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Comparative agriculture methods capture distinct production practices across a broadacre Australian landscape

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ABSTRACT

In farming systems research the link between farm resources, management and performances is often described, but rarely confirmed or quantified. Problems arise in formalising such linkages because substantial spatial and longitudinal whole-farm data are difficult to acquire. This study used the integrative discipline of comparative agriculture to collect such information and address a wide range of related farming system questions. The mixed method procedure included a landscape analysis, a historical investigation, and the collection of current farm information from 36 farms, representing half the farming businesses of a 4 000 km^2 area in a region of the Western Australian wheatbelt (≈300 mm/year) with highly variable soils.

Land types influenced management, including cropping specialisation, and explained some of the regional variability in grain yield and enterprise mix. Rotations varied by soil type and farm type. On average their duration was 3–4 years, typically starting with a 2–3 years of wheat, resulting in overall composition of 64% cereals, 20% break crops and 16% pastures/fallows. Break crops were grown more on light sandy soils than on heavier fine-textured soils. Lights soils were managed similarly by all farmers but distinctions occurred on heavier soils between mixed crop-livestock farmers and cropping specialists. This divergence in farming production was explained by farm soil composition: whilst cropping appears more profitable in the region, mixed farmers retained animals and pastures as a strategy to cope with having greater proportions of land less suited to crop production. Typical farm grain yields were indeed found to vary in relation to farm soil composition. The location of the original family farm in the landscape is likely to explain these differences in farm land resources, and subsequently current farm performance, production strategies and trajectories.

This study highlighted the potential of a method that deserves wider application: comparative agriculture helped identify and establish complex relationships within the farming system, some of which challenge common assumptions. Further applications to define typical farms, monitor practices, and contribute meaningful divisions of agricultural landscapes are also discussed.

1. Introduction

The importance of soil type on agronomic performance is widely recognised, however the impacts of soil variability at the farm level are more difficult to assess. In farming system research, assumptions are commonly made about farming practices that are not validated, prompting questions as to what extent the farmers' objectives and the criteria that influence their management are integrated. In particular, farmers are known to manage soils differently, however the impact of soil heterogeneity on their practices is rarely quantified.

In low rainfall southern Australia, where winter cereals and mixed crop-livestock farming systems dominate, controlled experiments, field surveys and simulation modelling thus regularly demonstrate that soil types have a major influence on crop production and resource use efficiency. Effects may be further amplified by variations in rainfall amount and distribution (Lawes et al., 2009; Oliver et al., 2009; Seymour et al., 2012; Harries et al., 2015; McBeath et al., 2015). At the field level, optimal production performances may be achieved by matching management to soil type, particularly with regards to crop and pasture rotations as it

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has historically been the case in other Mediterranean environments (Mazoyer and Roudart, 2007). Broadacre practicalities may lead to simplifications, for instance choosing practices that fit the dominant soil type. At the farm level, further compromises may be necessary as farmers must ensure the economic and biophysical sustainability of very large farms, and must also consider external factors (Bell and Moore, 2012; Price and Leviston, 2014).

There have been, however, few attempts at describing the rotations these broadacre farmers actually implement across different soils types. At present, the main maps available at regional scales include crop capability and soil/landscape surveys (e.g. van Gool et al., 2008; Sawkins, 2010), but none show how the rotation strategies of farmers differ across the landscape. Partial surveys recording the crop and pasture history of fields are regularly conducted (e.g. in Western Australia Lawes, 2010; Harries et al., 2015), however these do not provide a farm-scale picture of how landscape heterogeneity influences the rotation strategies of farmers. Whilst regional, averaged rotations might be deduced from overall land use (e.g. Robertson et al., 2010), the management patterns of farmers across different soils are not characterised or quantified. For instance, it is not known whether and to which extent rotations do vary between soils and farmers, or how the farm soil composition impacts the farm enterprise mix and overall performance. Although sometimes hypothesised, it is thus unclear whether the move from mixed crop-livestock farming to specialised crop production is prompted by particular soil types on farm and whether this decision to re-orientate production leads to higher grain yields overall. In fact, the amount of observed variability in individual performances that can be attributed to differences in farm soil composition is yet to be determined.

Whole farm surveys that could answer these types of question are not conducted for practical reasons. The long-term and spatial nature of rotation information implies that recording detailed and complete data about all the crop and pasture sequences implemented by farmers represents an unmanageable task. Case studies are detailed, but low numbers and/or focus on given fields hinder extrapolation (e.g. House et al., 2008; van Rees et al., 2014). Studies investigating variations in regional farm performances can thus seldom account for the variability of farm soil resources in spite of acknowledging its importance, let alone compare longitudinal data describing the utilisation of the landscape, even when farm surveys are available (Hooper et al., 2011; Hughes et al., 2011; Lawes and Kingwell, 2012; Kingwell et al., 2013).

