Diversity and Intensity of Cover Crop Systems: Managing the Weed Seed Bank and Soil Health

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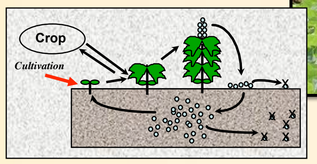
The Challenge

Weeds—the foremost production-related problem on organic vegetable farms

Cultivation works, but…

- efficacy is variable, affected by operator skill, weather, equipment, soil conditions, weed size, and
- only kills a proportion of seedlings present, a problem if the seed bank is high.



…and cultivation degrades soil quality: oxidizes organic matter; degrades physical structure; reduces moisture retention; and reduces microbial activity

Objectives

Determine the annual and long term effects of contrasting 2- and 4-year cover crop based vegetable rotations on (1) weed population dynamics; (2) selected soil quality parameters; and (3) crop yield, quality, and system profitability.

Cropping Systems Comparison

The Rogers Farm Cropping Systems Trial evaluated four cover cropping strategies used by experienced vegetable growers.

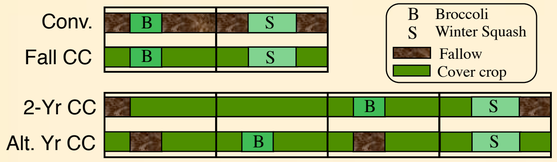
Conv. = conventionally managed rotation of broccoli and winter squash

Fall CC = an organic, "land-limited" system but with winter cover crops (e.g., rye/hairy vetch)

2-Yr CC = a rotation of broccoli, winter squash, cereal/red clover, red clover

Alt. Yr CC = a rotation of broccoli, cover crop/summer fallow, winter squash, cover crop/summer fallow

Systems (2- and 4-yr. rotations)



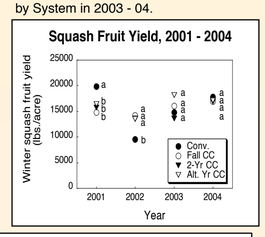
Broccoli & Squash Yields

Broccoli yields in 2002 and 2004 were lowest in the Alt. Yr CC System which lacked sufficient N.

Marketable broccoli crowns.

System	2002	2004
	(lbs/acre)	
Conv.	5954 a	3450 b
Fall CC	6637 a	4937 a
2-Yr CC	6144 a	3752 b
Alt Yr CC	3790 b	2655 c

Squash yield in the Conv. system exceeded that of the other systems in 2001, this effect was reversed in 2002; yield was unaffected by System in 2003 - 04.



EFFECT OF COVER CROP ROOTS

Red clover roots contributed as much or more to broccoli yields when incorporated (aboveground biomass removed) as did fertilizer N and whole red clover plants (Megan Gardner, M.S. research).

Broccoli Yield Following Cover Crop Total Biomass or Roots Only

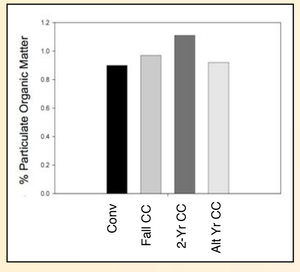
Treatment	2004 N fertilizer	2004 Total Plant Biomass (Mg ha-1)	2005 N fertilizer	2005 Total Plant Biomass (Mg ha-1)
RC2-RO	-	-	No	13.9 a
RC2-TB	No	14.9 a	No	9.2 a
RC2-TB	-	-	Yes	7.6 a
WR-WCC-RO	Yes	13.6 a	No	5.9 b
WR-WCC-TB	Yes	19.6 a	No	4.1 b
WR-WCC-TB	-	-	Yes	3.6 b

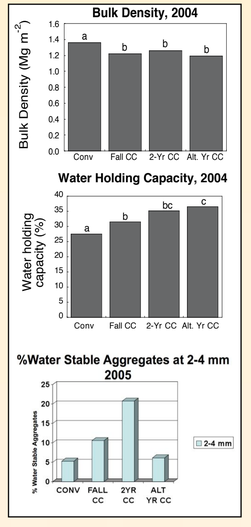
RC2 = 2yr red clover, WR-WCC = winter rye; RO=roots only, TB = total biomass

Soil Quality

Soil quality showed significant improvement in several parameters in cover cropped rotations compared to the conventional rotation.

- Bulk density was significantly lower by about 15% in all cover crop rotations after four years as compared to the conventional rotation.
- Water holding capacity increased significantly in all three cover crop rotations.
- Water stable aggregates in largest size fraction (2-4 mm) nearly 4x higher following two years of red clover than in the conventional soil with no covers.
- Particulate organic matter (POM), which estimates the active fraction of the OM, was significantly higher after two years of red clover than in the conventional rotation.



