Avoiding insecticides by mixing vegetables and sowing flowers

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While farming, it may be frightening to discover cabbages infested by caterpillars starting to devour the leaves, or lettuces full of aphids ready to transmit viruses to the plants. What can be done? The temptation could be high to rely on insecticides to eradicate these insect pests and save the vegetables. Nevertheless, insecticides should not be the solution because they are poisonous for humans and the whole environment (see Agenda no. 64). Alternative strategies exist! First, mixing the plants instead of cultivating them separately can reduce the ability of insect pests to colonize them and spread in fields. Second, sowing flowering plants can attract beneficial insects that are natural enemies of the pests.

Why mixing plants?

Most of insect pests feed on a limited number of plants. Cultivating a single plant species in a field provides high amount of food for the insects that feed on this single plant. Consequently, these insects will be attracted, and they will be able to multiply and spread in the field because all of the available plants will be suitable for them. Conversely, by mixing plants that are consumed by different insects, the amount of food available for each of them is reduced.

In addition, it would become difficult for the insects to identify the specific plant they are searching for. Indeed, insects use colors, contrasts of colors, but also odor blends to identify their host plant. Mixing plants would lead to mixing colors, modify the contrasts between them as well as odor blends. Some plants also produce repellent odors. In the end, insects would be disoriented and have difficulties to identify their host plants in the mixture.

Some insect pests would eventually succeed to colonize a plant. However, when different plants are mixed, they will have difficulties to spread because plants surrounding them would not be suitable. Indeed, each non-host plant for an insect will act as a barrier and limit pest spreading.

How to mix plants?

Plants are distinguished by their family, species and variety that partly describe their level of differences and similarities. Two plants can be: from different families, for example tomato (*Solanaceae* family) and cabbage (*Brassicaceae* family); from two species of the same family, for example tomato and potato (both of the *Solanaceae* family); or from two varieties of the same species, for example two varieties of tomato (which species name is *Solanum lycopersicum*). Family differences are generally larger than species differences, being also larger than variety differences.

Many insects are specialized in a single family of plant. This is the case of several pests of the *Brassicaceae* (cabbage, mustard, radish) like the cabbage aphid (*Brevicoryne brassicae*) or the cabbage butterflies (*Pieris rapae* and *Pieris brassicae*). Some insects are even limited to few cultivated plant species, or few varieties of a species, for example the lettuce aphid (*Nasonovia ribisnigri*). Mixing plants of different families maximizes the chance of limiting pest colonization. Mixing varieties of a same species or two species of a same family can also help to reduce risks from insect pests, compared to planting large patches of a same plant.

Nevertheless, there are also insects that can feed on plants from different families, for example the Japanese beetle (*Popillia japonica*). These insects are not easy to manage and mixing plants from different families may not be enough to ward them off. Carefully choosing plants that are known not to be the hosts of such generalist pests would be needed.

Experiments have shown examples of plant mixing that proved to efficiently reduce pest colonization and damages. Mixing carrots with onions can reduce attacks by the carrot fly (*Psila rosae*) and the onion thrips (*Thrips tabaci*) (1). Associating cabbages with tomatoes or green peppers can limit attacks and damages from the diamondback moth (*Plutella xylostella*) on cabbages (2). Onions can protect potatoes from attacks from the potato tuber moth (*Phthorimaea operculella*), aphids (*Myzus persicae*, *Aphis gossypii*), leaf hoppers (*Empoasca* spp.) and herbaceous ladybird beetles (*Henosepilachna sparsa*) (3). Growing zucchinis with buckwheat can lower colonization of aphids (*Aphis gossypii*) on zucchini and can delay the transmission of viruses (4). In addition, flowers of buckwheat can attract beneficial insects that are natural enemies of the pests.

Why sowing flowers?

While mixing plants is a first practice to limit the colonization and spread of pests on vegetables, sowing flowers in fields is a second and complementary technique. Its aim is to encourage a natural control of the pests by their natural enemies. Natural enemies are insects that are predators or parasites of other insects. When they attack pests of vegetables, natural enemies can be seen as farmers' 'helpers'.

Hoverfly adult feeding on coriander

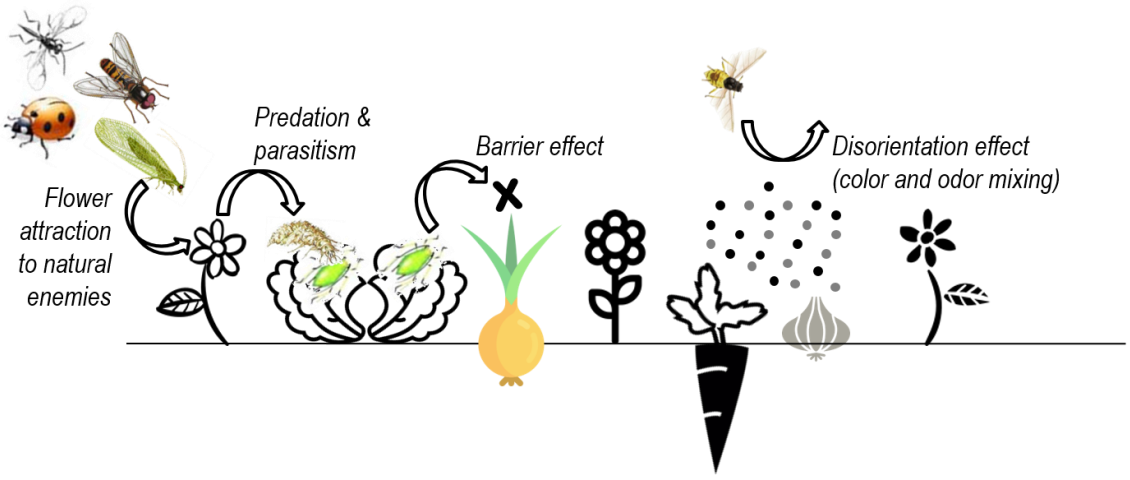
Predatory wasp adult feeding on shiso

Lacewing larvae feeding on aphid

To attract and reward these ‘helpers’, a farmer can sow flowers in their fields. Indeed, nectar and pollen of flowers represent important food source for many insects. Nutrient composition of pollen and nectar varies between flower species, but in general, nectar is rich in sugar that provides energy to insects, and pollen contains proteins useful for their fecundity. Although there are insects that feed only on flowers, like bees, others feed both on flowers and on other insects.

