Effect of management decisions on farm and household outcomes in an integrated crop-livestock agro-ecosystem in Yucatán, Mexico.

Agriculture in Yucatán.

The traditional agricultural practice of the Yucatán Peninsula, Mexico, is a form of shifting cultivation, known locally as milpa. A two to three year cultivation period is followed by a ten to twenty year period of forest fallow. Livestock ownership, including horses, cattle, hogs, fowl, and bees, has long been a part of traditional agriculture. Ownership of cattle is a more recent practice, but is becoming increasingly common, due to strong demand for mutton in Mexico City. For smallholder farmers this presents a development opportunity, with potential to diversify income and access potential complementarities between cropping and livestock.

Methods

The integrated model

An overview of the integrated model is shown in Fig 1. The APSIM model component uses climate and soil data to simulate plant growth. Three APSIM ‘paddocks’ (milpa, Guinea grass, and corn) are simulated simultaneously. The VenSim™ model component details management, stock dynamics, sheep production, partitioning of nutrients, labor, and economic outcomes. Data outputs from numerous SRNS (Small Ruminants Nutrition System) simulations are contained within the VenSim™ model. The VentLink module in APSIM enables APSIM and VenSim™ to communicate daily with specific variables. This structure allows communication between all parts of the model, enabling the reproduction of numerous system feedbacks.

Results

Livestock feeding practices.

A key hypothesis is that the practices used to feed animals is a key determinant of nutrient flows and hence the outcome of the system (see Fig 3). What feeding pathways are used, and whether fodders and nutrients are physically moved or moved by sheep makes a difference.

Discussion

Implications of model outputs

- It is logical for smallholders make use of the natural resources available e.g. focus on using common land and native tree legumes such as *Leucaena leucocephala*.
- Supplementing to improve live-weight gains can often decrease net income.
- Cut and carry systems can be more labor efficient than grazing systems (if continuous suspension is needed).
- Investment in increased integration through the use of crop by-products may not be a favorable option when common land is available.
- Investment in infrastructure to grow improved forages may lead to decreased returns to labor and net income.

Model limitations and improvements

- Phosphorus is an important nutrient but the grass module in APSIM does not track P, and neither does SRNS.
- A wider range of crop & forage modules are needed in APSIM.
- Verification is not included in APSIM.
- Only one soil type, and one milpa was simulated.
- Potential to define spatial relationship between locations.
- Lack of knowledge of the underlying processes of manure decomposition, particularly manure surface applied and in pili.
- Feed quality data that is not generated by APSIM (e.g. neutral detergent fiber; NDF) is needed to generate SRNS runs.
- A dynamic SRNS would offer numerous benefits.

Scenario analyses

What are the biophysical and household outcomes from differing:

1. Types of farms (sheep vs. crop vs. sheep & crop).
2. Manure management and use practices.
3. Livestock feeding practices.

Note: The model aims to maintain 11 ewes and 2 rams. All lambs and growing ewes are fed some grain.

Fig 1. Outline of the Integrated Model.