Agroecology and Sustainable Pest Management

Sundar Tiwari, PhD

Associate Professor and Chairman/Department of Entomology Agriculture and Forestry University, AFU

Presentation Outline

- Current issues in agriculture
- Way
- Ecosystem services and dis-services
- Agroecologically vulnerable practices
- Solution
- overall benefits
- Case studies
- Summary and Conclusion

Ccurrent issues in Agriculture

- Climate change
- Decline of flora and fauna species
- Frequent outbreak of crop pests and diseases
- Loss of biodiversity especially of local origins
- Invasive insect species problems
- Excessive growth of weed and invasive species affecting the persistence of native biodiversity
- Increasing surface runoff resulting in the decline of soil fertility
- Loss and degradation of the agricultural field due to landslides,

- Long term and frequent droughts and short rainy season’s results in water scarcity during critical growth period of crops decreasing the crop production
- Unpredictable weather patterns including rainfall
- Decreased availability of usable water
- Shifting of production zones as a result of an upward shifting of the snow line.
- And many more

Decline in the population of service providers

- Honey bee and bumble bee decline
- Impact on beneficial soil micro-organisms and other beneficial insects

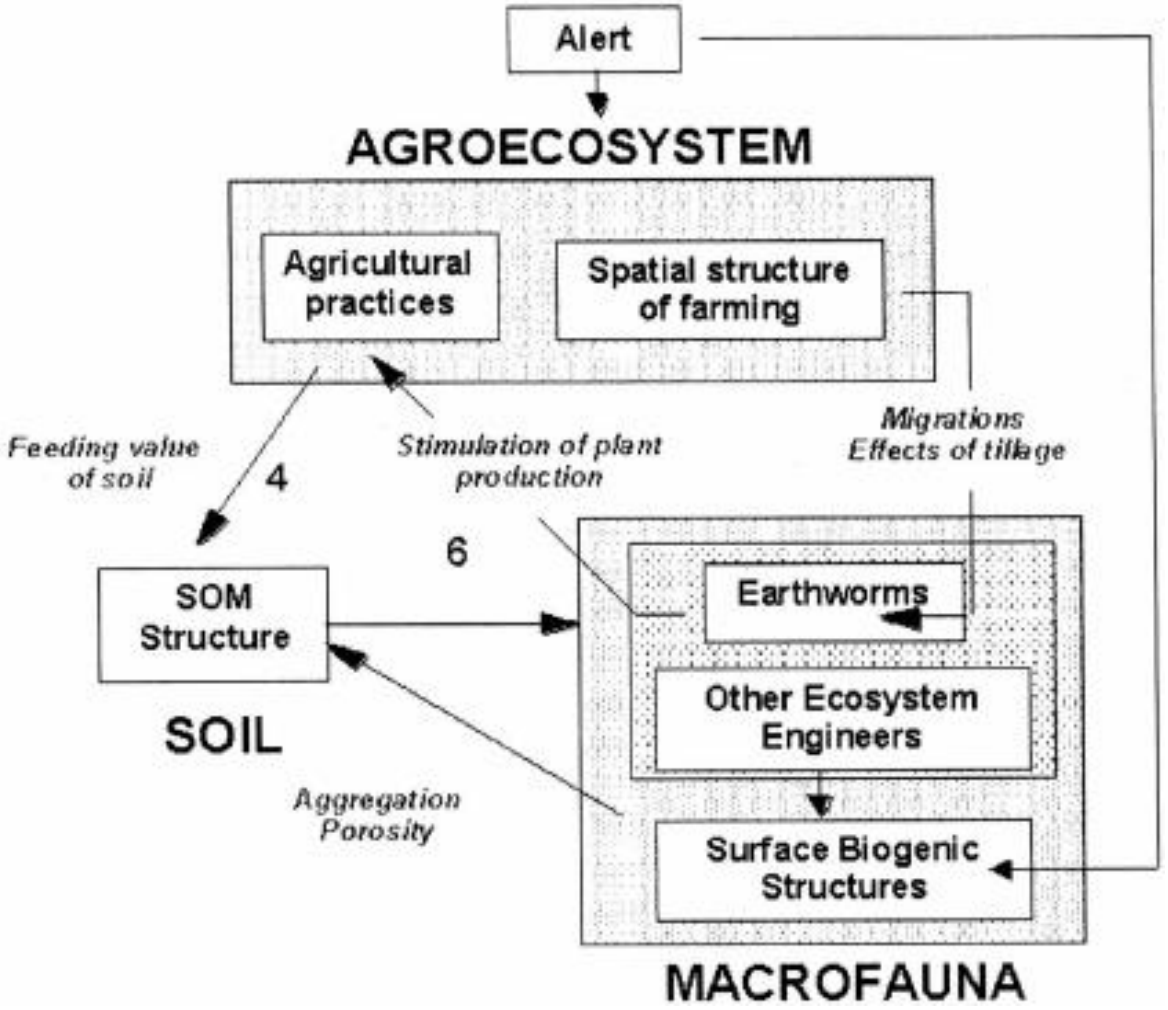
Solution

- Agroecological practices for sustainable agriculture

Agroecology is the application of ecological concepts and principals in farming.

