INNOVATION BRIEF 08

Conservation agriculture for upland rice

Low-input upland rice-based cropping systems with conservation agriculture

Introduction

Upland rice is an important production system in West Africa. For example, In Côte d'Ivoire, upland rice accounts for 72% of the total rice area.

One of the major constraints to upland rice production is water stress and poor soil fertility. Climate change models predict an increase in rainfall variability in the future, with more frequent extreme events and greater risks causing a negative impact on upland rice produced by smallholders in West Africa.

Conservation agriculture (CA) in upland rice-based cropping systems can be effective in mitigating yield loss in environments where there is increased weather risk.

Benefits of conservation agriculture systems

CA systems have three main pillars: minimum soil disturbance, permanent soil cover and crop rotation/association. CA systems allow soil regeneration, which relies on cover crops grown in rotation or in association with the main crop to produce high biomass. This biomass covers soils and provides several services, including restoration of soil structure and biological activity, and an increase in organic matter content and water holding capacity. Main crops and cover crops are planted directly in the soil cover, which is retained permanently to protect the soil. Soil tillage is avoided as it is harmful to biological activity and soil structure in the long run. Improved soil structure and biological activity, and increased water holding capacity result in better plant nutrition and plant health and, as a consequence, enhance yield and yield stability. Thick mulch and allelopathic effects by cover crops can reduce labor inputs for weed control.

The cultivation of main crops, such as rice or maize, in association with legumes has considerable advantages because legumes enrich the soil through high biomass production and nitrogen fixation. Perennial legumes can continue to grow during the long dry season and thus produce a high biomass. They cover the soil while preventing weeds from growing, and they improve the soil structure while promoting the decomposition of organic matter. These perennial leguminous plants also help to enrich the soil organically, maintain soil moisture and protect the soil from water and wind erosion. Rotation and diversification of crops on the plots also contribute to reduction of several diseases.

Several cropping systems have been tested and evaluated since 2015 in rotations at the Africa Rice Center (AfricaRice) research station at M'bé, Côte d'Ivoire. Located in the Bouaké region, this site is exposed to climatic constraints, with irregular rainfall and poor soils exposing the crops to water deficits. This research identified four promising CA cropping systems.

Characterization of four CA systems

Conservation agriculture system 1 (maize + cassava + stylo // cassava + stylo // rice + stylo)[1]

In the first year, maize, cassava and *Stylosanthes guianensis* (stylo) are planted. Stylo is planted one month after maize and cassava. Cassava and stylo are grown until the second year and third year, respectively. In the third year, after stylo has been slashed and mulched, rice is planted in March (1a in Fig. 1, despite a higher climatic risk, it allows an early harvest, when the rice price is higher on the market) or June (1b in Fig. 1, lower climatic risk, but lower market price). It should be noted that slashing and mulching can be managed simply by cutting and rolling the biomass, but this requires a lot of work. Other approaches are use of a knife roller and/or herbicide, which require less labor but can be costly. Stylo naturally regrows after slashing, but it can also be re-planted locally where its density is too low to ensure full soil coverage. In this system, cassava and stylo are expected to provide substantial biomass for improving soil structure and providing nitrogen. In addition, cassava provides good economic returns, and higher rice yield is also expected due to soil regeneration.

Furthermore, it is possible to grow stylo for longer (e.g. in year 3, stylo will be continuously grown and rice will be planted in year 4). This may be appropriate when cultivation is not possible due to external constraints (e.g. labor shortage). This is done in systems 2 and 3.

Rice + stylo (CA system 1 in third year, CA system 2 in second year, or CA system 3 in third year)

Conservation agriculture system 2 (maize + stylo [in March] // rice + stylo [in June])

This crop rotation system involves covering soils to prevent water and wind erosion, and improving the structure of the soil through the contribution of organic matter provided by the biomass of maize and stylo that is planted in the first season. Maize is planted in March in the first year, and stylo is planted one month later. In the second year and third year, rice and maize can be planted in June to allow a sufficient time period for stylo to produce enough biomass to promote rapid soil regeneration.

