Weed diversity decreases pest abundance without yield loss

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Abstract

Farmers spend much of their time and money managing weeds because they compete with crops but weeds also provide ecosystem services on farms. They introduce plant diversity in a crop monoculture and are important habitats for beneficial insects, providing alternative food resources and refuge from weather and predation. In this experiment we measured effects of weed diversity on the density of predators in eggplant crops and on biological control of pests and weed seeds. We manipulated weed density in 10 small plots, performed weed surveys, and sampled pest and predator communities with pitfall traps, visual surveys, and vacuum collection. We measured biological control of weed seeds and insect prey as well and collected eggplant yield data to measure potential costs of weed tolerance. In weedy plots we found more predators, fewer pests, and observed higher rates of consumption of seeds than in weed-free plots. However, pupae consumption between the two treatments were not statistically different. Importantly, there was no yield cost to weed tolerance in our system. While weeds do not always lead to reduced crop production, the biodiversity they provide can encourage pest control services in agroecosystems.

Methods

Experimental design

- Eggplants planted at student organic farm
- 10 plots, 7 plants per plot
- Two different treatments: **weedy** and **weeded**
- Odd number plots were weeded, even number plots were weedy
- In weedy treatment weeds were kept to 8 inches tall and 5 cm away from the eggplants
- Weeded plot were weeded every week after weed surveys

Weedy Plot

Bare Plot

Weed surveys

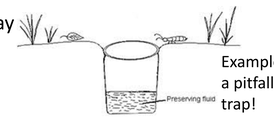
- Weeds were identified and counted in a quadrat on the focal plant

D-VAC!

Weed Survey!

Insect surveys

- Insects on the focal plant were visually sampled
- Insects were also vacuum sampled
- Pitfall traps were set every Friday and collected every Monday
- Predators and herbivores were identified to the family level



Example of a pitfall trap!

Seed and prey removal

- Petri dishes with seeds and larvae were set out
- Number of seeds/larvae left were counted

Seed and prey plates!

Results

Fig. 1 *

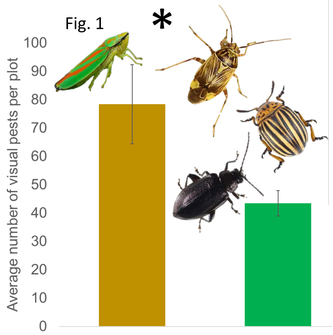
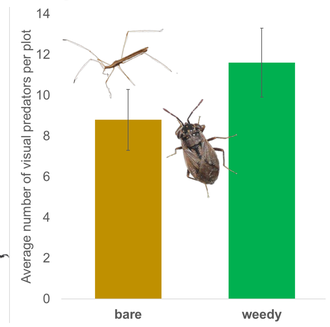
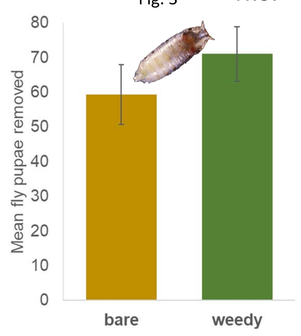


Fig. 2 *



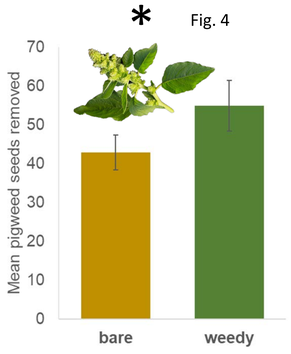
We found more predators and fewer pests in the weedy plots.

Fig. 3 n.s.



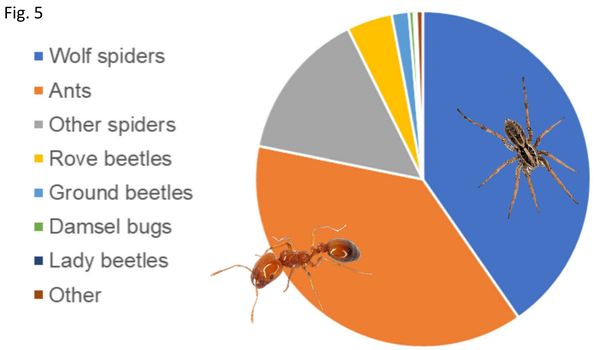
Seed removal was greater in weedy plots but pupae consumption was not.

