Weeds may augment biological control of insects

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Outbreaks of some insect pests are more likely to occur in weed-free than in weed-diversified crops.

Weeds have traditionally been considered totally unwanted plants that reduce yields by directly competing with crops or by harboring insect pests and plant diseases. Certain weeds, however, can be regarded as important components of agroecosystems, which can complement existing insect pest management systems. Outbreaks of some insect pests are more likely to occur in weed-free than in weed-diversified crop systems. Moreover, crop fields with a dense weed cover and high diversity usually have more beneficial insects than do weed-free fields. Plants commonly considered weeds in many situations are considered desirable wild plants in this case.

In spite of the obvious beneficial implications of these findings for integrated pest management, implementation of weed control programs compatible with insect management systems has not yet emerged. However, work in Colombia (South America) and in the southeastern United States has provided encouraging results. Weed manipulation could be a practical technique to augment biological control of insects in California agroecosystems.

Experimental evidence

In tropical Colombia, establishment of borders of wild grasses (*Eleusine indica* and *Leptochloa filiformis*) around small plots of dry beans effectively reduced populations of leafhoppers (*Empoasca kraemeri*), the main bean pest of the Latin American tropics. Further tests indicated that these grasses exerted a repellent effect on the leafhoppers.

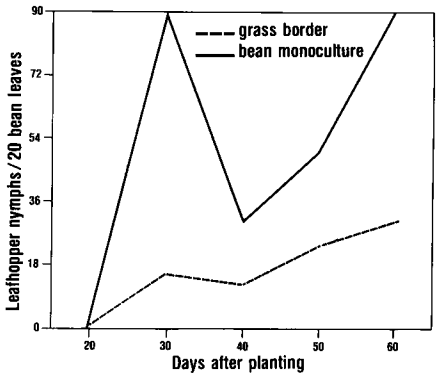
Experiments in northern Florida corn fields revealed that allowing a strip of native and selected wild plants to grow in every tenth row of corn substantially reduced the incidence of fall armyworm (*Spodoptera frugiperda*), and increased the number of predators.

Leaving a ground cover of johnsongrass or sudangrass in vineyards of the San Joaquin Valley, California, reduced densities of the willamette mite, presumably by enhancing activity of a predaceous mite, *Metaseiulus occidentalis*. Similarly, in Georgia, soybean plots with a dense cover of sicklepod (*Cassia obtusifolia*) were less susceptible to attack by velvet bean caterpillar (*Anticarsia gemmatalis*) and green stink bug (*Nezara viridula*) and had more predators than weed-free plots. More importantly, these trends were still prevalent in soybean plots weeded for two to four weeks after soybean emergence, but allowed to remain weedy thereafter. No further weed removal after the two- to four-week period was necessary to obtain maximum yields.

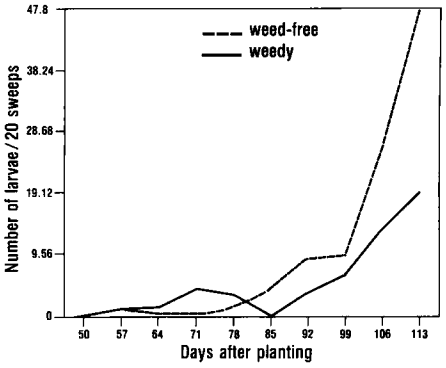
Weeds can also affect the field performance of insect parasites. For example, the extent to which naturally occurring populations of parasitic wasps (*Trichogramma* spp.) parasitized artificially placed corn earworm (*Heliothis zea*) eggs on soybean plants depended on the plant species associated with soybean. Higher egg parasitization was recorded on soybean associated with *Desmodium* sp. and *Croton* sp. than on soybean intermingled with grasses or in soybean monocultures. Further studies indicated that the field behavior and efficiency of *Trichogramma* spp. could also be manipulated by spraying crop plants with water extracts of several plants. For example, parasitization of corn earworm eggs increased significantly in soybean, tomato, cowpeas, and cotton plots sprayed with water extracts of corn and pigweed (*Amaranthus* sp.).

Weeds growing on crop field borders can also affect the dynamics of beneficial insect communities in a particular crop system. In Georgia, predator numbers in soybean rows declined sharply the farther the rows were from a weedy ditchbank adjacent to the field. These findings suggest that manipulation of border vegetation can help maintain a natural balance of beneficial insects in a cultivated area. Encouragement of wild plants that provide shelter, pollen and nectar, or alternate prey or hosts for predators and parasites along field margins might prove beneficial.