Source: https://xerces.org/blog/tag/conservation-biological-control-cbc

Complex phenomen

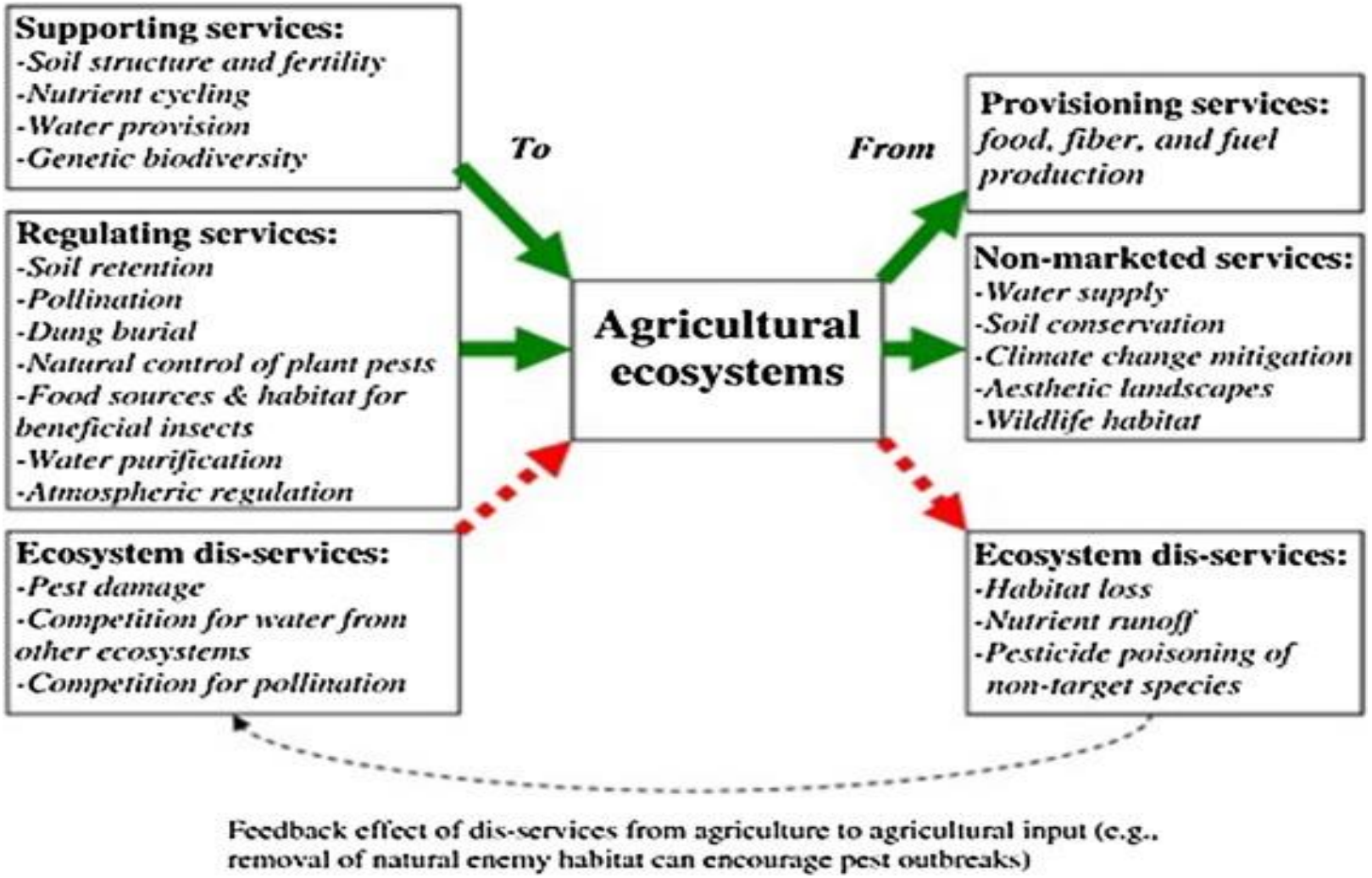


- A complex network or interconnected system
- Biotic and abiotic components
- Plants
- Soils
- Herbivores
- Carnivores
- Micro-organisms
- Abiotic factors (Soil, water, humidity, temperature, soil stress)
- Sunlight
- Air

Main aim: Maximizing ES

- ES can be enhanced by human manipulation such as planting non-crop vegetation (habitat management) that benefits biological control agents .

Ecosystem services



Feedback effect of dis-services from agriculture to agricultural input (e.g., removal of natural enemy habitat can encourage pest outbreaks)

Multiple ecosystem services

Agroecosystems also produce a variety of ecosystem services, such as regulation of soil and water quality, carbon sequestration, support for biodiversity and cultural services.

Ecosystem disservices

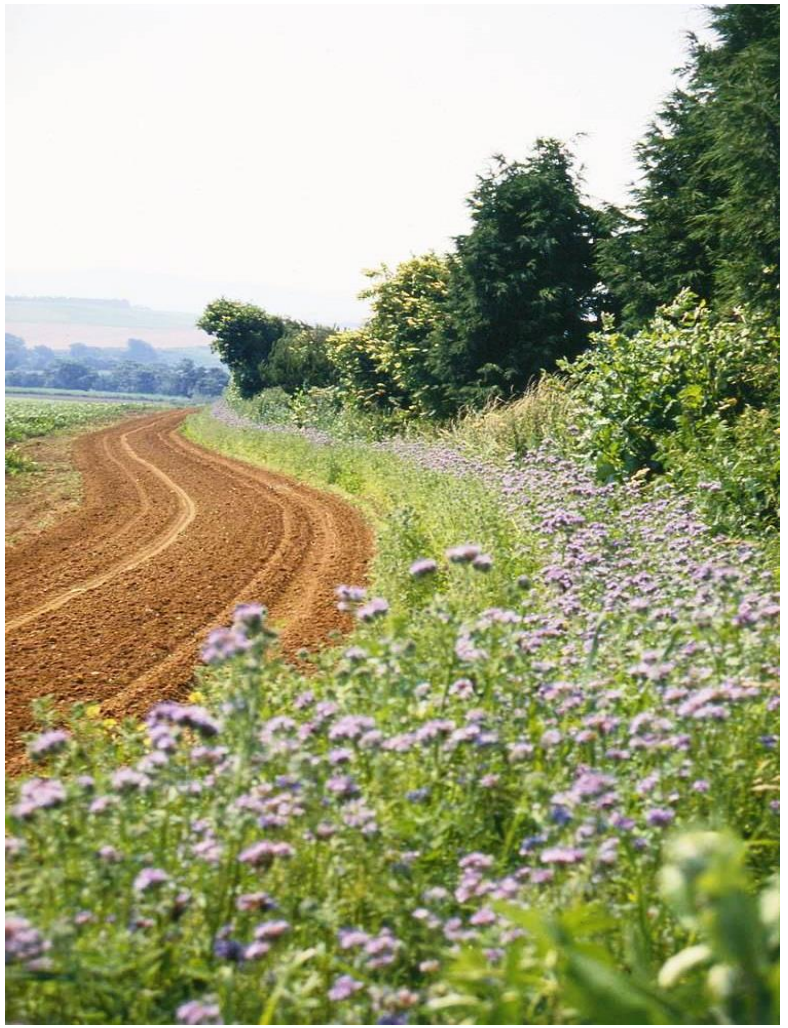
Agriculture: disservices, including loss of wildlife habitat, nutrient runoff, sedimentation of waterways, greenhouse gas emissions, and pesticide poisoning of humans and non-target species.

