Can Mulch Increase Predatory Arthropod Populations in Agricultural Crops?

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Abstract Integrated pest management describes management of agricultural pest populations without resorting to chemical pesticides. One way to reduce pest populations is to increase the populations of pests' natural predators. Previous research shows that using mulch as a ground cover decreases pest populations, and suggests that this decline is due to higher populations of natural predatory arthropods. To determine if this is actually the case, I measured the relative population sizes of seven species of predatory arthropods in mulched and unmulched broccoli and bean plots over a 10-week period. My analysis shows that, contrary to my hypothesis, mulch either has no impact, or has a negative impact, on the population sizes of predatory arthropods.

Introduction

Sustainable agriculture is the concept that we can produce sufficient food without depleting or polluting our natural resources. One possible approach to making agriculture more sustainable is through the use of integrated pest management, which is a technique for managing pest populations without resorting to chemical pesticides that have damaging effects on ecosystem and human health. A key strategy in integrated pest management is to increase the populations of natural predators of agricultural pests (Symondson et al., 2002). Some of the most effective predators are surface-active arthropods, including ladybugs (family Coccinellidae), ground beetles (Carabidae), rove beetles (Staphylinidae), earwigs (Forficulidae), garden spiders (Linyphidae), harvestmen (Phalangidae), and centipedes (Lithobiidae) (Wratten and Powell, 1991). Previous studies have shown these beneficial predatory arthropods to be effective against many agricultural pests, including beetles, weevils, sciarids, whiteflies, aphids, mealybugs, scale insects, spider mites, slugs, snails, and woodlice (Heyler et al., 2003). Farmers may increase natural predatory arthropod populations by directly releasing these insects onto their crops (Kehrli et al., 2000). Another method of increasing beneficial predator populations that has not been as well studied is improving beneficial predatory arthropod habitat by adding ground cover like mulch. Mulch is normally added to soils to decrease water depletion and increase irrigation efficiency (Huang et al., 2004). It is also used as a method of weed suppression to reduce dependency on chemical herbicides (Jenni et al., 2004). Several studies have shown the link between the use of mulch and a decrease in pest populations (Wise et al., 1999; Humphreys and Mowat, 2004; Way, 1992; and Sunderland and Samu, 2000). These studies assume that beneficial arthropod populations are responsible for the decrease in the pest population and that mulch improves beneficial arthropod habitat by offering cover from their own predators, protection from sunlight, moist soil, and increased nesting sites. M. Schmidt provided evidence for this by sampling not only pest populations but predator populations in both mulched and unmulched plots (Schmidt 2004).

I plan to clarify the link between mulch and beneficial predator populations. My research objective is to determine whether there is a significant increase in beneficial predatory arthropod populations in mulched plots compared to unmulched plots. I hypothesize that the plots with mulch will have higher predator populations than those without, and that weeds will not be a factor in predator population sizes.

Methods

I conducted my research at the Gill Tract Agricultural Research Station in Albany, California. I used plots established by Dr. Miguel Altieri's lab at this site. I sampled the beneficial arthropod populations in five plots (Table 1.) The plots differ in the crop grown, the presence/absence of weeds, and the presence/absence of mulch. The plots are in two groups: those growing broccoli, and those growing beans. In the broccoli group

there are three plots: one with mulch, one with no mulch, and one with no mulch that is kept weed-free through hand weeding.[1] In the bean group there are two plots: one with mulch and no weeds, and the other without

Table 1. Comparison of the Five Plots

	Broccoli	Bean	Weeds	Mulch
Plot 1	X			X
Plot 2	X		X	
Plot 3	X			
Plot 4		X		X
Plot 5		X	X	

mulch but containing weeds. These two plots are a separate experiment that will provide additional evidence for my study regarding the effect of mulch on different types of crops.

I sampled the arthropod populations using pitfall traps. Each pitfall trap consists of a nine-ounce plastic cup filled halfway with a 50/50 concentration of ethylene glycol (a preservative) and water. The cups are planted in the ground so the rim is flush with the top of the soil. Soil arthropods moving across the soil enter the cups and drown in the preservative. These traps follow a modified version of designs used by J.P. Isaach and K.L. Collins. Pitfall traps, although not useful in extrapolating actual population size of invertebrates, have been shown to be accurate in comparing relative population sizes of the same species of invertebrate between different plots (Isaach et al., 2005). I placed 10 traps in each of the five plots. The traps are placed between plants in a crop row, and staggered evenly in a grid pattern that avoids the edges of the crops (Fig. 1.)

[1] The justification for the third plot is that the other crop with no mulch is overrun with weeds, unlike the crop with mulch, because the mulch suppresses the growth of weeds. Having a plot overrun with weeds is not a realistic scenario for an actual agricultural plot because no farmer would allow his crop to be overrun with weeds. Also, the presence of weeds may be a confounding factor as the arthropods may have no preference for mulch or no mulch, but prefer a habitat with a high prevalence of weeds.