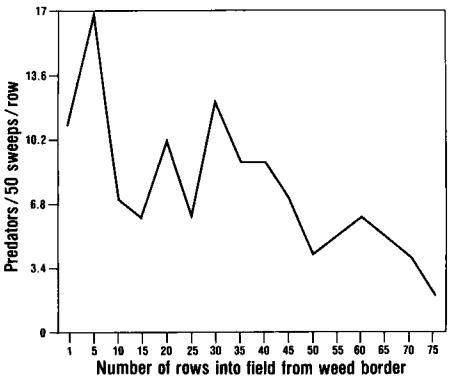
The effectiveness of *Anagrus epos,* an egg parasite of the grape leafhopper, was enhanced in California vineyards where patches



Effect of grass weed borders on leafhoppers in dry-bean fields in Colombia.



Abundance of velvet bean caterpillar in weedy and weed-free Georgia soybeans.



Predator numbers in Georgia soybeans with increasing distance from weedy ditchbank.

Opposite: Encouraging grass borders can reduce leafhopper densities in dry beans.

TABLE 1. Incidence of Fall Armyworm (*Spodoptera frugiperda*) and Predators in Weed-Free and Weed-Diversified Corn in Northern Florida

Crop system	Armyworm-damaged corn plants*	Predators*†
	%	
Monoculture	31.5 a	7.0 a
Selected weed associations	16.5 b	8.8 b
Natural weed complex	15.8 b	8.6 b

*Means followed by the same letter in each column are not significantly different (P = 0.05).
†Number of individuals per 30 corn plants.

TABLE 2. The Effect of Plant Assemblages on Parasitization of Corn Earworm (*Heliothis zea*) Eggs by Parasitic Wasps (*Trichogramma* spp.) in Georgia Soybean Fields

Plant associated with soybean	Egg parasitization*
	%
Desmodium sp.	71.0 a
Croton sp.	65.0 ab
Cassia sp.	60.0 b
Corn	55.0 b
Grasses	14.0 d
Soybean	28.0 c

*Means followed by the same letter are not significantly different (P = 0.05).

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Weeds and biological control, *continued*

TABLE 3. Parasitization of Corn Earworm Eggs (*Heliothis zea*) by Naturally Occurring Populations of *Trichogramma* spp. Wasps in Crops Sprayed with Water Extract of Corn, Pigweed (*Amaranthus* sp.), or Water

Treatment	Parasitization of corn earworm eggs*			
	Soybean	Cowpeas	Tomato	Cotton
	%	%	%	%
Pigweed	21.4 a	45.4 a	24.3 a	13.6 a
Corn	17.4 b	45.8 a	21.1 a	—
Water	12.6 c	31.6 b	17.6 b	4.2 b

*Means followed by the same letter in each column are not significantly different (P = 0.05).

of wild blackberry (*Rubus* sp.) were preserved along field borders.

At times, special manipulations, such as periodic clipping, might be required to force beneficial species to move from the borders into the crop. These practices should be carefully timed, based on the biology of the beneficial species involved. For instance, the annual cleanup of weeds along edges of alfalfa fields should be delayed until after the aggregations of dormant lady beetles have largely dispersed.

As these examples have indicated, surveys of cropping systems, including coexisting weeds and associated insect communities, can help determine relevant biological interactions and therefore suggest how agroecosystems could be structured to minimize pest incidence while augmenting natural controls. Tolerable levels of weeds that support populations of beneficial insects can be attained within fields by designing competitive crop mixture systems, cover crops, row spacing patterns, periods of weed-free maintenance, mulching, and cultivation regimes. A series of other cultural practices can be used to manipulate the vegetation of crop field borders.

With the active participation of farmers, a new interdisciplinary project will be started in northern California orchards and vegetable and row crop fields. Weed research will be concerned with the integrated components of insect and disease management systems. Possibilities of exploiting wild vegetation will be investigated in the hope that, ultimately, farmers will benefit from the environmentally safe, energy-conserving features of diverse, pest-stable, self-sufficient agroecosystems.

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Weed strips within Florida corn fields reduced fall armyworm infestations.