Agroecology vulnerable agricultural practices

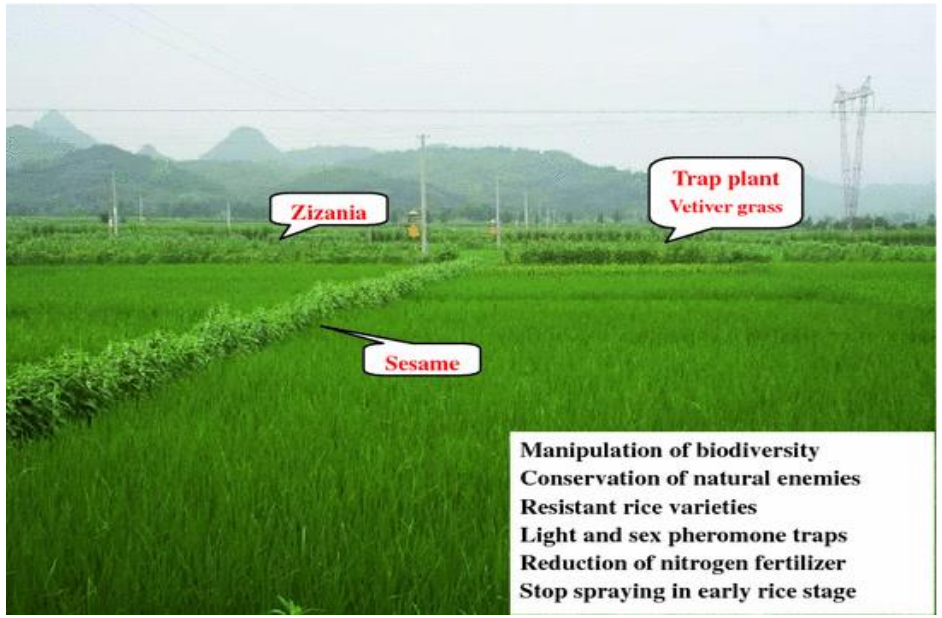
- Pesticide use
- Monocropping
- Chemical fertilisersNatural Enemies or pollinators declining
- Not known/Low research
- Crop diversity loss
- Reduced OM in soil

Solution: Strengthening agroecosystem practices for ecosystem services

- Habitat manipulation or ecological engineering
- Soil organic matter: Application and addition
- Reducing intensified agriculture
- Addition of soil residues
- Composting/Vermicomposting/Organic manure
- Mix cropping with legume incorporation
- Crop rotation



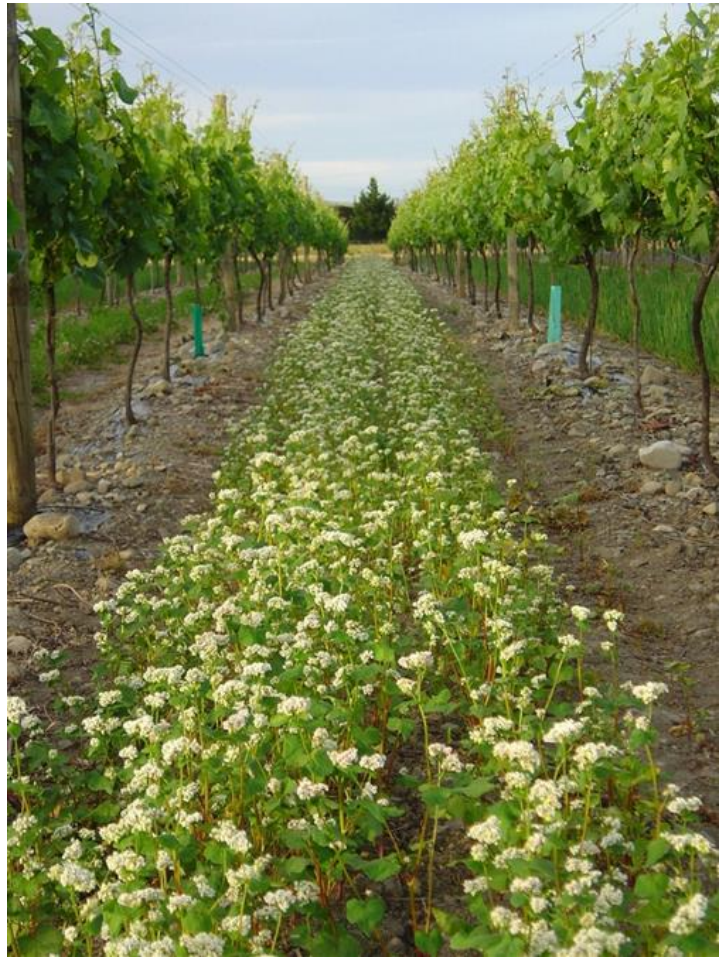
- Planting of Flowering plants (Alyssum, Phacelia, Buckwheat, Coriander) and their fitness to NE
- Diversified farming (cowpea, maize, cucurbits)
- Sesame planting in bund cultivation



