How far can soil fertility in agro-pastoral villages of West Africa be sustained by biomass flows?

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1. Introduction

In the agro-pastoral areas of West Africa, traditional by-laws regulating the communal use of natural resources prescribe the grazing of crop residues by free-roaming resident or transhumant livestock during the dry season. New crop management practices based on recycling of crop residues as compost or their use as mulch in conservation agriculture (CA) are promoted by research and development programs in order to improve soil fertility (Corbeels at al., 2014; Tittonell et al., 2012). These practices can potentially improve crop yields for individual farmers but may lead to conflicts between private interests (i.e., soil fertility maintenance of farmers' personal fields) and communal agreements (i.e., feeding the village herd during the dry season) (Andrieu et al., 2015). Some authors have analyzed the specific trade-offs that can occur between livestock and crop production at farm level after the introduction of CA (Naudin et al., 2011). However, such trade-offs must also be analyzed at the village scale. Agent-based models were shown to be effective tools to capture interactions on resource use between farmers and their effects on the agricultural systems (Schreinemachers and Berger, 2011). We developed and used with farmers and pastoralists an Agent-based Model of Biomass flows in Agro-pastoral areas of West Africa (AMBAWA). The objective of this paper is to assess the effects of introducing the practice of CA on farm productivity in a village of central Burkina Faso using an agent-based model that simulates the flows of biomass and nutrients between crop and livestock systems at the field,

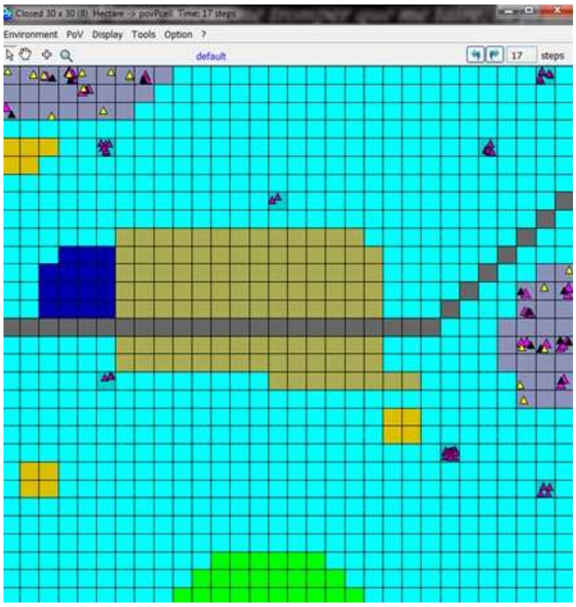


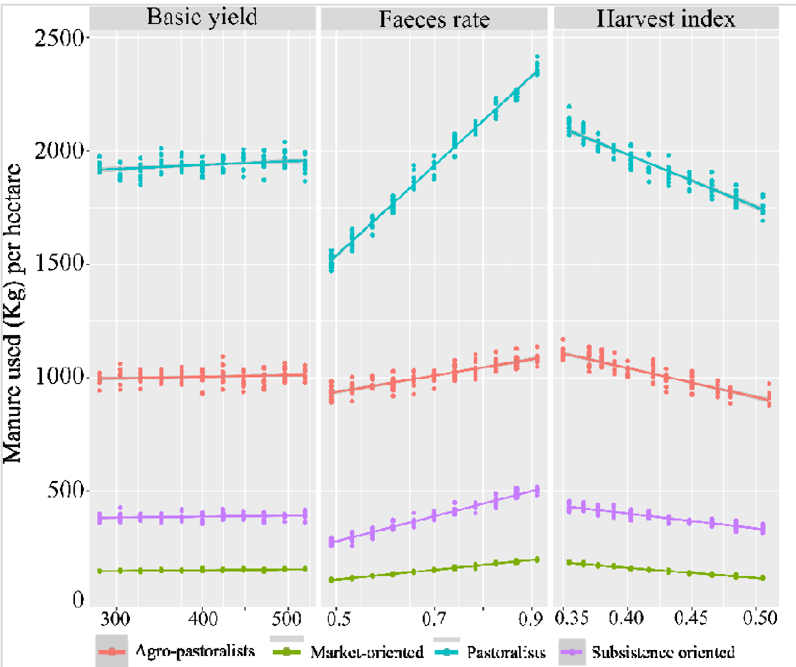
Figure 1: Livestock (triangles) during the rainy season on the grazing (gray) and fallow (7 pale blue) areas, cultivated land being in light blue, watercourses in dark blue, protected areas in green, road in brown, and buildings in yellow (Peul encampments) and pale brown (homes of sedentary villagers).

farm, and village scales.

