Prototyping rotation and association with cover crop and no till

Naudin K1, Scope1E1, Husson O2, Auzoux S1, Penot E3, Giller KE4

1 CIRAD, UPR Annual Cropping Systems, 34398 Montpellier, France; krishna.naudin@cirad.fr
2 CIRAD, UPR Conservation Agriculture and Systems Engineering, 34398 Montpellier, France
3 CIRAD, UMR Innovation, 34398 Montpellier, France
4 Plant Production Systems, Wageningen University, 6700 AK Wageningen, The Netherlands

Keywords: whole farm systems modelling, cropping system, cover crop

Introduction
Crop rotations, between season and year, and within season, are one of the pillars of conservation agriculture (CA) (FAO, 2010; Reicosky, 2008). Moving from conventional to CA implies deep changes in the organization of cropping systems. The rules driving such changes have rarely been formalized, sometimes in a technical manual (Husson et al., 2009; IIRR, 2005), but never as a model as has been done for other non-CA cropping systems, e.g. ROTAT (Dogliotti et al., 2003) and ROTOR (Bachinger and Zander, 2007).

Our aim, by creating PRACT (Prototyping Rotation and Association with Cover crop and no Till) was to develop a tool not only able to select a single cover crop for a specific environment or specific goals, but to propose cropping systems defined by the association and/or rotation between cover crop and main productive crops. Until now PRACT has been applied to forty plants (Table 1) in the context of the lake Alaotra region of Madagascar.

Table 1. List of plants available in PRACT

<table>
<thead>
<tr>
<th>Type of plants</th>
<th>Name of plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover crops Legumes</td>
<td>Arachis pintoi, A. repens, Cajanus cajan, Desmodium uncinatum, Dolichos lablab, Crotalaria grahamiana, C. juncea, C. spectabilis, Lupinus alba, Mucuna pruriens, Pennisetum clandestinum, Stylosanthes guianensis, Trifolium repens, T. semipilosum, Vicia villosa, Vigna umbellata, V. unguiculata</td>
</tr>
<tr>
<td>Cover crops Other plants</td>
<td>Avena sativa, Brachiaria brizantha, B. humilicola, B. ruzzeniensis, Cydonon dactylon, Eclaisina coracana, Hordeum vulgare, Lolium multiflorum, Pennisetum glaucum, Raphanus sativus, Sorghum bicolor</td>
</tr>
<tr>
<td>Main crops</td>
<td>Arachis hypogaea, Glycine max, Ipomoea batatas, Manihot esculenta, Oryza sativa, Phaseolus vulgaris, Solanum tuberosum, Triticum durum, Vigna umbellata, V. unguiculata V. subterranea, Zea mays</td>
</tr>
</tbody>
</table>

Materials and Methods
PRACT was developed with the database management system Microsoft® Access 2007. This software was chosen as it is accessible for potential users in Madagascar. PRACT allows the user, for a defined agro-climatic context, to generate crop rotations based on CA principles that are best adapted to face local constraints. It is constructed around a knowledge database including data on: crops, cover crops, agronomics units, and relation between these three elements (Figure 1). This knowledge database came from expert knowledge already formalised in a technical manual (Husson et al., 2009; Husson et al., 2011, in press). Agronomic units are areas which are homogeneous regarding position in the toposequence and biophysical conditions that impact plants. For Lake Alaotra in Madagascar each of the 22 agronomic units is defined by: i) position on the toposequence, ii) water logging status, iii) irrigation management, iv) soil texture, v) possibility or not to grow an off-season crops (Husson et al., 2011, in press). Plants (crops and cover crops) are defined by their name, their taxonomic level (variety, species, genus, family) and rules for being cultivated. These plants are characterized by their quantitative outputs (grain production, biomass/forage production) and qualitative impacts on agro-ecological functions (Table 2). The production of each crop/forage came from continuing surveys by development agencies (Donas et al., 2010). Qualitative indicators are documented from expert knowledge (Husson et al., 2009). They concern agro-ecological functions (soil structure improvement and soil organic matter increase, erosion control, N input, nutrient cycling, weed control, pest and disease control) and or characteristic such as “simplicity for management” which can help to sort cropping systems looking for easier systems to implement by farmers. During the generation of crop rotation/intercropping these indicators are aggregated to produce the same indicators at rotation/association level. Plants associate plants between them (competition in time or space), iii) Possibility for one plant to follow another in the rotation. Two types of rules were defined: 1) “simple” rules, such as compatibility of plants to grow together in mixtures and compatibility between plants and agronomic units, and 2) more elaborate rules regarding plants successions and associations, e.g. for all upland agronomic units, if in year 1 the cover crop is S. guianensis then in year 2 the cover crop should be S. guianensis, because S. guianensis needs two seasons to produce sufficient biomass in uplands. Rules and fit responses of plants to agronomics units and indicators/outputs are defined with a seasonal time step, i.e. hot wet rainy season and dry cool off-season.
Table 2. List of indicators and outputs defining each cropping systems generated by PRACT

<table>
<thead>
<tr>
<th>Type</th>
<th>Indicators</th>
<th>Levels/units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qualitative indicators (for each year of the cropping system)</td>
<td>Soil structure improvement and soil, organic matter increase, Erosion control, N input, Nutrient cycling, Weed control, Pest and disease control, Simplicity for management</td>
<td>Very high/ high/ average/ bad</td>
</tr>
<tr>
<td>Quantitative indicators, production (for each year of the cropping system)</td>
<td>Rice grain, Legume grain Cassava tuber, Above ground biomass of legumes, Above ground biomass of grass</td>
<td>kg/ha</td>
</tr>
</tbody>
</table>

Results and Discussion

PRACT allows the user to formalize expert knowledge in choosing rotations of crops and cover crops for CA systems. For example, an advanced user can easily modify rules in an interactive process if proposed systems are technically impossible. A new user can compare systems proposed by PRACT with their current cropping systems or a new rotation they intend to test. When comparing PRACT’s cropping systems to farmers’ ones, three situations can occur, they can be: equal, a priori worse, or a priori better from an expert point of view. In the second case the comparison allows formalization of technicians’ and farmers’ knowledge and eventually introduction of new rules or parameters in PRACT from expert knowledge (including farmers, technicians, and scientists). In the last case, technicians and farmers can plan to test the new proposed systems on a small area to evaluate them under real conditions. PRACT is also useful for generating a large range of cropping systems as inputs for farm modelling and for scenario testing. For example, as shown by Dogliotti et al. (2005), linear programming can be used to select among the cropping systems which better fit to farmers’ goals and constraints. If PRACT were used in a decision support system (DSS), it should first be used as a stand-alone tool not connected with other programs, as users do not like “black boxes” where equations or calculations are not clear (McCown, 2002). Secondly, PRACT should be regarded as a “learning” tool rather than a “solver” (a tool from which output should be implemented without questioning the proposed choice). Third, the tool and any DSS version of PRACT is designed for technicians and scientists - not for direct use by farmers who in Madagascar have neither the means nor interest to use such a tool.

References


