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Spatial patterns of farm land use in fragmented semi-arid landscapes: The case of Lebna catchment (Cap Bon, Tunisia)

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Introduction

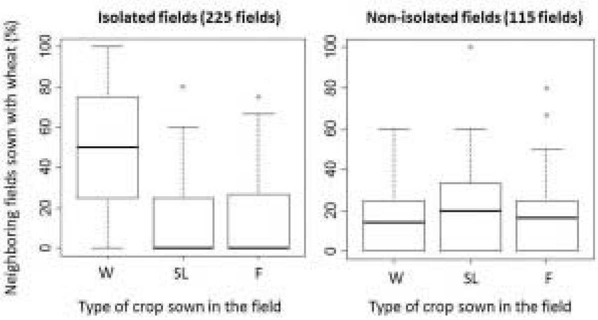
Mediterranean agricultural landscapes provide ecosystem services driven by land use patterns such as crop spatial distribution (Millennium Ecosystem Assessment, 2005). Assessing the determinants of crop location is therefore a prerequisite for exploring spatially-explicit land use scenarios and evaluating the subsequent ecosystem services (Benoît et al., 2012). Although remote sensing techniques are now able to provide time series of land use patterns, they do not permit to identify the driving factors of crop location that are related to farm characteristics. Intra-farm land fragmentation is a typical characteristic of rural landscapes (Demetriou, 2014), and we hypothesized in the current study that it may strongly influence crop spatial patterns. Therefore, this paper aims to study, within a semi-arid rural zone of Tunisia, the impact of farmland fragmentation for farmers' decisions of crop location, with a focus on the decision rules concerning preceding and neighboring crops.

Materials and Methods

The study was conducted over the Lebna catchment (210 km^2 – Tunisian Cap Bon Peninsula), which is typified by a hilly topography, scattered small farm territories, pasture vegetation, rainfed mixed farming (wheat, fodder, spices and legumes) and livestock. We characterized spatial pattern of crop location at the catchment scale and we analyzed the role of farmland fragmentation in the observed pattern by using Spot imagery-based classification and a geo-referenced database of field observations. The database included 340 fields belonging to 30 farms selected according to their land structure (scattered or aggregated fields) and 1220 neighboring fields. The collected variables were (i) the crop type in all fields for the 2016 cycle, to account for spatial dependencies between neighboring fields, (ii) the crop type in the 340 aforementioned fields for the 2015 cycle, to account for crop rotation driver and (iii) the field context (isolated or non-isolated field relative to the other fields and to the farm facilities). We first mapped crop distribution by applying a Random Forest model on the field database and three Spot images collected between mid-March and late April 2016. Then, univariate analysis permitted to characterize the variability of both crop distribution in neighboring fields and previous crop in the same field, in accordance to crop and field context. Finally, linear discriminant analysis permitted to quantify the ability to predict crop type from the variables describing neighborhood and previous year crop.

Results and Discussion

The distribution of annual crops in the Lebna catchment was mainly characterized by aggregates of several neighboring fields with the same crop type. Rules of crop location depended upon field context. For isolated fields, crop distribution in neighboring fields significantly depended upon the crop sown in the field (Fig. 1, for the case of wheat). Neighboring crops and crop rotation had the same weight on crop choice (Tab. 1). Overall, it seems that farmers' strategy rely on agreements with their neighbors to sow the same crop type and therefore to follow the same crop rotation. These agreements are likely to permit management of constraints related to field accessibility and free grazing after crop harvest. In non-isolated fields, such agreements are unnecessary. Distribution of neighboring crops appears to be more random, and crop choice significantly depends more upon crop rotation than upon neighboring crops.



(https://agromed2016.files.wordpress.com/2016/11/13_fig1.jpg)

***Figure 1**. Distribution of neighboring wheat plots according to crop type and field context*
W: wheat, SL: spices or legumes, F: fodder (mainly other cereals). (click to enlarge the figure)

Tested variables	Average rate of good prediction of the type of crop (standard deviation)	
	Isolated fields	Non-isolated fields
Random distribution	0.34 (0.04)	0.37 (0.04)
Neighboring crops (percentages of neighboring fields sown in each crops type)	0.56 (0.05)	0.49 (0.07)
Main previous year crop	0.56 (0.05)	0.63 (0.07)

***Table 1**. Results of the multi linear regression obtained from 1000 cross-validations and comparison with random distributions.*

Conclusion

Our study revealed the significant effect of farmland fragmentation on the spatial pattern of land use at the catchment scale. For a complete overview of the driver complexity, other potential determinants should also be explored, including productive strategies of farmers and physical characteristics of their fields. Furthermore, our findings underscore the need to deepen our knowledge of existing agreements between farmers to refine our understanding of crops distribution.

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