2. Materials and methods

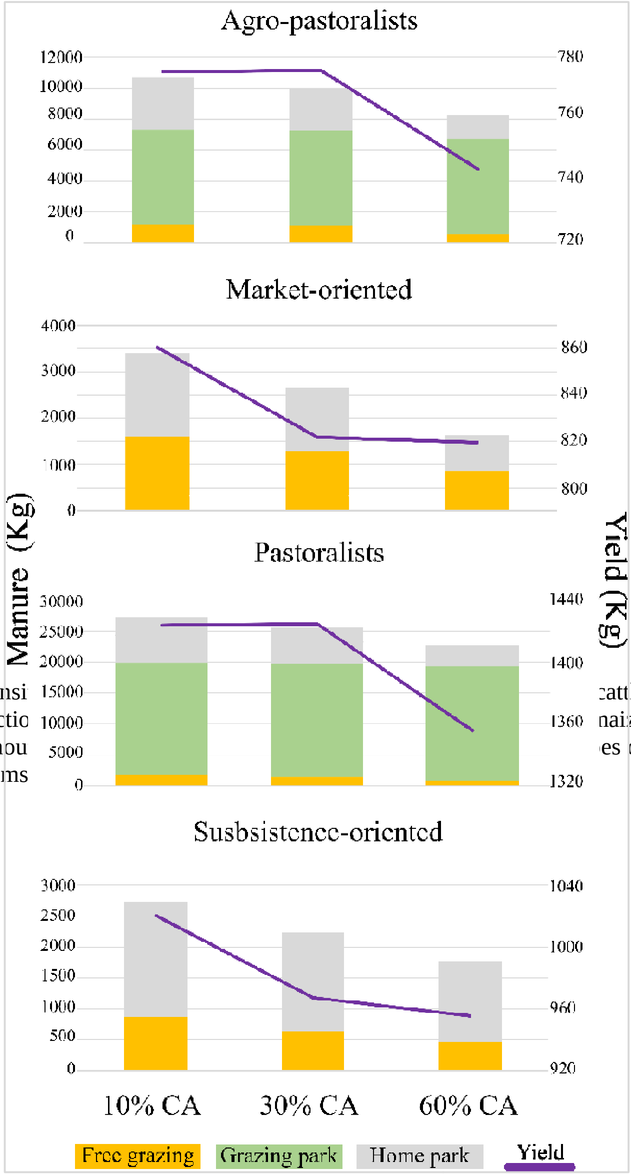
The study was carried out in Koumbia, a village situated in the cotton-growing region of Burkina Faso. During the rainy season (800–1200 mm of rain between May and October) crops are grown and cattle are assigned to the savannah rangelands. Draught oxen are kept on the respective farms and fed on the fallow fields. During the dry season, farmers harvest a certain amount of maize residues from the fields of their farm for use as fodder (based on observed practices). Cattle leave the rangeland areas and together with the draught oxen are during the day assigned to the cropped land for feeding on the remaining maize residues left in the fields (unharvested fraction), while at night they are corralled (manure production). When the residues are exhausted on the cropped land, the animals are fed on the fodder stocks of their own farm. Once these fodder stocks are consumed, the animals exit the simulation until the end of the dry season (transhumance). Based on empirical data on nutrient balances, a farm typology based on 53 household surveys (subsistence-oriented crop farmers (SO), agro-pastoralists (AP), market-oriented crop farmers (MO) and pastoralists (PA)), and simple equations of maize yields and fertility management, we translated these practices of biomass use in space and time into an agent-based model within the CORMAS (COmmon-pool Resources and Multi-Agent Simulations) platform (Bousquet et al., 1998) to simulate the impacts of residue collection for mulching (protected from livestock) at farm and village scale (Figure 1).

3 – **Results & Discussion**



First, a sensitivity analysis (Figure 2) reveals relatively low model sensitivity of manure production per hectare to basic (without nitrogen input) maize yield (default value, 400 kg per ha) and maize harvest index (default, 0.42). On the other hand, the effect of the partitioning of cattle faeces production between day and night (default, 30% at night and 70% during the day) on total manure production per hectare is high, specifically for PA farmers who owns the majority of cattle. Introduction of CA impacts the quantity of residue available for grazing during dry season, as areas with mulch are protected from livestock. Consequently, manure deposited on cropping land is reduced (Figure 3). For SO farmers who do not send cattle to grazing parks and for MO farmers who entrust their animals to PA farmers, this reduction affects significantly the total amount of manure available to fertilize their fields at the beginning of the next cropping season. This leads to a crop yield reduction, which to a certain extent is compensated by the yield increase due to mulching (10% in the model). Nonetheless, figure 3 underlines the yield decrease with higher amount of land under CA. Therefore, positive effect of mulch on soil fertility does not compensate the lack of manure deposition during free grazing nor the deficit in residue for feed due to cropland protection from cattle.

Figure 2: Sensi ... cattle faeces productio ... maize yield, i.e withou ... es of farming systems



4 – **Conclusions**

We showed that the introduction of CA practices has contrasting effects on available manure for crop yield enhancement depending on the type of farms and linked to the size of their herd. With CA, the amount of available maize residues for cattle feeding during the dry season decreases over time, so does the amount of animal manure available for soil amendment, affecting in a distinctive way productivity of the four farming system types considered.

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Figure 3: Source and quantity of manure used by four farm types to fertilize maize field, and corresponding maize yield, with 10, 30 and 60% of land cultivated under CA

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