In contrast, a large body of modelling literature has been produced that investigates farm soil profiles, rotations and performances at various spatial and temporal scales, notably using the APSIM, APSFarm, MIDAS and LUSO models (e.g. Moore et al., 2011; Finlayson et al., 2012; Kragt et al., 2012; Rodriguez et al., 2014; Lawes and Renton, 2015). Promising avenues to integrate social behaviour and landscape heterogeneity are also investigated (e.g. agent-based models, Asseng et al., 2010). The objectives of these modelling studies are generally to evaluate the impacts of adopting new technologies, practices, plant species or policies on farm management and performances. This is typically achieved by determining the allocation of farm resources that optimises farm production, financial return, or a desirable soil characteristic (e.g. organic carbon), under varying farm profiles (e.g. soil composition) and scenarios (e.g. changing prices or climate). Solutions notably reside in adjusting the farm enterprise mix and rotation strategies. The research questions and assumptions about farms in a region, for which these studies are based upon, are usually derived from case studies, local expert opinion and national surveys. More details on the practices that dominate different areas of the agricultural landscape could improve baseline information and contribute to model validation.

This study employed a novel, applied approach to examine the impact of soil heterogeneity on farmers' practices, production orientation and crop performances, expressed as rotation composition, farm type and grain yield, for a region of the Western Australian wheatbelt with high soil variability (Sawkins, 2010;

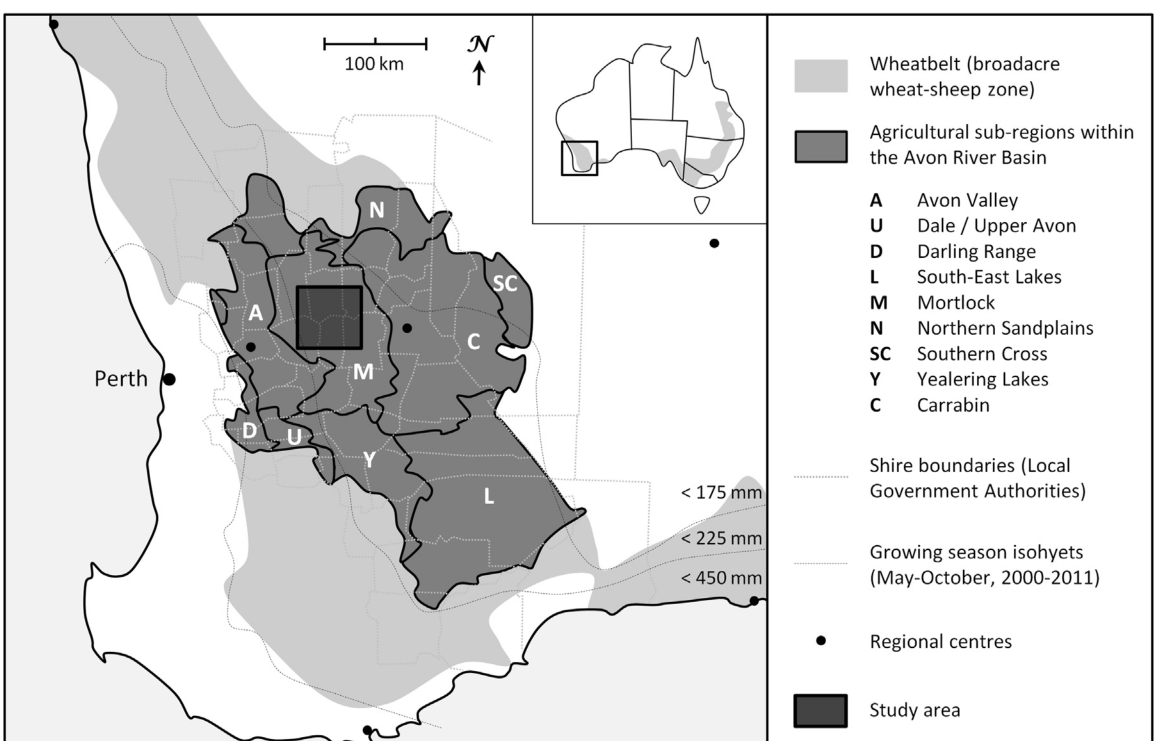

Fig. 1. Central Western Australian wheatbelt and study area.

Sources: DAFWA (2014); Galloway (2004).