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Diverse dynamics in agroecological transitions on fruit tree farms

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ABSTRACT

Agroecological transition refers to the adoption by farmers of practices based on on-farm biological processes rather than imported or non-renewable inputs. Drawing from a comprehensive survey of 31 diversified farms cultivating citrus on Réunion Island (Indian Ocean, France), this study aims to understand the diverse dynamics in farmers' agroecological transitions and to identify the factors and processes driving farmers' choices. The analysis considers both the current protection, fertilization and weed control practices implemented by farmers in their orchards and the trajectories of change they have followed over the last thirty years. Orchard management was categorized according to the kind of inputs mobilized (i.e., "synthetic inputs", "alternative off-farm inputs" and "alternative on-farm inputs"). Diverse managements were observed, targeting security, autonomy, ecology or simplicity. The six types of practice trajectories identified illustrate the diverse and incremental nature of agroecological transition. Drawing from these results, drivers of alternative practice adoption and lock-in effects in synthetic input reliance were characterized. Internal drivers, depending directly on the farmer and his/her farm, included the characteristics of the orchard and its environment, the labor force, and the farmer's environmental concerns. External drivers included local citrus markets, public legislation, access to extension services, the organization of input supply and the social environment. The combination of these internal and external drivers at the farm level makes each farm relatively unique. However, three factors determine the main differences in practices: the marketing channel used, the farmer's environmental objectives, and the farmer's economic behavior, which is linked to the weight of the crop activity in farm revenue. Understanding farmers' points of view and decisions regarding agroecological transition deserves the attention of scientists, agricultural advisors and policy makers when designing innovative cropping systems, new support methodologies and incentives to respond effectively to farmers' objectives and contexts of action.

1. Introduction

A key challenge facing agricultural sciences is to identify ways to support farmers' efforts to reduce the negative impacts of agriculture on health and the environment while increasing global food security. Agroecology is increasingly proposed as a solution (De Schutter, 2012), but this complex concept remains difficult to translate into agricultural practices. A strict definition considers practices to be agroecological when they rely only on on-farm biological processes (Rosset and Altieri, 1997). A broader definition also includes practices such as physical control or off-farm biological inputs (Wezel et al., 2014). Regardless of the definition used, agroecological practices are supposed to reduce the use and negative environmental impacts of synthetic inputs.

Many research studies have aimed to define and evaluate at the plot level the best practices based on agroecological principles (Reckling et al., 2016). Only a few have focused on understanding how farmers shift from conventional practices (i.e., based on synthetic inputs) to agroecological ones by taking into account the whole farm level, considered as a system (Le Gal et al., 2010). These studies have investigated either the diversity of farmers' current practices or their trajectories of practice changes. Analyses of current practices have sought to clarify the reasons alternative practices are adopted, based either on statistical analyses of quantitative questionnaires applied to large samples (Epule and Bryant, 2016; Fairweather and Campbell, 2003) or in-depth explorations of a few case studies (Brodt et al., 2007). Studies based on statistical analyses have highlighted interactions between socio-economic characteristics of farms/farmers and current practices (Pannell et al., 2006). Meanwhile, studies based on case studies have highlighted the drivers of current practices, such as marketing channels and farmers' social, economic and environmental goals (Pissonnier et al., 2016). Analyses of the trajectories of practice changes have focused on either all of the activities on a farm or specific farming activities. At the farm scale, increased agrobiodiversity and off-farm activities have been described as being part of the agroecological transition process (Blesh

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and Wolf, 2014). At the scale of the cropping system, multiple pathways of synthetic input reduction have been described, but disconnected from explanative elements of farm context (Chantre et al., 2015; Lamine, 2011). These trajectories differ in terms of the timeline of intermediary steps classified with the "Efficiency-Substitution-Redesign" (ESR) framework (Hill and MacRae 1996). This framework assumes that farmers first move from an intensive use of synthetic inputs to a more rational use of synthetic inputs to improve "efficiency" (E). They then move to a "substitution" (S) of synthetic inputs by non-synthetic ones, used exactly in the same way and for the same purpose. Eventually, they "redesign" (R) the entire system as an agro-ecosystem based on ecological processes rather than external inputs (e.g., introduction of legumes in the crop sequence). Two weaknesses of the ESR framework limit understanding of farmers' transitions: (i) the three steps may be implemented at the same time by a farmer at the scale of crop management (Chantre and Cardona 2014); and (ii) some practices are difficult to classify as either "substitution" or "redesign". For instance, mechanical mowing may correspond to a simple substitution of equipment and inputs or may be part of a redesign strategy aiming to improve biological control.

