Agroecology-based aggradation-conservation agriculture (ABACO): targeting resource-limited and degraded environments of semi-arid Africa

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Introduction

Poor soil fertility and soil physical degradation are major limitations to food security in sub-Saharan Africa, placing many smallholder farmers in a vulnerable position. Conservation Agriculture (CA) is increasingly promoted as an alternative to address soil degradation resulting from agricultural practices that deplete the organic matter and nutrient content of the soil, aiming at higher crop productivity with lower production costs (e.g. Kassam et al., 2009). In areas of climatic variability, CA may represent a low-investment strategy to increase water productivity and mitigate risks, by breaking the vicious cycle of low rainfall, poor yields, low investment, soil degradation and food insecurity. In spite of experimental evidence showing increased water productivity and crop yields under CA, its adoption by smallholder farmers in sub-Saharan Africa seems to be hampered by (Giller et al., 2009): (i) Concerns on initial yield decreases often observed (or perceived) with CA; (ii) Lack of sufficient biomass for effective mulching due to poor crop productivity or to competing uses for crop residues in crop-livestock systems; (iii) Increased labour requirements when herbicides are not used, and a gender shift towards female labour for weeding (since labour saved from ploughing is typically male labour); (iv) Lack of access to and use of external inputs such as mineral fertilisers and herbicides. A fundamental problem with the adoption of CA is its promotion as an indivisible package that farmers find hard to adopt in full, lacking the contribution of farmers to the design/selection of CA alternatives, overlooking the fact that the process through which innovation systems emerge are complex and non-linear (i.e., not as unidirectional research-extension-farmer flows).

The ABACO initiative

An EU-funded project on agro-ecology based aggradation-conservation agriculture (ABACO) emerged as a need for *action* identified during the implementation of the CA2Africa initiative (cf. Corbeels et al., this conference), which brought together a large number of partners working on CA in Africa, including those from international research centres, and the African Conservation Tillage (ACT) network. ABACO aims at establishing site-specific innovation systems that rely on agroecology principles and aggradative measures to restore soil productivity in semi-arid regions of West, East and Southern Africa. This will be done by fulfilling the following ***specific objectives***: (1) To **target** CA to smallholder African farmers by studying which principles of CA, and under which conditions, contribute to the effects sought in terms of food production and land rehabilitation in the face of climatic variability; (2) To involve farmers and research in co-**innovation** platforms to promote the adaptation/appropriation of technologies by local communities; (3) To assess the social and economic viability and **tradeoffs** of implementing CA at farm and village scales, and across scenarios, to inform policies; (4) To promote **dissemination** of targeted CA alternatives and approaches through divulgation, training and capacity development. Project activities in West, East and Southern Africa are organized around four themes: (I) Water productivity and climatic risks; (II) Soil fertility and land rehabilitation; (III) Agroecological functions and environmental services; and (IV) Livelihood, gender and policy analysis. These themes are addressed by four multi-disciplinary work packages: WP1, diagnosis design and testing; WP2, innovation support; WP3, model-aided feasibility and trade-offs evaluation through participatory, multi-scale scenarios; WP4, dissemination, impact and networking.

The various constraints that hamper widespread adoption of CA in Africa do not have the same origin, and they operate at different scales. If widespread adoption of CA is to be achieved, current technical knowledge and innovations should be targeted to meet the particular demands and constraints of smallholder African farmers. The promotion of CA benefits should be based on:

i. **Rehabilitation of degraded soils** to restore biomass productivity, in order to secure the various functions of CA that depend on above and belowground plant biomass;
ii. Increased **water productivity** and soil water buffering capacity to face risks associated with climate change, creating more conducive conditions for farmers' investments;
iii. Intensifying **agroecological functions** to capitalise on natural interactions, increase resource use efficiency and reduce dependence on external inputs;
iv. Embeding these principles in sustainable **innovation support systems** that recognise the complexity and non-linearity of agricultural innovation processes;
v. Institutionalization of **enabling policies and market conditions** so as to facilitate uptake and promotion of CA among smallholder farmers

The implementation of these five principles should be done while embracing the diversity of situations that characterise African agriculture.

Aggradation-conservation agriculture

The term ‘aggradation’ has been coined in physical geography to refer to the raise in grade or level of a river valley, a stream bed, etc. by depositing detritus, sediment, or the like. Here, we use this *analogy* to refer to the gradual rehabilitation of soils that underwent physicochemical degradation. ABACO’s approach of aggradation-conservation agriculture consists of implementing measures that have been traditionally promoted as “soil and water conservation”, “water harvesting” technologies in semi-arid environments or (indigenous) agroforestry, during an initial phase of soil restoration or ‘greening’. Initial investments aiming at increasing agroecosystem primary productivity are necessary, prior to the implementation of the classical CA principles. Particularly in dry environments, and under rainfed agriculture, the response of agroecosystem primary productivity to soil restorative measures may exhibit a faceted pattern (Figure 1). This pattern is characterised by an initial response to increased water availability (i.e., the ‘greening’ effect) with a slight loss in water productivity (or use efficiency), followed by a response to increased soil fertility once nutrients become available (resulting in greater water productivity).