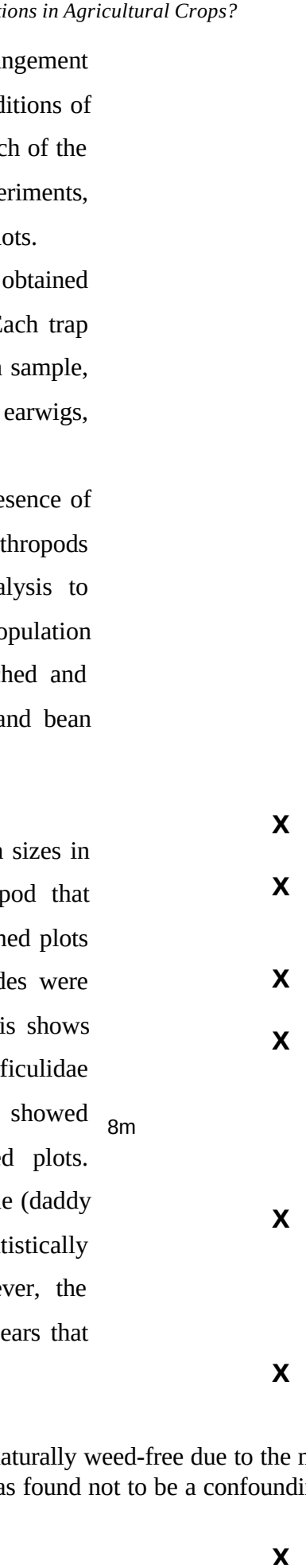
The justification for this arrangement is to standardize the arrangement between each of the plots, and to avoid edge effects from the conditions of the land that borders each of the crops. Because the land around each of the crops is not standardized, i.e., some includes crops for other experiments, this bordering land could influence traps set near the edges of the plots.

I collected the traps every two weeks for 10 weeks, and obtained samples on 9/28/05, 10/12/05, 1026/05, 11/9/95, and 11/23/05. Each trap produced five samples over the course of the experiment. For each sample, I recorded the number of ladybugs, ground beetles, rove beetles, earwigs, garden spiders, harvestmen, and centipedes.

I used a single-factor ANOVA analysis to determine if the presence of weeds had an impact on the populations of beneficial predatory arthropods in unmulched plots. I also used a single-factor ANOVA analysis to determine if there was a statistically significant difference in the population sizes of each species of beneficial predatory arthropod in mulched and unmulched plots. This analysis was the same for the broccoli and bean crops.

Results

Table 2 shows the results of comparing the relative population sizes in the broccoli crops with and without mulch.[2] The only arthropod that showed the expected results of having higher populations in mulched plots were the Lithobiidae (centipedes.) A greater number of centipedes were found in plots with mulch than without, and an ANOVA analysis shows this difference to be statistically significant. Neither the Forficulidae (earwig) nor the Staphylinidae (rove beetle) populations showed statistically significant differences in mulched and unmulched plots. Carabidae (ground beetle), Linyphidae (garden spider), Phalangidae (daddy long-leg), and Coccinellidae (ladybug) populations all showed statistically significant differences in mulched and unmulched plots, however, the populations were higher in plots without mulch. Therefore, it appears that



[2] These plots were also different in that the plots with mulch were naturally weed-free due to the mulch, and the plots without mulch had weeds. However, the presence of weeds was found not to be a confounding factor.

mulch decreases the populations of some beneficial predatory arthropods, increases the populations of Lithobiidae, and has no effect on other species.

Table 2. Difference in arthropod populations in broccoli crops

	Total with Mulch	Total without Mulch	P-Value (if Statistically Significant)
Carabidae	38	571	0.000131
Forficulidae	0	0	
Linyphidae	7	20	0.004993
Phalangidae	0	104	0.002932
Lithobiidae	13	4	0.048631
Staphylinidae	0	2	
Coccinellidae	1	36	0.003659

In the bean plots, I also used a single-factor ANOVA to compare the relative population sizes of each arthropod in crops with and without mulch.[3] Table 3 shows that the Lithobiidae were the only arthropods that showed the expected results of having higher populations in crops with mulch. The only other arthropods that produced statistically significant results were the Carabidae and Linyphidae, and both of these had higher populations in the crops without mulch. As with the broccoli plots, it seems that mulch stimulates the populations of Lithobiidae, decreases the populations of other species, and has no effect on the populations of others.

Table 3. Difference in arthropod populations in bean crops

	Total with Mulch	Total without Mulch	P-Value (if Statistically Significant)
Carabidae	93	402	0.000250
Forficulidae	2	0	
Linyphidae	44	117	0.000562
Phalangidae	341	365	
Lithobiidae	46	15	0.008093
Staphylinidae	19	22	
Coccinellidae	0	0	

Discussion

As I hypothesized, weeds were not a confounding factor in the presence of arthropods. Using a single-factor ANOVA analysis, I determined that the presence of weeds was not a confounding factor in the relative population sizes of arthropods in the broccoli crops. I compared the number of each type of arthropod collected on each sampling date between broccoli crops with weeds and broccoli crops that were kept weed-free from hand-weeding (neither of these plots had mulch.) There was not a statistically significant difference in the number of arthropods collected in these two plots.

