PLANTING FOR PEST CONTROL

By Janet Wallace

On a farm, one crop does not stand alone. The crop-pest relationship, like most relationships, is complex. It is affected by the crops grown the previous year, the neighbouring plants and weeds.

The surrounding environment may harbour pests, or, preferably, provide habitat for beneficial organisms. Rather than using a spray to kill pests, organic farmers can influence pests indirectly by managing neighbouring plants.

Specialist pests (e.g., Colorado potato beetle, carrot rust fly, corn borer) feed on a specific group of plants. Many studies reveal that specialist pests are more abundant in monocultures and well weeded fields than in fields with a greater diversity of plants. Plant diversity can be provided through intercrops, cover crops or weeds.

Pests are more abundant in monocultures than in fields with a greater diversity of plants.

Scientists have tried to explain how non-crop plants interfere with pests. The only clear message is 'no one size fits all.' The relationship between pests and hosts is influenced by many factors.

Companion and neighbouring plants can reduce pest pressure in the following ways:

1. **Provide habitat for the pests' enemies**
2. **Confuse pests and camouflage crops**
3. **Trap pests**
4. **Repel pests**

Does companion planting control pests? Can farmers get the same benefits by simply managing the weeds and wild areas of the farm? The Organic Science Cluster (OSC) is exploring these questions.

Boisclair and colleagues found lady beetles in higher numbers on marigolds and nasturtiums.

1. Provide habitat for 'enemies'

In the struggle against pests, farmers become allies with the 'enemies' of the pests—those birds, amphibians, insects and other creatures that attack the pests.

Natural enemies are organisms that harm pests, and can include birds, parasitic wasps and flies, and predators (e.g., ground beetles, ladybugs, assassin bugs and spiders).

Parasitic wasps are black, with long antennae and very pronounced 'waists.' Most are less than an inch long and do not sting humans. The females lay eggs in the eggs, larvae, cocoons or bodies of other insects. After hatching, the wasp larvae devour the host.

Companion plants, and even weeds, can provide food and shelter to such enemies. The goal is to keep an army of enemies ready to spring into action when needed. Farmers can support enemies by maintaining a diversity of plants that bloom throughout the growing season, from spring to fall.

"It is now well recognized that the use of flowering strips may increase biodiversity as they provide food sources and habitat for beneficial insects," says Josée Boisclair, an OSC researcher at the Platform for Innovation in Organic Agriculture in Saint-Bruno-de-Montarville, Quebec.[1]

Pink lady beetles on a marigold.

Plants for beneficials*

Legumes: *alfalfa, vetch, fava beans, clover*
Flowering legumes provide food for pollinators, predators and parasitoids. Alfalfa and clover, in particular, attract predators such as ground beetles and big-eyed bugs, which prey upon flea beetles, mites and caterpillars.

Brassicas: *mustard, radish, alyssum*
Brassicas can bloom from spring to late fall. The flowers provide food for predators and parasitoids, such as braconid wasps, which parasitize armyworms, cabbageworms, corn borers, beetle larvae, flies and aphids.

Umbellifers: *wild carrot, coriander, dill*
Flowering umbellifers are particularly attractive to parasitoids. Strips of flowering dill and coriander can lead to increased predation of Colorado potato beetles.

Asters (Compositae): *marigold, yarrow, tansy, sunflower, goldenrod, echinacea, coreopsis, cosmos, knapweed, aster*
Asters provide habitat for beneficials, including minute pirate bugs which eat thrips, mites, leafhoppers, corn earworm and caterpillars.

Buckwheat
Flowering buckwheat attracts predators and parasitoids. Buckwheat is linked with greater predation of thrips and leafhoppers.

Phacelia
Phacelia has a long flowering time and supports hoverflies. Like buckwheat, it is unrelated to other crops. A border of phacelia can reduce the number of aphids in cabbages.

* Cited in references 2 and 3

Flowers can provide food for many insect predators and parasitoids. For example, adult parasitic wasps often feed on nectar and/or pollen, while their larvae feed on soft-bodied insects, including pests.

