Functional agrobiodiversity: approach, examples, and applicability to banana cropping systems

Paolo Bàrberi
Institute of Life Sciences
Sant’Anna School of Advanced Studies, Pisa (IT)
p.barberi@sssup.it
• **Part I:** Agriculture and biodiversity: friends or foes?

• **Part II:** What is functional agrobiodiversity (FAB)?
  • Definition
  • FAB vs biofunctionality
  • FAB components
  • FAB study and application: a 4-step approach
  • Two examples from our research

• **Part III:** FAB in banana agroecosystems
  • Recent examples
  • Opportunities for further exploitation
I. Agriculture and biodiversity: friends or foes?
1. To ensure long-term sustainability and resilience of agricultural and food systems we need ...
I. Agriculture and Biodiversity

AGRICULTURE serving BIODIVERSITY (A for B)

• Non production-related ecosystem services (e.g. species/habitat conservation, cultural/amenity values)

or

BIODIVERSITY serving AGRICULTURE? (B for A)

• Production-related ecosystem services (e.g. soil fertility, biological pest control, weed suppression)

Bàrberi et al. (2010). Weed Research 50, 388-401

X International Symposium on Banana – ISHS ProMusa Symposium
Agroecological approaches to promote innovative banana production systems
Montpellier (FR), 10-14 October 2016
II. What is functional agrobiodiversity (FAB)?
II. Functional agrobiodiversity

- ‘That part of the total biodiversity composed of clusters of elements (at the gene, species or habitat level) providing the same (agro)ecosystem service, that is driven by within-cluster diversity’ (Moonen & Bàrberi, 2008)

- **Biofunctionality**: service given by presence of functional elements

- **Functional identity**: service given by presence of a given functional element, e.g. species, carrying the desired trait(s) (Costanzo & Bàrberi, 2014)

- **Functional composition**: service given by the complementary effect of different traits, expressed by co-occurring functional elements (*ibid.*)

- **Functional diversity s.s.**: service given by direct effect of heterogeneity within the crop stand, i.e. genetic diversity (*ibid.*)
II. FAB: a 4-step approach

<table>
<thead>
<tr>
<th>Step No.</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Definition of the context (target agroecosystem) and related objectives</td>
<td>Olive grove with organic management</td>
</tr>
<tr>
<td>2</td>
<td>Definition of priority agroecosystem functions</td>
<td>Control of the olive fly</td>
</tr>
<tr>
<td>3</td>
<td>Definition of the agroecosystem functional group</td>
<td>Species of parasitoids and hyper-parasitoids of the olive fly, wild plant species and structures (e.g., hedgerows, woodland) attracting natural enemies of the olive fly, olive cultural practices known to affect olive fly (e.g., cultivar type, pruning, types and amount of natural pesticides sprayed)</td>
</tr>
<tr>
<td>4</td>
<td>Definition of space and time boundaries for the study of the agroecosystem functional group and of pertinent indicators</td>
<td>Field and landscape scale, whole year, number of fruits with fly punctures (sample), number of parasitized fruits and natural enemies species (sample), presence and abundance (e.g., percent area cover) of wild plants and structures supporting natural enemies of the olive fly, details (e.g., type and rates of active ingredients used) of cultural practices known to affect the olive fly (see step 3)</td>
</tr>
</tbody>
</table>

Modified from Moonen and Bàrberi (2008).

II. FAB: a 4-step approach

Choosing cover crops to enhance ecological services in orchards: a multiple criteria and systemic approach applied to tropical areas

Magalie Lesueur Jannoyer, Fabrice Le Bellec, Christian Lavigne, Raphaël Achar, Eric Malézieux, *
II. Example #1: Designing cover crop mixtures to improve weed suppression

**Functional Groups (FG)**

<table>
<thead>
<tr>
<th>Pure Stands</th>
<th>Large Seeded Legumes</th>
<th>Small Seeded Legumes</th>
<th>Grasses</th>
<th>Brassicaceae</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>Pisum sativum</em></td>
<td><em>Vicia sativa</em></td>
<td></td>
<td><em>Raphanus sativus</em></td>
</tr>
<tr>
<td></td>
<td><em>Trifolium incarnatum</em></td>
<td><em>Trifolium squarrosum</em></td>
<td></td>
<td><em>Brassica nigra</em></td>
</tr>
<tr>
<td></td>
<td><em>Hordeum vulgare</em></td>
<td><em>Avena sativa</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Raphanus sativus</em></td>
<td><em>Brassica nigra</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Trifolium incarnatum</em></td>
<td><em>Trifolium squarrosum</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>T. incarnatum + T. squarrosum</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>T. squarrosum + B. nigra</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>T. incarnatum + A. sativa</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>P. sativum + H. vulgare</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diversity</th>
<th>n° of FG</th>
<th>Mixtures</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-species mixtures</td>
<td>1</td>
<td><em>T. incarnatum + T. squarrosum</em></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td><em>T. squarrosum + B. nigra</em></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td><em>T. incarnatum + A. sativa</em></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td><em>P. sativum + H. vulgare</em></td>
</tr>
<tr>
<td>4-species mixtures</td>
<td>2</td>
<td><em>P. sativum + V. sativa + H. vulgare + A. sativa</em></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td><em>P. sativum + V. sativa + H. vulgare + R. sativus</em></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td><em>T. squarrosum + T. incarnatum + A. sativa + B. nigra</em></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td><em>P. sativum + T. incarnatum + H. vulgare + B. nigra</em></td>
</tr>
<tr>
<td>8-species mixture</td>
<td>4</td>
<td><em>P. sativum + V. sativa + T. incarnatum + T. squarrosum + H. vulgare + A. sativa + R. sativus + B. nigra</em></td>
</tr>
</tbody>
</table>

Ranaldo et al., in preparation
II. Example #1: highlights

Cover crop biomass

- Land Equivalent Ratios of all mixtures was >1, showing a positive effect of mixtures on total cover crop biomass over the average of their component species. Differences were statistically significant in 5 out of 9 cases.