Fig. 4 *



Soil-surface predator community

Fig. 5



Foliar predator community

Fig. 6

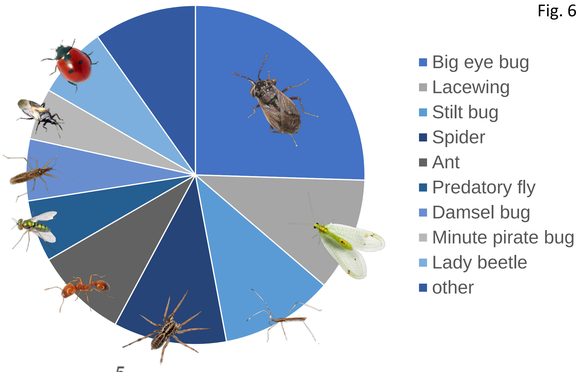
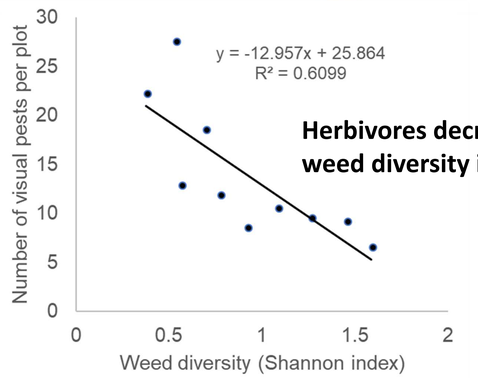


Fig. 7



Herbivores decreased as weed diversity increased.

Fig. 8

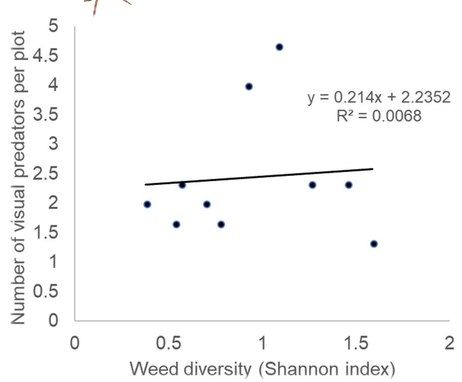
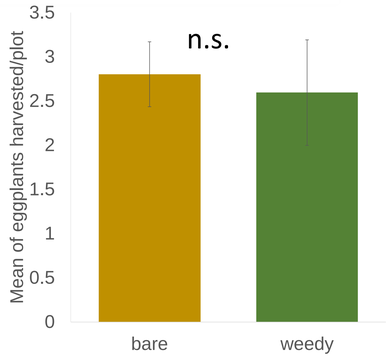
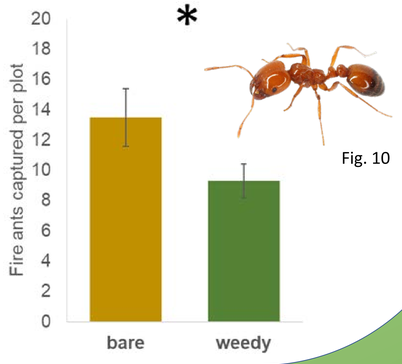


Fig. 9



Weeds had no influence on eggplant yield!

Fig. 10



Discussion

- The higher number of pests observed in the weed free plots (Fig. 1, Z = -7.00, df = 8, p = > 0.001) is consistent with both the 'resource concentration hypothesis' and the 'enemies hypothesis' (Root 1973). The former hypothesizes that weeds surrounding a crop interfere with way specialist pests locate the crop they feed on. The latter hypothesizes that the plant diversity in the system encourages the number of predators, lowering the number of herbivores on the crop.
- Weed presence encouraged predator presence (Fig. 2, Z = 1.73, df = 8, p = 0.08), but weed *diversity* had no effect on predator presence (Fig. 8). This suggests that weeds provide preferable structure and microclimate (shade), but diversity may not predict predator activity.
- Weedy plots encouraged more biocontrol on weed seeds (Fig. 4, T = 5.688, df = 8, p = 0.004).
- Weeds provide habitat for the granivores (Blubaugh 2016), therefore tolerating a small amount of weed growth may ultimately increase seed destruction.
- Pupae consumption did not differ between weedy and weeded plots (Fig. 3, T = 0.889, df = 8, p = 0.399), likely because the soil-surface community was dominated by fire ants (Fig. 5) which were more active in bare plots (Harvey 2004). Fire ants are an invasive species that rapidly eat whatever is on the soil-surface, especially nutrient-rich fly pupae.
- What is important to note is that all these different ecosystem services provided by weeds did not affect yield. The number and the weight of the eggplants harvested from the 10 plots were not significantly different (Fig. 9, F = 0.03905, df = 8, p = 0.8483). This means that instead of maintaining a strictly weed-free farm, a farmer could allow weeds to grow until they reach the point where competition is a concern, saving time and suffering.