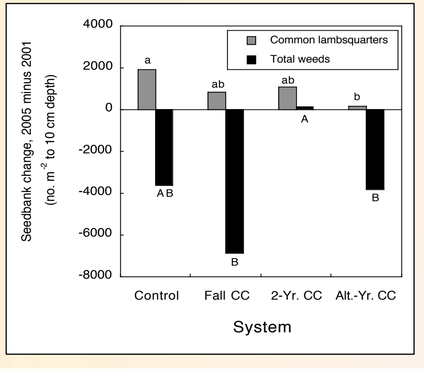


Weed Seed Bank

Alt. Yr CC prevented increases in common lambsquarters; red clover (2-Yr CC) maintained or increased the seedbank.

Seed Bank Change *2004 minus 2001*

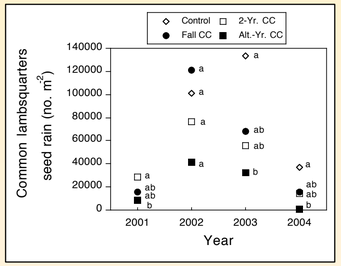
Despite a decline in the total weed seed bank, common lambsquarters increased in the Conv, Fall CC, and 2-Yr CC Systems. This increase did not occur in the Alt. Yr CC system. The decline in the seedbank due to the disturbance-intensive cover cropping practices (Alt. Yr CC) was evident in comparison to the sod-based cover cropping system (2-Yr CC), with mean densities of 1200 and 4600 germinable *C. album* seeds m^{-2}, respectively.



Seed Rain

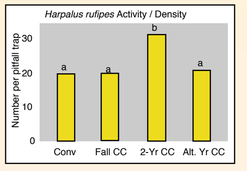
Alt. Yr CC consistently prevented large inputs of common lambsquarters seed.

Despite fall mowing, mature seed was often produced in red clover (2-Yr CC).



Seed Predation

The predominant invertebrate seed predator across all cropping systems was a carabid, *Harpalus rufipes* which was more abundant in red clover, compared to treatments recently tilled and planted to a fall cover crop. "Feeding" trials showed that most predation (>70%) was attributed to invertebrates.



Conclusions

Only the Alt. Yr CC system, with its summer fallow periods, successfully controlled the difficult-to-manage common lambsquarters. Although the 2-Yr CC benefitted seed predators, seed rain and infrequent disturbance maintained weed seeds in this system. The abundance of invertebrate seed predators and the high level of predation imposed on weed seeds at the soil surface, indicates that cover cropping strategies should consider late-season weed management which maintains seeds on the soil surface and provides desirable habitat for invertebrate predators

Soil physical parameters in the cover cropped systems have improved relative to the conventional system, and the improvement has generally been proportional to the period of time that each rotation is dedicated to cover crops. Soil inorganic N availability still appears to be insufficient to meet crop needs from fixed N in at least two of the cover cropped systems (Fall CC, "Beech Hill" and Alt. Yr CC, "Nordell") after three years.

Publications and Presentations

Peer-reviewed publications (4)

Gallandt E.R. (2006). How can we target the weed seedbank? Weed Science 54, 588-596.

Gallandt, E.R. (2005). Experimental substrate affects rate of seed removal in assays of invertebrate seed predation. Weed Technology 19:481-485

Gallandt, E.R., T. Molloy, R.P. Lynch, and F.A. Drummond. (2005). Effect of cover cropping systems on invertebrate seed predation. Weed Science 53:59-76.

Gallandt, E.R. (2004). Soil-improving practices for ecological weed management. in Weed Biology and Management, Inderjit, ed. Kluwer Academic Publishers, The Netherlands. pp. 267-284.

Invited presentations (5)

Managing the weed seedbank. Northeast Organic Farming Association 31st Annual Summer Conference, Amherst, MA (August 13, 2005).

How can we target the seed bank? Symposium, North Central Weed Science Society annual meeting, Columbus, OH (December 15, 2004).

Soil-improving practices for ecological weed management. Biology Department, Colby College, Waterville, ME (November 19, 2004).

Diversity and intensity of cover crop systems to manage the weed seed bank. Maine Organic Farmers and Gardeners Association, and the University of Maine Cooperative Extension annual Farmer-to-Farmer Conference. Bar Harbor, ME (November 6, 2004)

Integrated weed and soil management. United States Department of the Interior Fish and Wildlife Service National Integrated Pest Management Coordinators annual meeting. Ellsworth, ME (August 29, 2002; 12 in attendance).

Volunteered Presentations at Professional Meetings (2)

Gallandt, E. and T. Molloy (2004). Diversity and Intensity of Cover Cropping Systems: Effects on Weed Seedbank Dynamics. Northeast Weed Sci. Soc. Am. Abstr. 58:158.

Lynch, R. and E. Gallandt (2004). Effects of Cover Cropping Systems on Resident Weed Seed Predators. Northeast Weed Sci. Soc. Am. Abstr. 58: 155.

Outreach/Presentations to Growers (7)