Some of these natural enemies are very well known and loved by humans. This is the case of the ladybird beetles (*Coccinellidae*). Ladybird beetles mostly feed on other insects but they can also survive by feeding on flower nectar and pollen. Other natural enemies are not as popular among humans. This is the case of the large wasps (*Vespidae*), of which people are often afraid of being bitten. However, many large wasps that feed on sugar sources such as flower nectar as adults can be very helpful because they attack other insects to feed their young.

Most natural enemies are often unknown to non-entomologists but they play great roles in regulating insect populations. For example, hoverflies (*Syrphidae*) and lacewings (*Chrysopidae*) only feed on flowers as adults but the larvae of many species are predators, especially of aphids. Also, many small wasps feed on flower nectar as adults and parasitize other insects to reproduce. Parasitizing means that the adults lay their eggs on—or into—another insect’s body (the host) and their larvae will feed on it until killing it. Such hosts can be pests of vegetables, like aphids or caterpillars. To wrap up, flowers can attract and sustain adults of natural enemies in a first step, and these adults will search for prey or hosts for their young in a second step, finally leading to a natural control of the pests.



Mechanisms related to mixing plants and sowing flowers to limit pest abundance on vegetables

Which flowers to sow?

Many flower species can be sown in fields and experiments have been carried out to evaluate which ones are useful to attract and support the natural enemies. Some of these flowering plants can also be consumed by people as food and medicine, thus sowing them would not mean losing field space. Coriander (*Coriandrum sativum*), dill (*Anethum graveolens*) or fennel (*Foeniculum vulgare*) are examples of aromatic flower plants that are both consumed by people and appreciated by insect natural enemies (see table for more examples). Also, current research at Kyoto University is evaluating the attractiveness and benefits of shiso (*Perilla frutescens*) for natural enemies. Experiments done in laboratory show that ladybird beetles can survive several days when feeding on shiso flowers only, and a mixed diet of shiso with prey food can improve their early reproduction (5). In fields, a large diversity of insects has been observed visiting shiso flowers, among them hoverflies and wasps.

Table *Ten flowering plant species that can be sown to attract and support natural enemies against insect pests*

Plant family	Plant scientific name	Plant common name	Natural enemies
Apiaceae	*Anethum graveolens*	Dill	Ladybird beetles, hoverflies, lacewings, parasitic wasps
Apiaceae	*Coriandrum sativum*	Coriander	Ladybird beetles, hoverflies, lacewings, parasitic wasps
Apiaceae	*Foeniculum vulgare*	Fennel	Ladybird beetles, hoverflies, lacewings, parasitic wasps
Boraginaceae	*Borago officinalis*	Borage	Hoverflies, lacewings
Lamiaceae	*Agastache rugosa*	Korean mint	Hoverflies
Lamiaceae	*Mentha* spp.	Mint	Hoverflies, parasitic wasps
Lamiaceae	*Lavendula stoechas*	Lavender	Hoverflies, parasitic wasps
Lamiaceae	*Ocimum basilicum*	Basil	Lacewings
Lamiaceae	*Perilla frutescens* var. *crispa*	Shiso	Ladybird beetles, hoverflies, predatory wasps
Polygonaceae	*Fagopyrum esculentum*	Buckwheat	Hoverflies, parasitic wasps

When choosing flowering plants to sow, attention should be paid on their blooming period. While some tend to bloom in spring, like coriander, others bloom in autumn, like shiso. Sowing different flower species that bloom at various periods is important to provide food sources to natural enemies from spring to autumn. In this way, natural enemies will be sustained all along the cropping season and will be ready to regulate pests in case of outbreak.

Re-imagining old ideas

Mixing plants and favoring natural enemies are not new ideas and have been used by famers before the industrialization of agriculture. In her book *Silent Spring* (6) published in 1962, Rachel Carson already recalled that 'an insect that lives on wheat can build up its population to much higher levels on a farm devoted to wheat than on one in which wheat is intermingled with other crops to which the insect is not adapted.' The great role of natural enemies in the self-regulation of insects was also obvious to her, when she cited the entomologist Robert Metcalf highlighting that 'the greatest single factor in preventing insects from overwhelming the rest of the world is the internecine warfare which they carry out among themselves.'

More than 50 years have passed since the publication of *Silent Spring*, and agriculture has greatly evolved, but insecticides are still widely used. Therefore, remembering the mechanisms leading to the natural regulation of insect pests on plants remains useful. Imagining how to apply them in today's agricultural fields is the challenge that must be overcome. While farmers can try out mixing plants, sowing flowers and observing natural enemies in fields, scientists must work at understanding how ecosystems function. Consumers can support farmers by buying organic food at farmers' markets and retail shops, through teikei groups or co-ops. Finally, a general change of the whole food system will be possible if policy makers assume their responsibility to implement adequate environmental and agricultural policies, which could start by simultaneously banning the use of pesticides, and supporting farmers' transition to a pesticide-free agriculture. As citizens, our responsibility is to elect representatives that consider such a transition as a priority.

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