Acknowledgments

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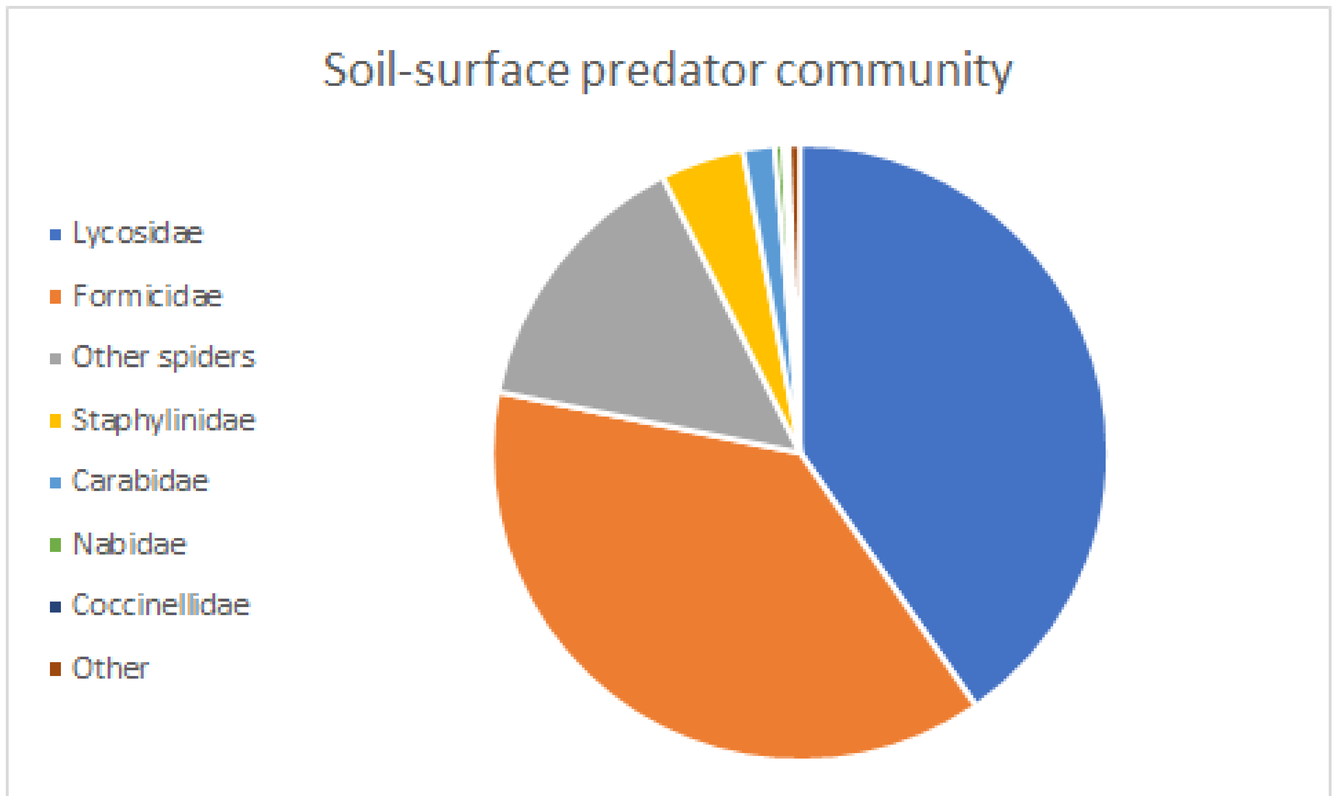
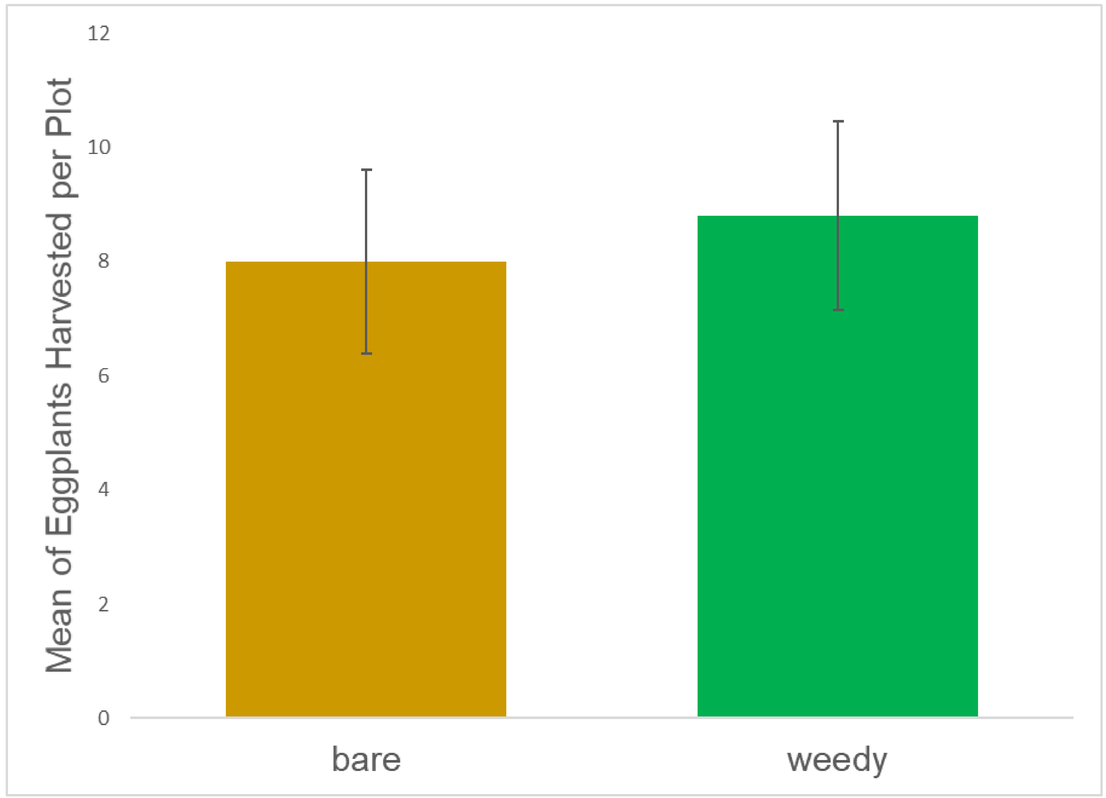
References