In both broccoli and bean plots, the only arthropod that showed a higher relative population size in mulched plots was the Lithobiidae. The other arthropods either did not show a statistically significant difference in population sizes between mulched and unmulched plots, or had higher population sizes in unmulched plots.

There are two possible explanations for these findings. Contrary to previous research, the arthropods may have preferred plots without mulch, and avoided areas where mulch was present. This finding refutes the theory that mulch may be used as an integrated pest management technique. Another possibility is that the experiment design was flawed, and the pitfall traps did not accurately measure the arthropod populations. From observation of the traps, it appeared that arthropods may have been able to escape more easily from traps set in mulched plots, as fallen mulch provided ladders out of the traps. If this is the case, more research is needed to repeat this study with a different trapping mechanism.

Another potential source of error is the fact that I could not control for variance in weather throughout the duration of the experiment. Arthropods may have altered their mulch preference in response to the rain or other elements, and I could not control for these weather elements without moving the experiment to a greenhouse setting and therefore making the experiment less realistic and applicable to actual agricultural settings.

More research could also be directed towards determining the value of Lithobiidae in pest control. If Lithobiidae provide a significant degree of pest control compared to other arthropods, mulch may in fact be beneficial in controlling pest populations.

With the exception of Lithobiidae, the presence of mulch is either not a statistically significant factor, or is a deterrent to the population sizes of predatory arthropods. The presence of weeds is not a statistically significant factor in the presence of these arthropods.

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References

Ali, A.D., and T.E. Reagan. 1985. Vegetation manipulation impact on predator and prey populations in Louisiana sugarcane ecosystems. *Journal of Economic Entomology*. 78: 1409-1414.

Harvey, C., and M. Fubanks. 2002. effect of habitat complexity on biological control by the red imported fire ant (Hymenoptera: Fomicidae) in collards. *Biological Control*. 29:348-358.

Heyler, N., Brown, K., and N. Cattlin. 2003. *Biological Control in Plant Protection.* Timber Press.

Huang, Y., Liding, C., Bojie, F., Zhilin, H., and J. Gong. 2004. The wheat yields and water-use efficiency in the Loess Plateau: straw mulch and irrigation effects. *Agricultural waste Management*. 72: 209-222.

[3] As in the broccoli plots, the crop without mulch had weeds whereas the crop with mulch was weed-free. However, weeds were not a confounding factor for the presence of arthropods.

Humphreys, I.C., and D.J. Mowat. 1994. Effects of some organic treatments on predators (Coleoptera: Carabidae) of cabbage root fly, *Delia radicum* (L.) (Diptera: Anthomyiidae), and on alternative prey species. *Pedobiologia*. 38: 513-518.

Jenni, S., Brault, D., and K.A. Stewart. 2004. Degradable mulch as an alternative for weed control in lettuce produced on organic soils. *Acta horticulturae*. 638-111-118.

Kehrli, P., and E. Wyss. 2000. Effects of augmentative releases of the coccinellid, *Adalia bipunctata*, and of insecticide treatments in autumn on the spring population of aphids of the genus *Dysaphis* in apple orchards. *Entomolgia Experimentalis et Applicata.* 99:245-252.

Scheu, S. 2001. Plants and generalist predators as links between the below-ground and above-ground system. *Basic and Applied Ecology*. 2:3-13.

Schmidt, Martin H., Thewes, U., Thies, C., and T. Tscharntke. 2004. Aphid suppression by natural enemies in mulched cereals. *Entomologia Experimentalis et Applicata* 113: 87-93.

Sunderland, K.D., and F. Samu. 2000. Effects of agricultural diversification on the abundance, distribution, and pest control potential of spiders: a review. *Entomologia Experimentalis et Applicaata.* 95: 1-13.

Symondson WOC., Sunderland K.D., and H.M. Greenstone. 2002. Can generalist predators be effective biocontrol agents? *Annual Review of Entomology* 47: 561-59.

Way, M.J., and K.C. Khoo. 1992. Role of ants in pest management. *Annual Review of Entomology*. 37: 479-503.

Wise, D.H., Snyder, W.E., Tuntibunpakul, P., and J. Halaj. 1999. Spiders in decomposition food webs of agroecosystems. Theory and evidence. *Journal of Arachnology.* 27: 363-370.

Wratten S.D., and W. Powell. 1991. Cereal aphids and their natural enemies. *The Ecology of Temperate Cereal Fields. 32nd Symposium of the British Ecological Society.* 223-257.