Most studies of agroecological transition trajectories have focused on farmers who are deeply involved in the transition process. Knowledge is lacking on the trajectories of other farmers, although they remain in the majority. Moreover, to the best of the author's knowledge, no study has jointly analyzed the drivers of farmers' choices in both their current practices and their trajectories of practice changes, although these two areas could provide complementary findings. This paper aims to fill these gaps by describing the dynamics of the agroecological transitions of all of the diverse types of citrus farmers and farms on Réunion Island, and clarify the drivers of these transitions. Knowledge about the objectives and constraints of farmers and the progressiveness of change at the farm level should improve the way scientists design innovative cropping/livestock systems by including adoptability in the design process. Policy makers and agricultural extension services could also benefit from this knowledge by adjusting their support of agroecological transition to different farm situations.

The study is based on a comprehensive survey of 31 farms cultivating citrus combined with others crops and livestock on Réunion Island (Indian Ocean, France). This context presents particularly interesting characteristics for studying agroecological transition at the farm level. Firstly, fruit tree farms face high pressure from pests and diseases with constraints such as the absence of annual crop succession, but also enjoy opportunities to enhance conservation biological control, such as the permanence of habitats (Simon et al., 2017). Secondly, Réunion Island applies public regulations and objectives regarding pesticide usage both at European (e.g., the Pesticides Directive 2009/128/EC) and French levels (e.g., Ecophyto 2), which should encourage farmers' dynamics of change. Thirdly, perennial citrus crops are traditionally grown in orchards in contrasting environments with regard to altitude, crop combinations and marketing channels. This diversity enables a large range of situations to be explored within a small sample of farms. Three management dimensions (protection, fertilization and weed control) were jointly studied to evaluate the progressiveness of change within each farm. These management dimensions were chosen for their range of input use, from conventional synthetic ones to agroecological alternatives, following the broad definition of agroecology. The agronomic, political and economic context of citrus production on Réunion Island is first presented to ground the case study in its explanatory context. An alternative to the ESR framework is then developed in the case study. Current farmers' practices and trajectories of practice changes are described combining two approaches to construct farm typologies. The drivers behind and barriers to agroecological transition are formalized. Finally, the contributions of the study to research on sustainable farming transitions are discussed.

2. Materials and methods

2.1. Context

Réunion is a small island (2512 km^2) in the southwestern part of the Indian Ocean (21°S, 55°E). Due to the mountainous relief, the citrus production area includes a range of altitudes (0–1200 m), average annual rainfall (from 500 to 3500 mm) and temperature conditions (from +15 °C to +25 °C). Compared to Mediterranean regions, citrus face high pest pressure which damages visual quality.

More than 25 species and varieties of citrus are grown on the island. The main cultivars grown are mandarins (Citrus reticulata Blanco), oranges (Citrus sinensis (L.) Osb.) and lemons (Citrus limon (L.) Burm), while combavas (Citrus hystrix DC.) and limes (Citrus aurantiifolia (Christm.) Swing. and Citrus latifolia Tanaka) correspond to niche markets with higher added-value. Most farms combine several citrus species and varieties in their orchards.

At the beginning of the 1960s, local citrus farmers were supported by a reliable network of public extension services. In the 1980s, mainstream orchard management was based on synthetic inputs (systematic synthetic pesticide applications, synthetic fertilizers and chemical weeding in ranks and alleys) (Grisoni et al., 1993). The first agri-environmental measures were proposed to farmers in the late 1990s, when the public extension services supported farmers to establish permanent grass cover in inter-rows controlled with mechanical weeding to reduce erosion. In the 2000s, the extension services began to provide information about the role of grass cover in biological control and to test cover crops with legumes on farmers' plots. Farmers were also supported in the adoption of chemical traps, biopesticides and removal of fallen fruits. More recently, in the 2010s, support has been given to farmers to recycle wood from pruning instead of burning it to increase soil organic matter.

Since the 1960s, citrus have been sold by farmers to local retailers or directly on street markets. From the 2000 s onwards, public policies have encouraged the formation of co-operatives to integrate farmers into the formal economy, which currently includes only 10% of the Island's total citrus area. By joining a cooperative, farmers gain access to public subsidies ranging from 195 to 375€/ton of citrus fruit; subsidies can be even higher if the farmer is part of a quality certification process such as organic farming (OF). Cooperative members benefit from technical support for some alternative practices such as mechanical weeding and inundative biological control. Cooperatives mainly sell to local supermarkets. The marketing of citrus thus uses various channels (see Table 1).

2.2. In-depth exploration of farm case studies

A case-study based methodology was chosen as the most relevant

Table 1
Characteristics of the marketing channels used for the hybrid "Tangor" (source: own survey conducted in 2015).

Marketing channel	Selling price (€/kg)	Requirements
Juice producers	0.9	Small fruits
Local retailers	[0.8–1.8]	Large fruits with no visual damage
Cooperatives	[0.9–1.3]	Large fruits with no visual damage
Cooperatives with OF[a] label	[1.8–2.2]	Large fruits with no visual damage − OF label
Direct selling	1.8	Large fruits with no visual damage
Direct selling with OF label	2.8	No biopesticide residues on fruits − OF label

[a] Organic Farming.