Boisclair and other OSC researchers are digging deeper into the relationship between insects (both pests and beneficials) and flowers. Specifically, they are studying alfalfa, petunia, phacelia, mustard, yarrow, alyssum, coriander, cosmos, French marigold and nasturtium.[1] In their 2010–11 experiments, Boisclair and colleagues found lady beetles (pest predators) in all the plants, but lady beetles were consistently found in higher numbers in marigolds and nasturtiums. Previous studies suggest that flowers, including cosmos, wild mustard and Queen Anne's lace, appear to improve the survival and reproduction of parasitic wasps.[2]

"A spectacular parasitism increase has been observed in annual crops and orchards with rich undergrowths of wildflowers,"

states Miguel Altieri.[3] He cites a Canadian study that found the eggs and larvae of tent caterpillars and codling moths were parasitized eighteen times more often in apple orchards with wildflowers than in orchards without flowers. Similarly, Altieri reports that when mustard flowered among cole crops, more cabbageworm larvae were parasitized. Some researchers have found cultivated flowers attract beneficials and reduce pest pressure substantially; other studies have shown that wild areas or clover/grass patches attract more beneficial invertebrates than cultivated flowers.[4]

Trap crops may help to reduce damage by the Colorado potato beetle.

2. Confuse pests and camouflage crops

For pests, monocultures are great places to live. With just one type of plant growing in bare soil, food is concentrated and easy to find. Weeds, companion plants or anything other than bare soil can interfere with the pest's search for food and ability to travel between plants. Even green paper or paper replicas of weeds between plants can reduce pest pressure on crops.[5]

An intercrop may serve to mask the odour of the crop, which can attract certain pests such as the carrot rust fly. Intercropped carrots and onions, in comparison to monocultures, have been shown to have reduced rust fly damage on carrots and less thrip damage in the onions.[6] More enemies of rust flies were found in the intercropped carrots (but only when the onions were young).[6]

There are benefits to undersowing. Pressure from certain pests, including cabbage maggot and carrot rust fly, is often less severe in undersown crops. Finch and Collier proposed that cover crops interrupted egg laying of the cabbage fly.[5] The flies land several times on brassicas before laying eggs, and receive chemical triggers from the brassicas that partially stimulate egg laying. Each time a fly lands on a non-brassica, the cycle is interrupted and must start over again. In the lab, 36% of flies laid eggs on brassicas in bare soil compared to 7% on brassicas intercropped with clover.

However, intercropping isn't always effective. A study conducted at the Organic Agriculture Centre of Canada found ***more*** Colorado potato beetles in potatoes grown with flax, marigold or horseradish, compared to potatoes grown alone.[7] OSC researchers in Quebec are now studying how intercropping carrots and leeks affects insects.

3. Trap crops

Trap crops are "plants of a preferred growth stage, cultivar or species that divert pest pressure from the main crop because they are more attractive."[8] For example, flea beetles and aphids prefer mustard to collards. When planted together, the mustard attracts the pests and leaves the crop with less damage. The infested trap crop can be mowed or tilled to kill the pests before they reproduce.

Wheat seedlings appear to be a promising trap crop in carrots.

For example, some farmers use:

- bromegrass or solid-stemmed wheat to trap sawflies in spring wheat;
- alfalfa to trap the lygus bug in strawberries; and
- oilradish to trap cyst nematodes in sugar beets.

In Nova Scotia, OACC researchers are studying trap crops to control wireworms.[9] Wheat seedlings appear to be a promising trap crop in carrots.

In an OSC study led by Dr. Maryse Leblanc, petunias are

Examples of beneficial plant-pest relationships (based on Altieri and Nicholls, 2004)