- Integrated livestock and crop production practices
- Good agricultural practices
- Exploration of the natural soil biodiversity and manipulation of soil microbiota
- Promote or external use of plant growth-promoting rhizobacteria and biological control agents

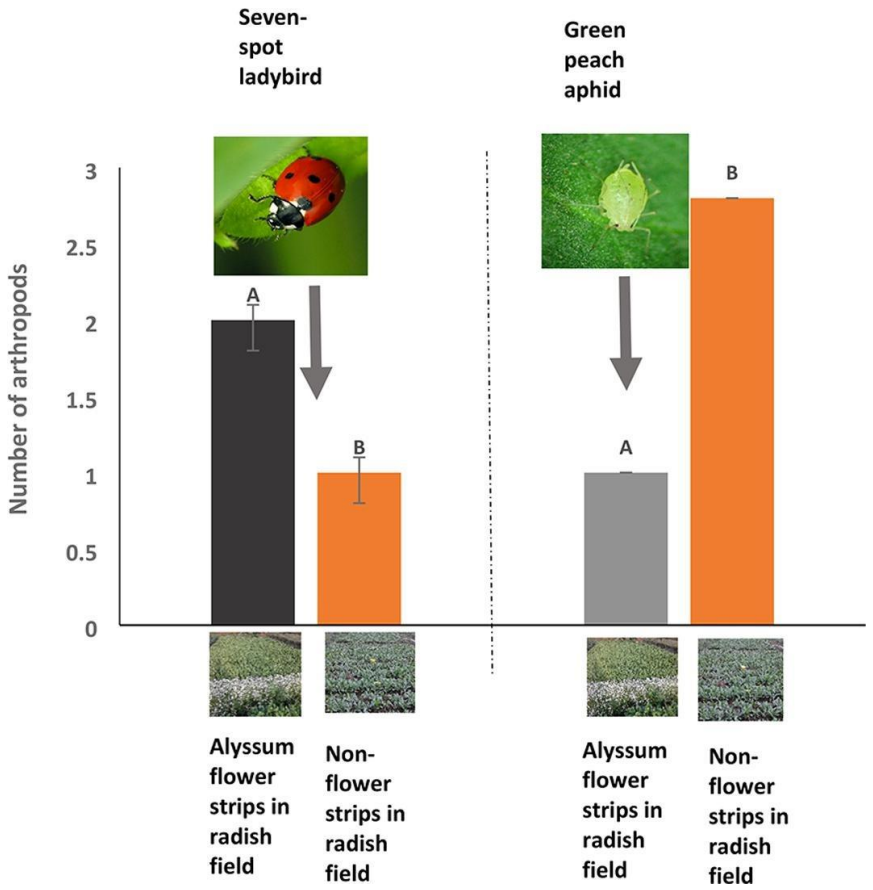
- Provision of beetle bank or grass covered earth banks located in the middle of a field
- Natural habitat management in agro-ecosystem
- Maintaining indigenous strips in our agro-ecosystem
- Minimum tillage
- Shelter habitats effects on biotic and abiotic component (Holland et al, 2000)
- Promoting bee keeping

Flowering strips of phacelia (*Phacelia tanacetifolia* Benth) (left) and buckwheat (right) in vineyards, providing shelter and food resources to beneficial insects



Greening Waipara Project of NZ. Photo: Jean-Luc Dufour, Accolade Wines.

Flower in Radish



Tiwari et al., 2020. Flowering alyssum (Lobularia maritima) promote arthropod diversity and biological control of Myzus persicae. *Journal of Asia-Pacific Entomology*, *23*(3), 634-640.

Trap cropping

Tiwari et al. (2020). Evaluation of potential trap plant species for the wheat bug Nysius huttoni (Hemiptera: Lygaeidae) in forage brassicas. *Agricultural and Forest Entomology*, *22*(3), 263-273.

Intercropping

Beetle Bank

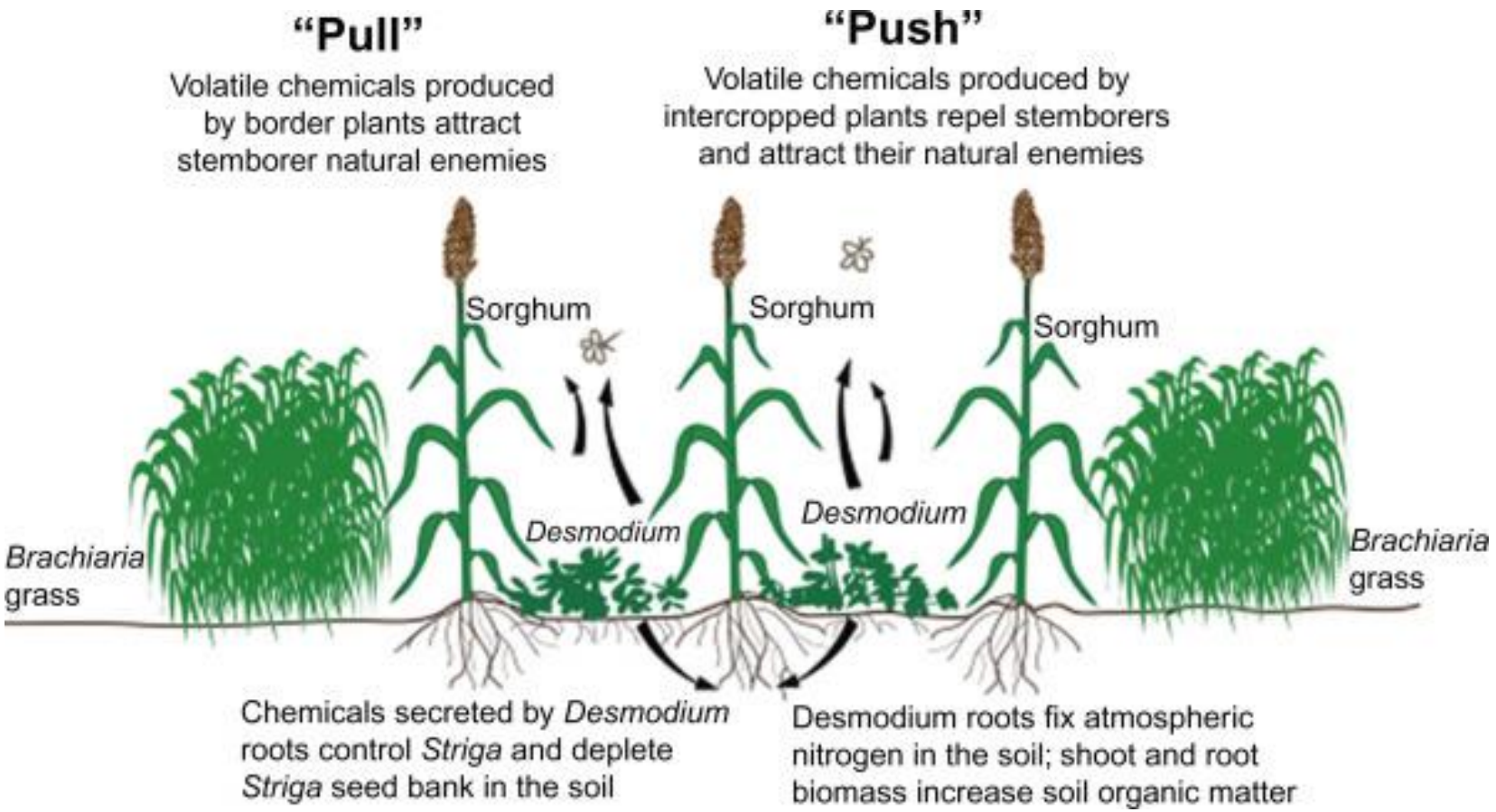
Beetle banks, which are strips of non-crop vegetation established in the middle of fields to help natural enemies to overwinter, have been used as refuges in arable land to increase the abundance and effectiveness of epigeal arthropods such as Carabidae, Staphylinidae, Lycosidae, and Linyphiidae.