Total weed biomass

- 8 out of 9 mixtures significantly suppressed weeds compared to the control. Absolute total weed biomass was generally lower in the mixtures than in single species cover crops, with the exception of grasses.
- However, in the majority of cases cover crop biomass and weed biomass were not significantly correlated.

Relationship between weed biomass and diversity

- Total weed biomass showed a strong negative correlation with cover crop species richness in the mixtures, and an even stronger one with the functional diversity of the mixtures.
II. Example #1: conclusions

• Weed suppression was higher with higher cover crop biomass only in the legume functional group

• Other mechanisms (such as allelopathy) may explain weed suppression in Poaceae and Brassicaceae

• Increasing the level of diversity leads to better weed suppression

★ This effect is higher for Functional Groups diversity than for species diversity
II. Example #2: interplay between local and landscape scales on biological pest control

Effects of local and landscape factors on spiders and olive fruit flies

Malaya S. Picchi, Gionata Bocci, Ruggero Petacchi, Martin H. Entling

*Scuola Superiore Sant’Anna, Institute of Life Sciences, M. M. della Liberta 37, 56127 Pisa, Italy
**Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany
***Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

Agroecological approaches to promote innovative banana production systems
Montpellier (FR), 10-14 October 2016
II. Example #2

18 focal fields in ≠ landscapes (gradient of SNH %)


Fig. 1. Effect of management on the number of individuals of the three main spider families of spiders and on the two functional guilds (web-building and cursorial spiders): the difference among organic and conventional type of management is significant (*) for the Linyphiidae family ($F_{1,15} = 4.72$, $p$ value = 0.045; bars represent mean value of individuals with standard error) and for web builders ($F_{1,53} = 6.05$, $p$ value = 0.026; bars represent mean value of individuals with standard error).

Fig. 3. Effects of management ($F_{1,15} = 8.112$, $p$ value = 0.023) of Mediterranean garigue ($F_{1,15} = 6.407$, $p$ value = 0.012) landscape on Linyphiidae in olive groves.

Fig. 4. Number of Diptera (excluding S. olea) influenced by the amount of woody areas in the surrounding landscape ($F_{1,29} = 11.66$, $p$ value = 0.004) and, to a lesser extent, by the type of management of the olive grove ($F_{1,31} = 3.102$, $p$ value = 0.099).
II. Example #2

a) June

b) July

c) September

d) October


X International Symposium on Banana – ISHS ProMusa Symposium
Agroecological approaches to promote innovative banana production systems
Montpellier (FR), 10-14 October 2016
III. Functional agrobiodiversity in banana cropping systems
III. Trait-based approach

Using Functional Traits to Assess the Services Provided by Cover Plants: A Review of Potentialities in Banana Cropping Systems

Gaëlle Damour¹, Eric Garnier², Marie Laure Navas³, Marc Dorel* and Jean-Michel Risède

*CIRAD Persyst - UR Systèmes de culture à base de bananiers, ananas et plantains, Stazione de Neufchâtel, Sainte Marie, Capetière-Belle-Eau, Guadeloupe, France
²CNRS, Centre d’Ecologie Fonctionnelle et Evolutive (UMR 5175), Montpellier Cedex, France
³Montpellier SupAgro, Centre d’Ecologie Fonctionnelle et Evolutive (UMR 5175), Montpellier Cedex, France

Corresponding author: E-mail: gaelle.damour@cirad.fr

Advances in Agronomy, Volume 134
ISSN 0065-2113
http://dx.doi.org/10.1016/bs.agron.2015.06.004

© 2015 Elsevier Inc. All rights reserved.
III. Opportunities in the hidden half

Combination of Crotalaria spectabilis with Rhizophagus irregularis MUCL41833 decreases the impact of Radopholus similis in banana
Abla Anenea,b, Stéphane Declercka,*

a Institut Togolais de Recherche Agronomique (ITRA), B.P. 1163 Lomé, Togo
b Université catholique de Louvain (UCL), Earth and Life Institute, Mycology, Croix du Sud 2, bte 17.05.06, 1348 Louvain-la-Neuve, Belgium

Biocontrol Science and Technology

Plant-growth-promoting traits and antifungal potential of the Bacillus amyloliquefaciens YL-25
Jun Yuan, Lu Yu, Ning Ling, Waseem Raza, Qirong Shen & Qiwei Huang
III. Further opportunities

• Cover crops/living mulches
  • Explore the potential of mixtures to deliver agroecosystem services (possibly multiple)
  • Adapt cover crop management to banana planting system (e.g. strip mowing/mulching)

• Intercropping and agroforestry systems
  • Learn from success stories in small-scale family farming (e.g. in East Africa) and try to upscale them

• Engage in inter- and transdisciplinary participatory research
  • Co-definition of priority services and associated traits and co-evaluation and ranking of potential solutions will favour innovation uptake and deployment of true Agroecology