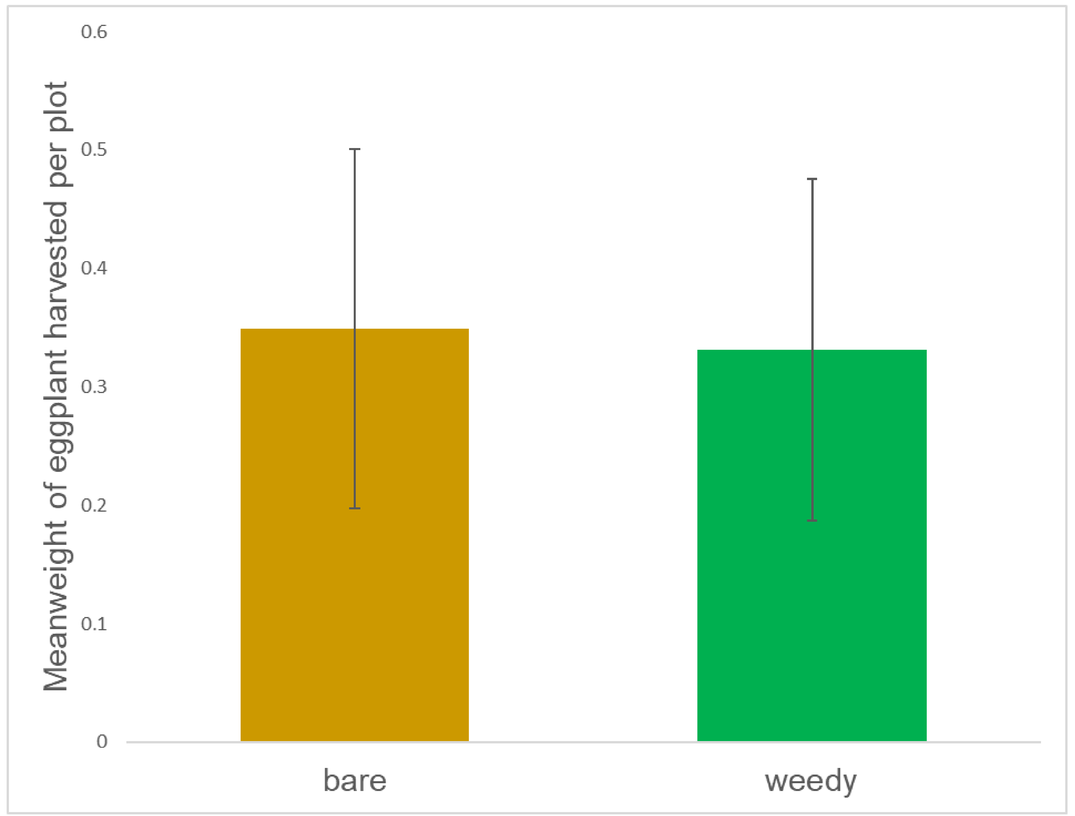
Root, R.B., 1973. Organization of a plant-arthropod association in simple and diverse habitats: the fauna of collards (Brassica oleracea). *Ecological monographs*, *43*(1), pp.95-124.