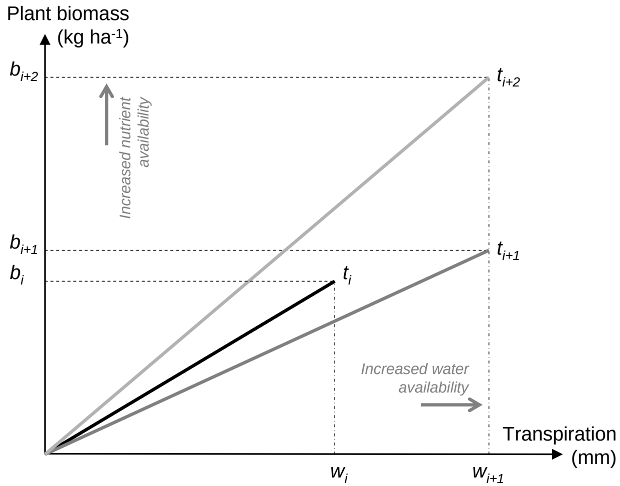

Figure 1: Scheme representing the faceted impact of aggradation-conservation agriculture on water productivity. Crops that used the available water w_i to produce an amount of biomass b_i under the baseline conditions (t_i) may exhibit a less than proportional increase in biomass (b_{i+1}) as a result of increased water availability (w_{i+1}). Once nutrients become available (t_{i+2}), water can be used more efficiently to produce greater amounts of biomass (b_{i+2}).

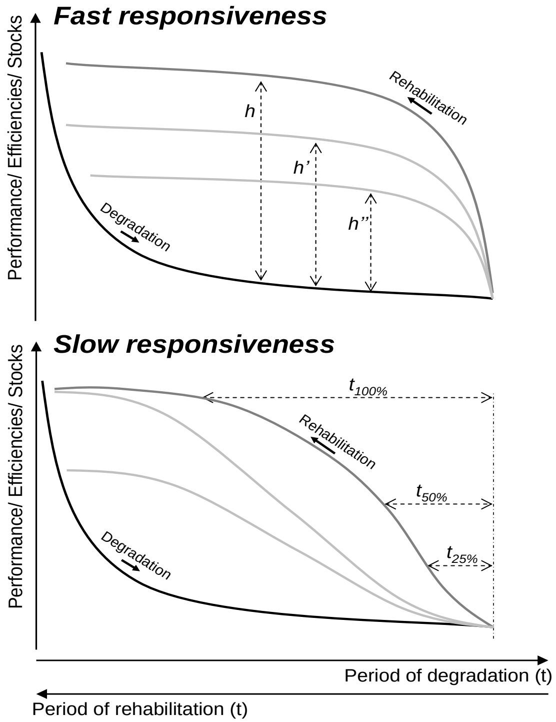

Figure 2: Theoretical schemes representing the concept of hysteresis (*h*) of land rehabilitation. After having undergone a degradation phase, the response of the agroecosystem to rehabilitation measures may be fast or slow, and exhibit weak or strong hysteresis (i.e., *h*, *h'* or *h''*). The periods $t_{25\%}$, $t_{50\%}$ and $t_{100\%}$ represent the delay necessary to achieve 25 to 100% of the original performance, efficiency or stock level. Measures to restore productivity may be hysteretic or not, and exhibit fast or slow responsiveness. Whether a response can be considered to be fast or slow, hysteretic or not depends on the indicator chosen to characterize the response (productivity, efficiencies, stocks), on the type of measure(s) implemented to restore productivity, on the biophysical properties of the agroecosystem under consideration, and on the behaviour of external drivers (e.g. rainfall).

Rehabilitating degraded soils, depending on the extent and type of the degradation process, may require sustained efforts for long periods of time, and responses to interventions may be weak. Slow and weak responses to soil restoration are a disincentive to smallholder farmers. The theoretical curves drawn in Figure 2 illustrate what some authors termed as 'hysteresis' (*h*) of land rehabilitation, represented by the deviation between the trajectories of soil degradation and rehabilitation (purposely plotted towards the opposite direction). The various technologies and measures that may fall under the general umbrella of CA should be strategically targeted according to the phase in which the system is, either in degradation, rehabilitation or stabilization. Situations (fields) that allow hysteretic, fast responsiveness are typically those that farmers prioritize for the allocation of their scarce resources (labour included), as the perceived returns to their efforts are more attractive and less risky (e.g., Tittonell et al., 2007). On the other extreme, severely degraded fields that exhibit weak hysteresis and slow responsiveness are often considered to be non-resilient, and may require profound reconversion of land use rather than investments to increase productivity under the current land use. The intermediate situations between these two extremes are those that must be the target of agroecology based aggradation-conservation agriculture.

Discussion

The presentation will offer an overview of the experience already gathered in the various project sites in West, East and Southern Africa, will discuss the major concepts underlying the five ABACO principles (Soil rehabilitation; Water productivity; Agroecological intensification; Innovation platforms; Policy and market support), and the major challenges for the promotion and widespread adoption of CA in the resource poor, degraded and climatically variable environments of semi-arid Africa.

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