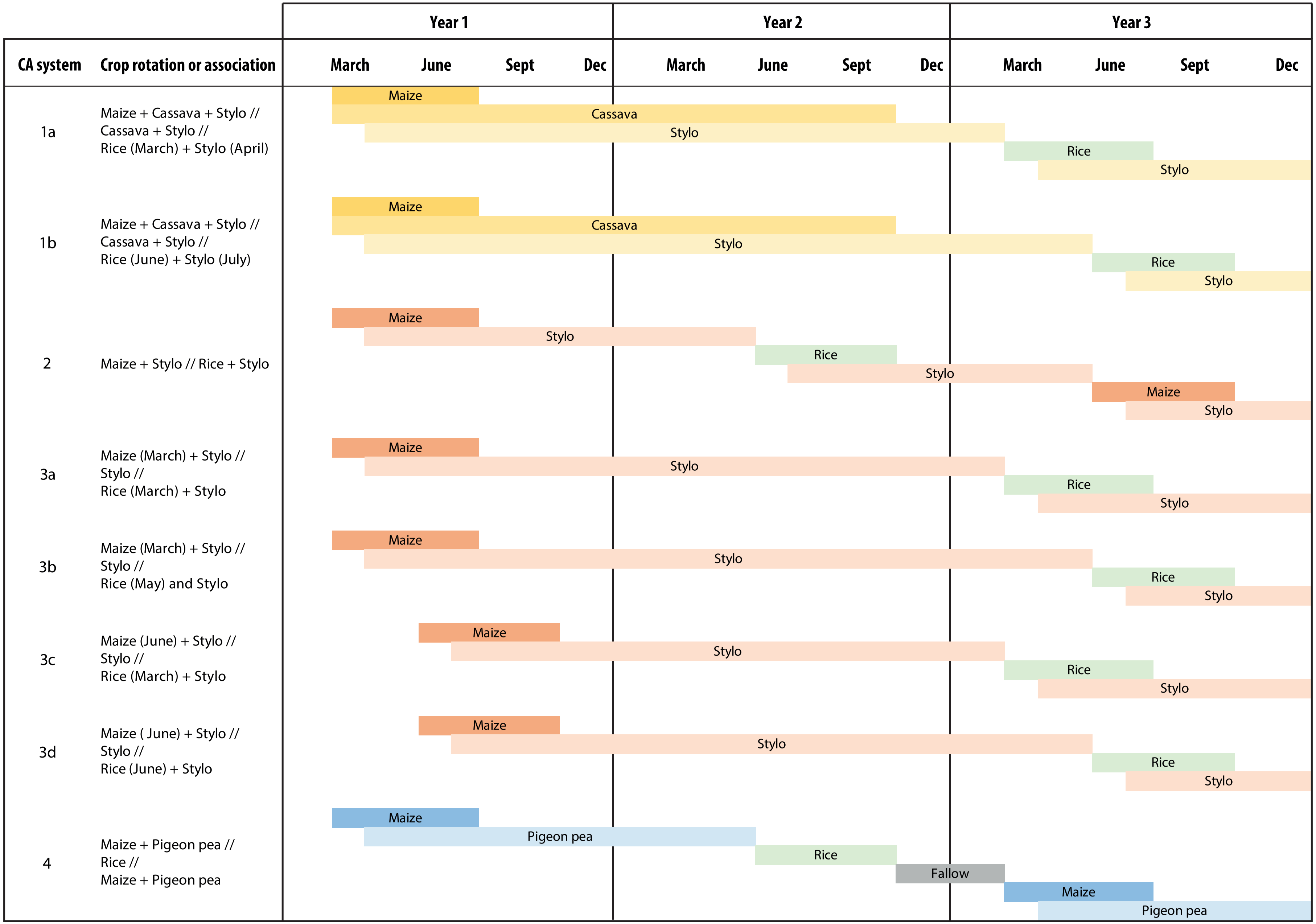
Cassava + stylo (CA system 1 in second year)

Conservation agriculture system 3 (maize + stylo // stylo // rice + stylo)

This crop rotation system keeps stylo for more than one year as improved fallow, allowing high biomass production and thus rapid improvement of soil fertility. The timing of planting maize and rice in the first and third years, respectively, is flexible in this system. They can be planted in March (higher climatic risk but also higher market price) or June (lower climatic risk, but lower market price).

1 '+' represents plant intercropping;
'//' represents the following year's rotation crop.

Figure 1. Cropping calendars for the four conservation agriculture systems



Conservation agriculture system 4 (maize + pigeon pea // rice // maize + pigeon pea)

A major advantage of this system is that unlike the systems growing stylo, it does not require specific equipment or herbicide to control *Cajanus cajan* (pigeon pea) before planting rice the following season, and the pigeon pea grains provide an extra income or a source of protein. Pigeon pea can also control a commonly observed weed, *Cyperus* spp. Maize should be planted in March (with a higher climatic risk than in June) and pigeon pea one month later to give sufficient time for pigeon pea to produce grains but to avoid competition with maize.

Challenges

The main challenge to the introduction of these systems is that all of them require seeds of the cover crops (stylo and pigeon pea), which can be a constraint in the first year. However, once they are planted, the seeds can be easily produced and harvested.

Our proposed systems and their cropping calendar are adapted to local climate conditions in Côte d'Ivoire. These conditions will vary from one region to another. Thus, local fine-tuning is essential for effective dissemination.

During the first few years after the introduction of CA systems, farmers might not be able to see clear benefits as the transition from conventional systems to CA systems takes some years. After a few years, benefits become clear, especially during dry years. For dissemination of CA systems, together with training programs for introduction of CA systems and their principles, long-term experimental plots should be established for field visits by farmers, extension officers and development agencies. This requires substantial efforts and resources, but the impact would be much higher than without such experiments.

Maize + stylo + cassava (CA system 1 in first year)

Maize + pigeon pea (CA system 4)

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