation as well as low % weed cover that increase crop yield.

The litter of the eucalyptus tree could have decreased crop yields in the two plots that it influenced as a result of the allelochemicals that its leaves contain (Babu and Kandasamy 1997). These plots were a control plot and a coffee mulch plot. Percent weed cover was higher in this coffee mulch plot than the other coffee mulch plots. Yet percent weed cover was higher in the control plot influenced by the eucalyptus tree than the other control plots. This difference in weed cover between the two plots could be possible because the coffee residues provided a barrier that probably delayed the seeping into the ground of the allelochemicals while the allelochemicals in the control plot seeped directly into the ground.

The total weight of chard crops in the control plot influenced by the eucalyptus tree was lower than the other control plot despite the low percent weed cover. This was probably the result of allelopathy in depressing chard yields. Babu and Kandasamy (1997) showed that the effect of the allelochemicals from eucalyptus varies from plant to plant, it could even increase growth of some plants. Thus, it is not known what kind of an effect these allelochemicals have on chard yields. The effect of these allelochemicals probably confounded the results.

Soil fertility probably varied within the field (Vasilikiotis 2000, pers. comm.). This would result in confounded results since some plots may have been more favorable to crop growth. It was observed that the level of soil compaction varied from plot to plot. This probably had an effect on chard yields since roots spread out less in more compacted soil and thus reach less nutrients and water, resulting in lowered yields (Brady and Weil 1996). This variability in compaction from plot to plot probably confounded the results.

This study cannot necessarily be applied to any crop. The effects of mulch types vary among vegetable species (Ricotta and Masiunas 1991). A lot of crops have similar pH tolerances, which means that the coffee mulch would have the same effects on a lot of crops (Pierce 1998). Yet one should not rely on the results of the coffee mulch for more acid tolerant or intolerant crops. Plants also have different nutrient and water requirements and thus can be affected differently by the same mulches (Altieri 2001, pers. comm.).

This study also cannot be applied to mulches that have been weeded directly prior to planting. This is because the weed cover was high during transplanting and the effect of weed competition on crop yields would be significant enough that the study cannot apply to weeded mulches (Vasilikiotis 2001, pers. comm.).

Coffee residues took a very long time to gather. Cafes give away coffee residues in small quantities which makes it very time consuming and inefficient. Thus this form of mulch is probably only suitable for the small garden. Newspapers are available in large quantities at recycling centers, making them not very time consuming to obtain. Clover mulch is probably the most feasible for large farms because it is much easier to apply.

This study implies that farmers or gardeners should use newspaper mulch rather than subterranean clover mulch if they plan to plant into mulch that has not been weeded for approximately three months if the farm is not too large. It does not necessarily imply that planting into any of the other combinations of mulches and bare ground would result in no yield differences because there is a high probability of confounded results and the chard crops were probably not in the ground long enough to give significant results

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