Bund Management

Practice in Vietnam and
China for BHP management

✓ 2300 (900 adult plus 1400 larva) LBB/Meter square adjacent to mustard field.

Push pull in maize



Source: © 2019 The Food and Agriculture organization of the United Nations (FAO). Published by Elsevier Inc.

Green manuring increased the abundance of spiders, ground dwelling arthropods

Depalo, L.; Burgio, G.; Magagnoli, S.; Sommaggio, D.; Montemurro, F.; Canali, S.; Masetti, A. Influence of Cover Crop Termination on Ground Dwelling Arthropods in Organic Vegetable Systems. *Insects* **2020**, *11*, 445. https://doi.org/10.3390/insects11070445

- Silicon in plants acts as a resistance inducer, increases protection against biotic stress, and decreases the injuries and/or damages caused by pests

- Has antibiosis effect on chewing and sucking insects, without causing deleterious effects to the natural enemies

Moraes et al., 2019. Use of Silicon as Resistance Factor for Plants Against Insect Pests. In: Souza B., Vázquez L., Marucci R. (eds) Natural Enemies of Insect Pests in Neotropical Agroecosystems. Springer, Cham. https://doi.org/10.1007/978-3-030-24733-1_40

SNAP

- ✓Shelter
- ✓Nectar and Extrafloral nectaries
- ✓Alternative Food
- ✓Pollen

Photo by Ryan Ryal and Steve Wratten

Source: https://the-natural-web.org/tag/extrafloral-nectaries/

Extra Floral Nectaries

Overall benefits

Above ground beneficial organisms

- Pollinators
- Carabids
- Collembolans
- Syrphid fly
- Lady birds

Below ground organisms

- Soil micro-organisms (*Metarhizium*, *Beauveria, Trichoderma, Mycorrhiza*)
- Soil health (Soil humus, OM content, Soil PH, Infiltration rate, soil microrganisms)
- Earthworms
- Symbionts
- Decomposers (worms, slugs, snails, nematodes)
- Shredders (CPOM to FPOM)

Monitoring practices: Agro-ecological parameters

Monitoring of bees

Bee bowls

- 24 bowls eight of each colour, and the colours are alternated throughout the transect.
- 5m apart in transects or X pattern
- Water and dishwashing liquid or laundry soap

- A minimum of 4 samples must be made per plot preferably spread across the whole season.
- Bowls can either be left out for any 24 hour period of good weather
- Pan traps should be placed in a plot prior to 9:00 am and picked up from the plot between 3:00 pm and 5:00 pm

“Gretchen et al., 2016. Protocol to Detect and Monitor Pollinator Communities Guidance for Practitioners. Food and Agriculture Organization of the United Nations Rome, Italy. 55 P http://www.fao.org/3/i5367e/i5367e.pdf.

Sweep net for bees and other arthropods

- Netting should be done for a total of one hour the morning (9 am-12 pm) and one hour in the afternoon (12 pm-3 pm).
- 25 sweeps
- A collector should spend no more than 5 minutes at any particular patch of plants.

Soil invertebrates

Earthworm/Shredders/Decomposers/Detritivores monitoring

- ✓ 3-5 quadrat/100 m2
- ✓ 10 – 20 cm digging
- ✓ Careful observation or sieving

Calculation of species richness, abundance and bio-diversity index

- Species richness: Number of species present in locality per unit area
- Abundance: Total number of each species

- Diversity (H): - Sum (Pi) x LN (Pi) (Shannon Diversity Index or Shannon Weiner Diversity Index)

- Pi: Proportion of individual of each species
- LN= Natural log of proportion of individuals