Blubaugh, C. K., Hagler, J. R., Machtley, S. A., & Kaplan, I. (2016). Cover crops increase foraging activity of omnivorous predators in seed patches and facilitate weed biological control. *Agriculture, Ecosystems & Environment*, *231*, 264-270.

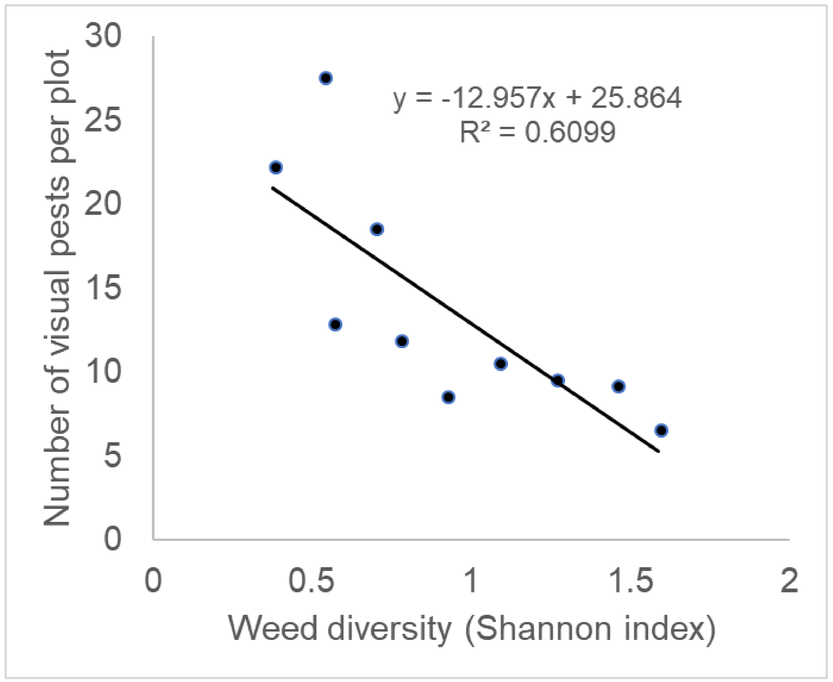
Harvey, C. T., & Eubanks, M. D. (2004). Effect of habitat complexity on biological control by the red imported fire ant (Hymenoptera: Formicidae) in collards. *Biological control*, *29*(3), 348-358.

