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Agroecological engineering of crop and livestock health. Case studies in the French West Indies

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Abstract

Current crop and livestock farming strategies based on elite varieties and breeds and intensive use of chemicals (pesticides, medicines) suffer from major limitations. Production losses, alteration of natural resources, loss of biodiversity, risk to human health, and vulnerability of the agrosystems dependent on polluted resources are part of the numerous undesirable side effects. The solutions derived from the paradigm of eradication of pathogens have shown their limits. The considerable variability and adaptability among pathogen strains results in emerging resistance and replacement of susceptible with resistant strains in many pathogen species. When extremely aggressive emergent pests or resistance breakage occur, no more food production is possible. Novel approaches and methods are needed to encourage diseases management. The development of an ecological engineering approach that combines nested multi-scale levers is necessary. Mobilizing ecological interactions, largely unexplored, is a key issue to design new health management options. Thus, it fits in with the “smart” (FAO 2011) approach required for the agroecological transition. We analyze how to enhance ecological interactions for crop and animal health. Based on a conceptual grid (Chave, 2015; Chave and Angeon, 2014), we show that consistent strategies for mobilizing ecological interactions rely on a complex activation of key levers at different spatial scales. We apply this analytical grid to two case studies relating to plant and animal health in the French West Indies. These areas face strong challenging diseases for which most of the conventional solutions requiring the use of chemicals barely function. By applying an analytical grid that constitutes the ABCs of ecological regulation to crop and livestock health, we point out strategic choices lead in the French West Indies to cope with diseases. We show how new multi-scale approaches are implemented to identify solutions to enhance ecological interactions for crop and livestock health.

Method

The suggested conceptual framework constitutes the ABCs of biological regulation (Chave and Angeon, 2014). It takes advantage of ecological interactions by increasing ecosystem services and reducing disservices. It originally derives from crop health management (Chave et al. 2014), but it can also aid the comprehension of sustainable

animal production (Botreau et al. 2014) as, in both animal and crop systems, the use of biodiversity is the cornerstone of agroecological principles. The grid tackles the key levers used to engineer beneficial or damaging interactions. It defines 6 main levers that appear to be key determinants of agroecological innovative practices.

Results

Two case studies are considered to discuss agroecological protection strategies.

The first one deals with the biocontrol of plants diseases (i.e. the soil bacteria *Ralstonia solanacearum*) in the French West Indies. *R. solanacearum* is one of the world's most important phytopathogenic bacteria due to its lethality, persistence in soil, wide host range and broad geographic distribution. A new pathogenic variant of *R. solanacearum* was detected in 1999, first in Martinique (Wicker et al. 2009). No resistance was effective for controlling this extremely aggressive new strain (Lebeau et al. 2011). As the use of methyl bromide has been banned for years, one promising approach was to encourage agroecological management. Multifunctional practices harnessing rhizosphere bioprotection were explored to overcome the limitations of conventional protection strategies. Integrating interacting species with strong ability to recruit beneficial microorganisms (i.e. arbuscular mycorrhizal fungi) or secrete toxic compounds in mixed cropping systems is a key issue. Harnessing these natural processes may also avoid the problem of pathogens quickly evolving resistance. Based on functional biodiversity management, numerous agroecological practices, such soil amendments (with compost or plant extract) and mixed cropping systems, also help to control soil diseases (Chave 2015). Breeding crop cultivars which capitalize on plant-microbiome interactions or associating plants and biocontrol agents early in their life offers innovative ways to contribute to disease-suppressive agroecosystems design (Chave et al. 2014). Beyond the practices themselves, it is their combination that is likely to produce synergies for an integrated bioprotection against soil-borne pests.

The second case study explores management strategies for integrated parasitic control. Gastrointestinal parasitism is probably the most widespread disease in grazing small ruminants in the tropics. Half a century of suppressive drenching has resulted sooner or later in the selection of parasite strains resisting to the chemicals employed, and in increasing production losses. Some small ruminant farmers are already facing multi-resistant parasites with no more chemical solution (Mahieu, Ferré et al. 2014). Integrated management must be thought at the whole small ruminant farming system, as a combination of strengthening the animal immune responses (through choice of parasite resistant breed, selection, suitable nutrition, vaccine policy when available), grazing management according to the parasite epidemiology, herbivore species associations, use of forage or plant with anthelmintic properties, and finally management of the residual efficacy of chemical anthelmintic using targeted selective treatments and managing the parasite population at the farm level (Mahieu 2014).

Conclusion

Agriculture has to shift from a simplifying industrial approach to an ecological approach, that enhances complex and non-linear interactions between living organisms and that leaves room for the farmer initiative. From these examples, we showed agroecological systems offer a wide diversity of levers of actions. Different actors implement the key levers depending on their area of action. Identifying a set of potential solutions in order to guide the stakeholders' choices to explore new combinations of levers, depending on their agrosystem and territorial contexts is a key issue to implement the agroecological

transition.

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