Crop	Weed or intercrop	Pest affected
Alfalfa	Weeds	Alfalfa caterpillar
	Grass	Leafhopper
Apple	Phacelia, sea holly	Scale, aphid
	Weeds	Tent caterpillar, codling moth
Beans (field)	Winter wheat	Leafhopper, aphid
Broccoli	Wild mustard	Flea beetle
Brussels sprouts	Fava beans and/or mustard	Flea beetle, aphid
	Beans	Cabbage root fly, aphid
	Weeds	Cabbage butterfly, aphid
	Corn spurry	Cabbage root fly, cabbage moth, aphid
Collards	Ragweed	Flea beetle
	Pigweed, lamb's quarters, cocklebur	Aphid
Corn	Ragweed	Corn borer
	Weeds	Corn moth, armyworm
	Foxtail	Corn rootworm
Cole crops	Mustard	Cabbage worm
Peach	Ragweed, smartweed, lamb's quarters	Oriental fruit moth
	Spirea, orchardgrass	Leafhoppers
Sorghum	Sunflowers	Aphid
Soybean	Broadleaf weeds, grasses	Mexican bean beetles
	Spurge, sicklepod	Stinkbug
Vegetables	Wild carrot	Japanese beetle
Vineyards	Blackberry	Leafhopper
	Johnson grass	Pacific mite

assessed as trap plants for cabbage maggot, and Jimsonweed to trap Colorado potato beetles. In another OSC study, Josée Boisclair and her team found more tarnished plant bugs on phacelia than other flowers, suggesting that phacelia might be a good trap crop in strawberry and vegetable fields.[1] Likewise, mustard and alyssum attracted more flea beetles than the other flowers.

Farmers sometimes also use an early planting as a trap crop. For example, onion maggots may be attracted to small or stunted onions that are planted early, thereby diverting damage from the more valuable, later planted onions. For Colorado potato beetles, the trap crop can be a row of early-planted or fast-growing potatoes placed between last year's potato patch and the current one. Once these plants are infested with larvae, the foliage is destroyed by tilling, mowing or flaming.

Farmers sometimes use an early planting as a trap crop.

4. Deterrents

Marigolds (*Tagetes* spp.) have long been used as companion plants. They release compounds that can repel insects and nematodes, and inhibit bacterial, viral and fungal pathogens.

Cabbage intercropped with marigolds was found to have fewer cabbage butterfly larvae and cabbage aphids than monocropped cabbage.[10] Likewise, carrots grown with marigolds had fewer forked or diseased roots than monocropped carrots, but the yields were sometimes lower, because the marigolds were too competitive.[11]

Wild areas

Farmers can manage insect activity by "changing sowing times, weed cover manipulation, and field boundary and margin management."[4] Mowing weedy field margins when pest populations

are high can cause the enemies to migrate into the field where and when they are needed. Strip harvesting is used by some hay growers so that there is always a flowering strip in the field to support beneficials.

In general, organic farms have greater biodiversity than conventional farms. Environment Canada researcher Dr. Céline Boutin studied soybean/cereal fields near Peterborough, Ontario. She found, compared to conventional farms, organic farms had more types and greater numbers of organisms (plants, moths, earthworms and birds) in fields and hedgerows.[12] By having more types of insects, there is a greater chance of having beneficials active throughout the growing season and affecting more types of pests.

Five times fewer aphids and far more predators of pests and plant species were found in organic triticale fields than their conventional counterparts.[13] Insecticide treatments led to short-term drops in the number of aphids in the conventional fields, but the population quickly rebounded. In contrast, the organic farms had natural enemies to control aphids throughout the season.

Marigolds can repel insects and nematodes, and inhibit bacterial, viral and fungal pathogens.

Organic fields might also have more pest enemies because of weeds. "Outbreaks of certain types of crop pests are less likely to occur in weed-diversified crop systems than in weed-free fields, mainly due to increased mortality imposed by natural enemies."[14] For example, if wild mustard is left in broccoli fields, the crop has fewer flea beetles compared to weeded fields.[3]

OSC researchers are assessing how strips of flowers, including cosmos, affect populations of pests and their predators.

Synthetic fertilizers also affect pest numbers. The use of conventional fertilizers has been linked to higher numbers of 'sucking insects,' such as aphids.[15]

A review of many studies found conflicting evidence as to the effect of non-crop plants on pest numbers.[15] In general, there were more pests on organic farms than on farms using insecticides. However, there were also more spiders and other pest predators on most organic farms. There is simply more life in organic fields, which have larger populations and greater diversity of both pests and beneficial organisms. The 'natural enemies' seem to keep the pests in check.

