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## Are agronomic models useful for studying farmers' fertilisation practices?

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## Abstract

Nitrogen fertilisation is a source of potential groundwater pollution and is a key issue in the current debate about the environmental impacts of agricultural production. It is also a key element in the management of cropping systems by farmers. Therefore, cropping system design entails the understanding and evaluation of farmers' fertilisation practices. Biophysical models describing the soil-plant system can serve this purpose. A comparison between model outputs and farmers' practices was made of a set of 128 apple (Malus domestica Borkh.) plots from 31 members of a farmers' co-operative in south-eastern France. Farmers' fertilisation practices were compared with theoretical practices generated by a series of soil-plant system models of increasing complexity, each model giving the amount of nitrogen that should be applied to the plot according to the knowledge included in the model. The model that reproduced farmers' fertilisation practices most closely was the most complex, taking all plant requirements, soil organic matter and residue mineralisation, denitrification and irrigation supply into account. A Monte Carlo method showed that the differences between farmers' practices and model outputs were not random. Spatial analysis showed a strong spatial organisation of these differences, mainly due to three farms. This congruence between farmers' practices and model outputs suggests the existence of some indicators that depict the N nutrition status of the orchard as a basis for rules indicating how much nitrogen should be applied. The spatial analysis suggests the existence of farmer and neighbourhood effects, which need to be explained. Models appear to be useful tools to study farmers' practices by removing biophysical effects (soil,

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variety, etc.). This raises new questions concerning agricultural research at the interface between the biophysical and social sciences. © 2004 Elsevier Ltd. All rights reserved.

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## 1. Introduction

Nitrogen fertilisation has an important effect on crop growth (Visser, 1983) but may also be a source of groundwater pollution (Weinbaum et al., 1992; Bellon et al., 2001). Potential groundwater pollution depends on the topography of each rural catchments and the spatial distribution of crops and agricultural practices (Beaujouan et al., 2001). Nitrogen fertilisation practices used by farmers are also a key issue in the current environmental debate about agricultural production (Sansavini, 1997; Reganold et al., 2001). Therefore, they are a key element in the management of cropping systems. To satisfy the need for agricultural sustainability and the demands of society, most cropping systems must evolve towards more environmentally friendly practices (Meynard et al., 2001).

In a context where N fertilisation and other cropping practices are supposed to change on the basis of technical recommendations and public policies or regulations, extension services need to find the best way to move from existing practices to new ones. For agronomic research, this prerequisite for change entails a deeper understanding of current farmers' practices and their determinants (Landais and Deffontaines, 1988; Meynard et al., 2002; Papy, 1998). Indeed, to find a common ground farmers and advisers need to refer to the same indicators and determinants.

Studies of cropping practices mainly concern annual crops. Most focus on the effects of a single technical operation on crop performance or its impact on environment. Other agronomic studies consider practices as being interrelated, supported by specific concepts such as the crop management sequence (Sebillotte, 1978, 1990) or as being related to work organisation (Aubry et al., 1998; Dounias et al., 2002; Sebillotte and Soler, 1988) or as being included in an innovative process (Fujisaka, 1993, 1997). Finally, the social sciences also take farmers' practices into consideration, in fields such as anthropology, sociology and geography (Marquié and Cellier, 1983; Soulard, 1999). To our knowledge, studies of farmers' practices have never been carried out in relation to fruit tree cropping systems.

In this paper, rather than studying decision-making processes per se (as done by Cerf (1994, 1998), for instance), we compared fertilisation practices assumed to be based on relatively informal practical knowledge with practices based on scientifically documented knowledge formalised in an agronomic model. In crop management, informal practical knowledge mostly relates to field observations, which are objects that farmers use to implement their decisions (Geertz, 1983).

Agronomic models, such as those used in this study, are essentially biophysical models integrating soil, plant and climate processes. They rarely include interactions

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