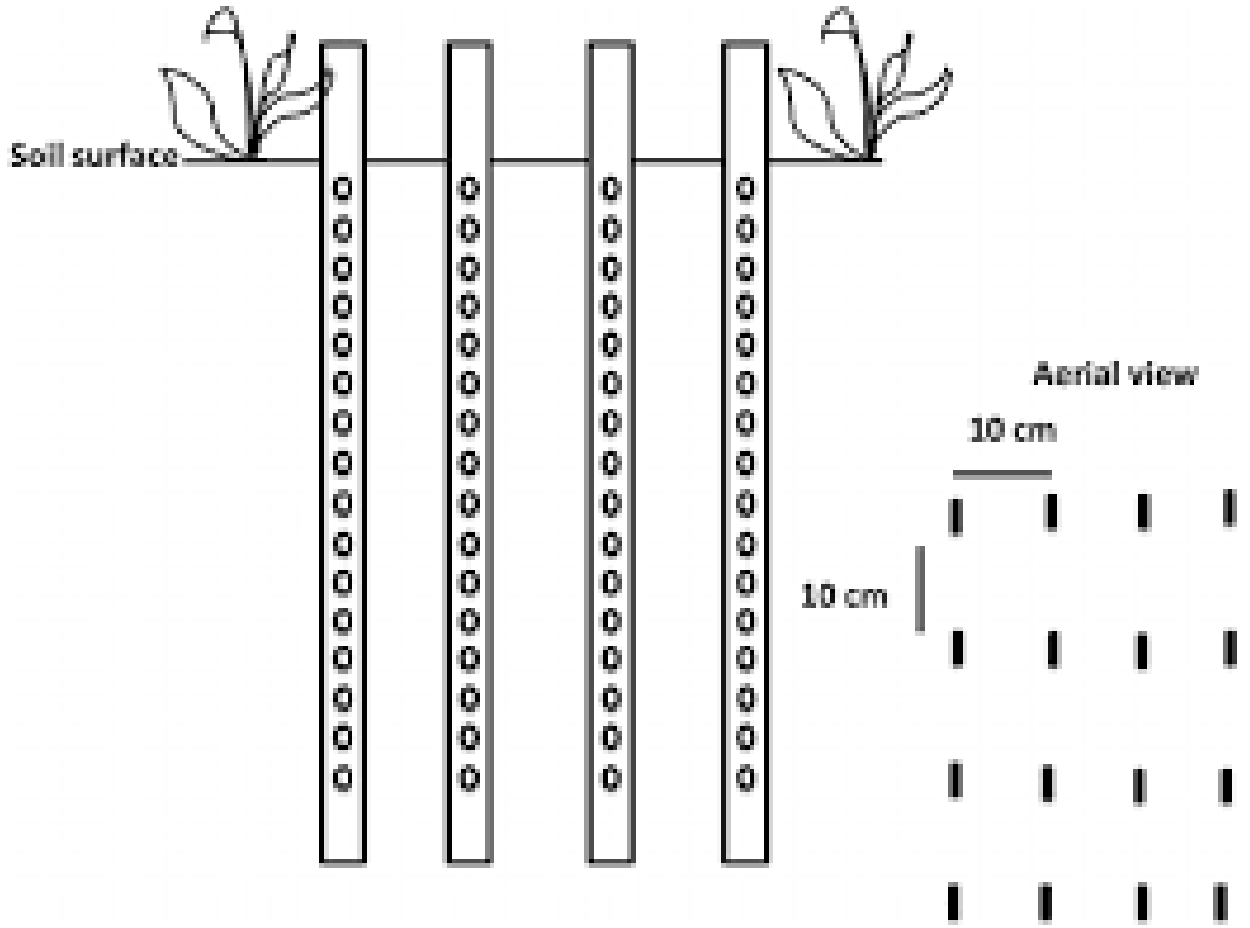
- If H < 1.5 = Low diversity
- H = 1.5 to 2.5 Medium diversity
- H = > 2.5 High diversity

Tea Bag Index

Microbial indicators for soil quality, since this reflects the potential capacity for soil ecosystem functions

Joost et al, 2013

Bait lamina test



Disappearance of the bait material is directly associated to the feeding activity of soil invertebrates, even if microbial processes

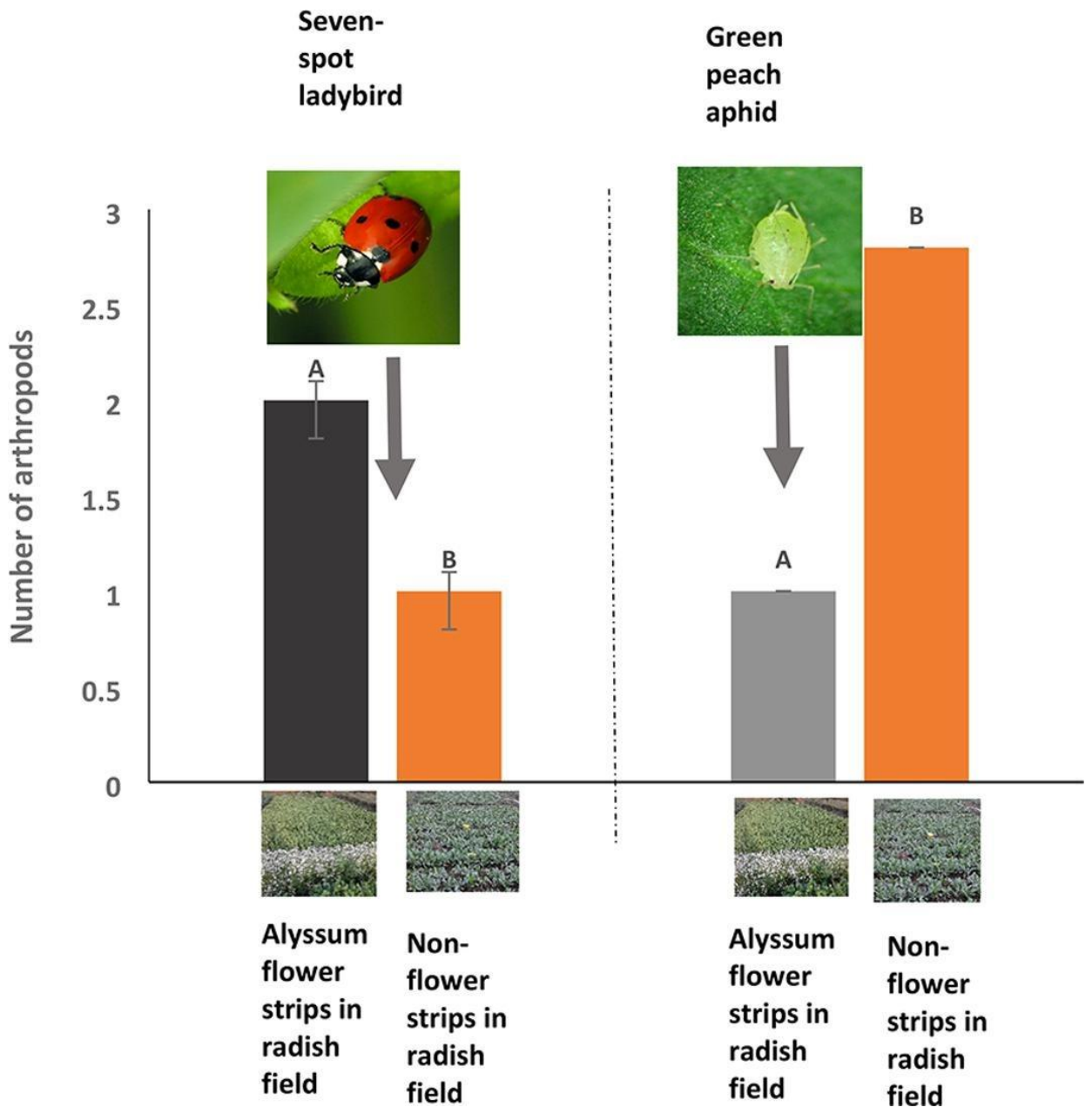
Ground oat grains,
Cellulose powder
agar-agar gel