A diversity of habitats on the farm appears to affect natural enemies more than intercropping.[16, 17] The key is to maintain biodiversity throughout the farm—using hedgerows, windbreaks, weeds, flowers and crop diversity.

The Organic Science Cluster projects described in this article are funded by Agriculture and Agri-Food Canada.

Photo credits: Josée Boisclair (pg. 16), Jean Brodeur (pg. 17), Janet Wallace (pgs. 18, 20 and 21)

References:

1. Boisclair, J, E Lefrançois, M Leblanc, K Stewart, D Cloutier, M Lefebvre, G Richard & G Moreau.

Compositae (including echinacea) provide habitat for beneficials, including minute pirate bugs which eat thrips, mites, leafhoppers, corn earworms and caterpillars.

2012. Preliminary observations on the potential of flowering strips to attract beneficial insects. *Proceedings of the 2012 Canadian Organic Science Conference.*

2. Wratten, S, L Berndt, G Gurr & J Tylianakis. 2003. Adding floral diversity to enhance parasitoid fitness and efficacy. *1st International Symposium on Biological Control of Arthropods.*

3. Altieri, MA & CI Nicholls. 2004. *Biodiversity and Pest Management in Agroecosystems. 2nd ed.* Haworth Press.

4. Eyre, MD, D Labanowska-Bury, R White & C Leifert. 2011. Relationships between beneficial invertebrates, field margin vegetation, and thrip damage in organic leek fields in eastern England. *Organic Agric.* 1:45–54.

5. Finch, S & R Collier. 2000. Host-plant selection by insects: a theory based on 'appropriate/inappropriate landings' by pest insects of cruciferous plants. *Entomol. Exp. Appl.* 96: 91–102.

6. Uvah, III & TH Coaker. 1984. Effect of mixed cropping on some insect pests of carrots and onions. *Entomol. Exp. Appl.* 36:159–167.

7. Moreau, T. 2004. Questionable companions: mainstay of organic pest control won't deter Colorado potato beetles. *Rural Delivery.* 29(2).

8. Cook, SM, ZR Khan & JA Pickett. 2007. The use of push-pull strategies in integrated pest management. *Annu. Rev. Entomol.* 52:375–400.

9. Nelson, KL, J L MacKenzie & AM Hammermeister. 2012. Organic and integrated approaches to European wireworm control in Atlantic Canada. *Proceedings of the 2012 Canadian Organic Science Conference.*

10. Jankowska, B, M Poniedzialek & E Jêdrszczyk. 2009. Effect of intercropping white cabbage with French Marigold (*Tagetes patula* nana L.) and Pot Marigold (*Calendula officinalis* L.) on the colonization of plants by pest insects. *Folia hortic.* 21(1): 95–103.

11. Blazewicz-Wozniak, M & D Wach. 2011. The effect of intercropping on yielding of root vegetables of *Apiaceae* family. *Acta Sci. Pol.* 10(4):233–243.

12. Boutin, C. 2012. Biodiversity as affected by farming systems and landscape. *Proceedings of the 2012 Canadian Organic Science Conference.*

13. Krauss, J, I Gallenberger & I Steffan-Dewenter. 2011. Decreased functional diversity and biological pest control in conventional compared to organic crop fields. *PLoS ONE* 6(5):e19502.

14. Risch, SJ, D Andow & MA Altieri. 1983. Agroecosystem diversity and pest control. *Environ. Entomol.* 12(3):625–629.

15. Garratt, MPD, DJ Wright & SR Leather. 2011. The effects of farming systems and fertilisers on pests and natural enemies: A synthesis of current research. *Agric. Ecosyst. Environ.* 141: 261–270.

16. Flavia, G, FL Wäckers & FJJA Bianchi. 2008. Hibernation of predatory arthropods in semi-natural habitats. *BioControl.* 54(4):529–535.

17. Winqvist, C et al. 2011. Mixed effects of organic farming and landscape complexity on farmland biodiversity and biological control potential across Europe. *J. Appl. Ecol.* 48:570–579.