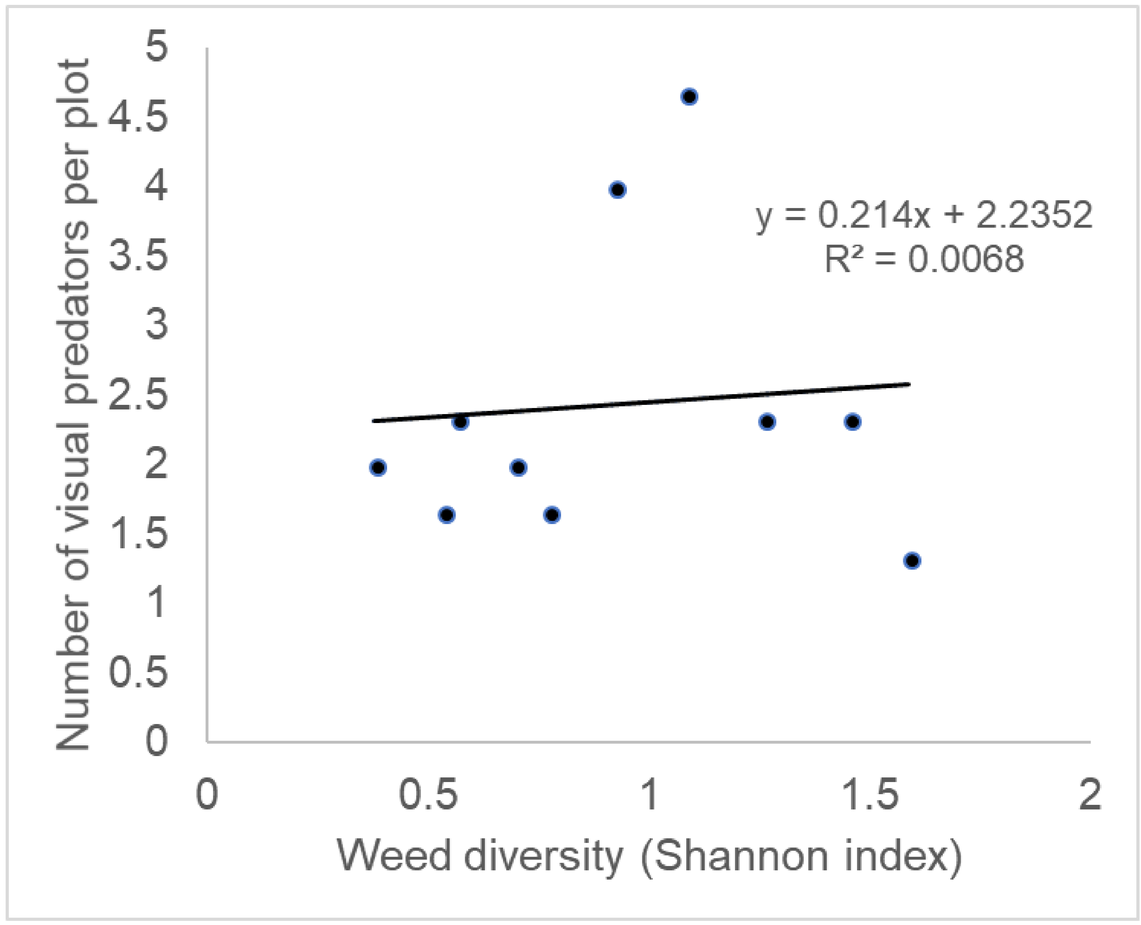

Soil-surface predator community
Lycosidae
Formicidae
Other spiders
Staphylinidae
Carabidae
Nabidae
Coccinellidae
Other





Mass of eggplants harvested did not differ between weedy and bare plots.
(F-statistic: 0.03905 on 1 and 8 DF, p-value: 0.8483)


y = -12.957x + 25.864
R² = 0.6099
Number of visual pests per plot
30
25
20
15
10
5
0
0
0.5
1
1.5
2
Weed diversity (Shannon index)


y = 0.214x + 2.2352
R² = 0.0068
Number of visual predators per plot
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
Weed diversity (Shannon index)