Case studies

- Species richness (2x2 meter square area)
- Syrphid fly/Aphid abundance and diversity/Sampling unit

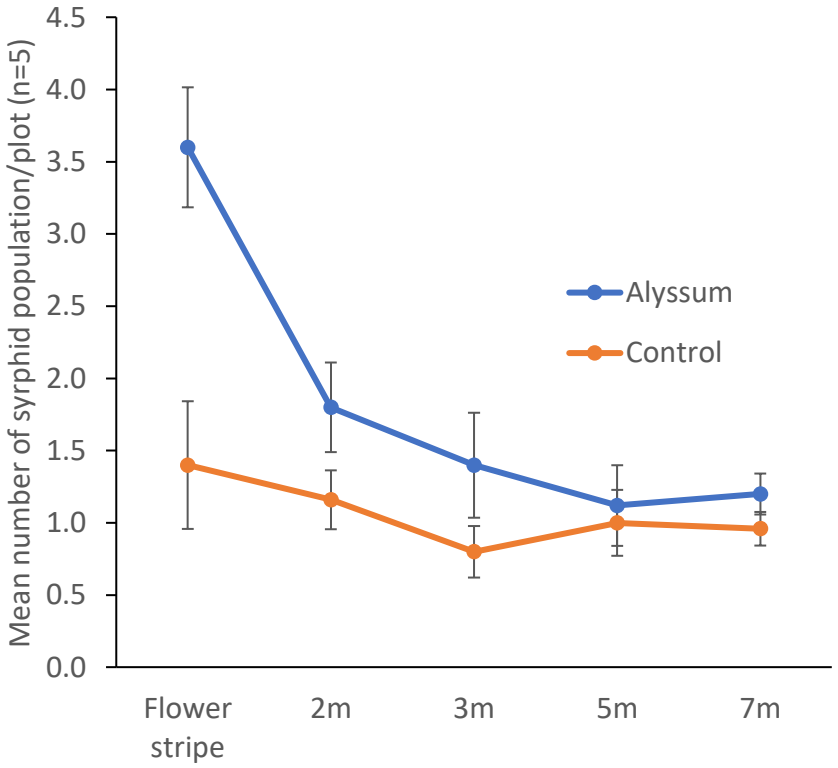
Density assessment

Arthropods	Radish plot adjoining to alyssum flower stripes	Control plot	Remarks
Carabidae	1.6	0.9	<0.001
Staphylinidae	1.5	1.1	0.05
Coccinellidae	2.0	0.7	<0.001
Wolf spider	1.7	1.1	0.002
Jumping spider	1.1	0.7	0.05
Vespidae	1.2	1.2	0.947
Formicidae	1.2	0.8	0.052
Apidae	1.8	0.8	<0.001
Parasitoids	1.9	0.9	<0.001

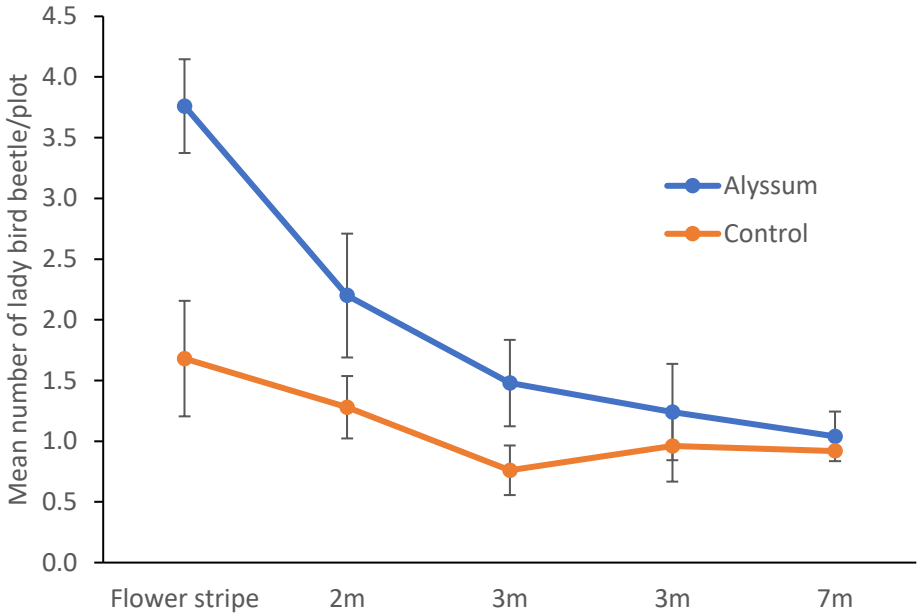


Tiwari et al., 2020. Flowering alyssum (Lobularia maritima) promote arthropod diversity and biological control of Myzus persicae. *Journal of Asia-Pacific Entomology*, *23*(3), 634-640.

Field deployment

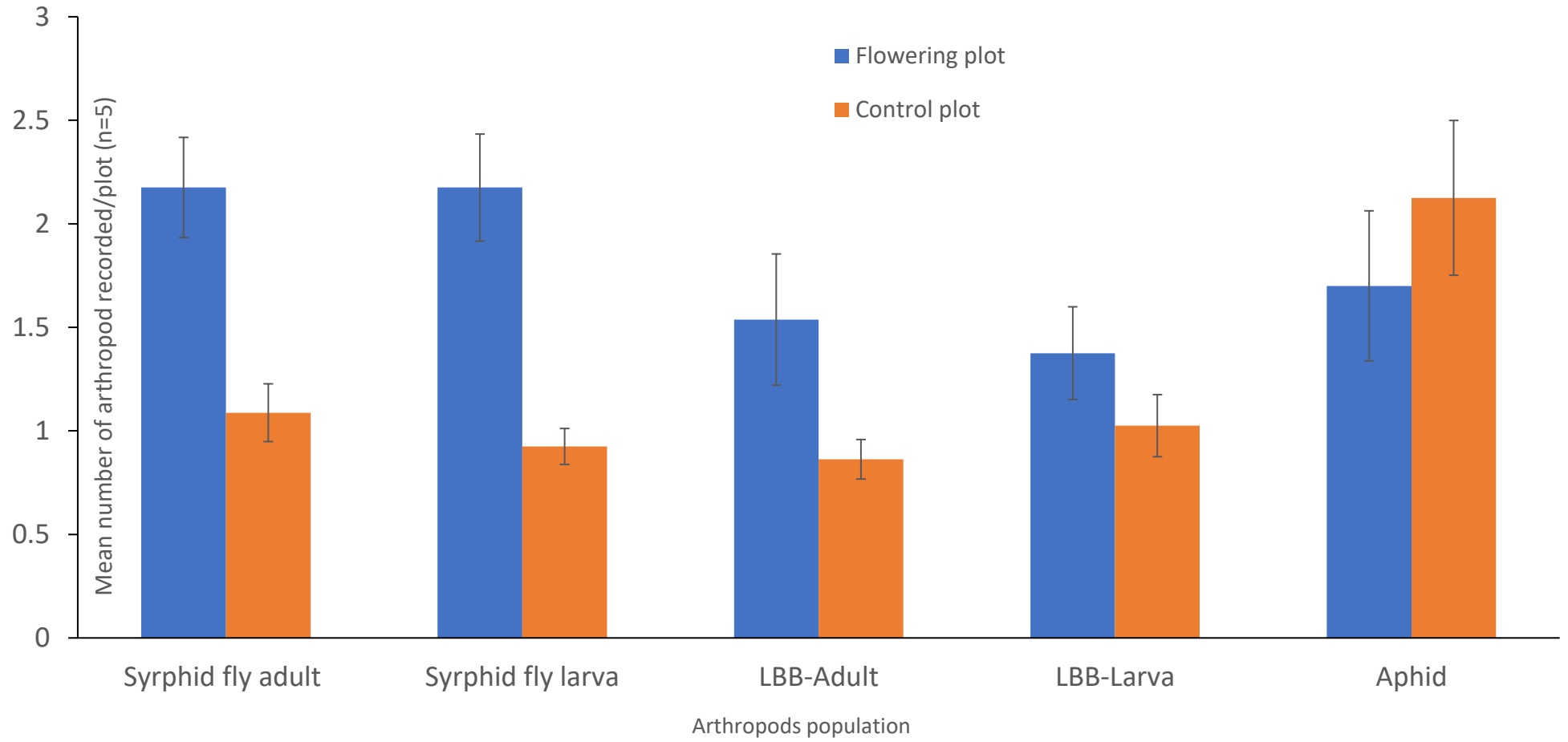


Syrhid fly adult population collected at various distances



Lady bird beetle adult population at various distances from flower stripes and control plot (n=5)

Flowering plants increase the fitness to Predators



Summary

- Agroecological practices are sustainable practices
- Habitat manipulation increase density and diversity
- Increase fitness of biological control agents
- Consider multiple ecosystem services and dis-services

References

- Douglas A. Landis Stephen D. Wratten and Geoff M. Gurr. 2000. Habitat Management to Conserve Natural Enemies of Arthropod Pests in Agriculture; Annual Review of Entomology 2000 45:1, 175-201
- Altieri MA, Letourneau DK. **1982**. Vegetation management and biological control in agroecosystems. *Crop Prot.* 1:405–30.
- 94.
- Landis DA, van der Werf W. **1977**. Earlyseason aphid predation impacts establishment and spread of sugar beet yellows virus in the Netherlands. *Entomophaga* 42:499–516.
- Gurr GM, van Emden HF, Wratten SD. 1998. Habitat manipulation and natural enemy efficiency: implications for the control of pests. See Ref. 12, pp. 155–83
- Wratten SD, van Emden HF. 1995. Habitat management for enhanced activity of natural enemies of insect pests. In *Ecology and Integrated Farming Systems,* ed. DM Glen, MP Greaves, HM Anderson, pp. 117–45. Chichester, UK: John Wiley. 329 pp.