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SIMLESA
Sustainable Intensification of Maize and Legume Systems for Food Security in Eastern and Southern Africa

RAB RWANDA

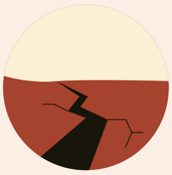
Australian Government
Australian Centre for International Agricultural Research

COUNTRY POLICY BRIEF ENHANCING AGRICULTURAL RESILIENCE AND SUSTAINABILITY IN RWANDA

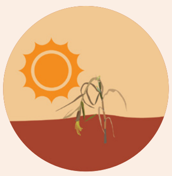
Agroecological solutions: Integrating conservation agriculture and agroforestry to boost Rwanda's Crop Intensification Program

Summary and key facts

Despite substantial investment, Rwanda's Crop Intensification Program (CIP) will not close the yield gap for priority food crops as fast as expected putting national food security at risk.



In many parts of the country, the production environment is showing severe signs of degradation in terms of increased erosion, water siltation, and soil fertility decline.

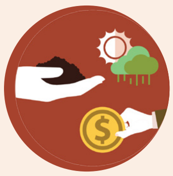


Climate change and more frequent dry spells are causing crop failure on subsistence farms.

An agroecological approach needs to be institutionalized in the CIP if Rwanda's farmers are to overcome increasing challenges and ensure household food security.

The agroecological approach uses site-specific Conservation Agriculture-based Sustainable Intensification practices, which are environmentally friendly and results in a substantial yield gain over current national yield averages for maize and beans.

The CIP needs to integrate agroforestry, including hedgerows along contour lines as a permanent source of mulching materials for conservation agriculture and site-specific nutrient supply.



Actions must be based on a clear understanding of the biophysical environment (soil and climate) and socio-economic context (farmers' purchasing power and their capacity to invest in transforming their productive environment).

What is the problem?

A lack of organic soil matter is holding back crop yield improvement

Rwanda invests substaintly 10 million USD every year to enhance crop productivity through the Rwanda Crop Intensification Program (CIP). This dedication to enhance productivity has been enforced since the elaboration of the Economic Development Poverty Reduction Strategy (EDPRS I & II) (2007-2012; 2012-2018), by the Government of Rwanda and is in line with the Abuja declaration of 2006.

The CIP has led to significant improvements in crop yields (e.g. maize, bean, rice, potato) in specific sites of many agroecological zones of Rwanda (MINAGRI, 2014). However, at national level, the yield gap for most priority commodities remains large; estimated at 3.2 - 7.7t ha-1 (72.7 - 87.5% of potential yield) for maize and 1.9 - 4.5t ha-1 (53.7 - 83.3% of potential yield) for common beans (Nduwumuremyi, et al., 2018).

The CIP has promoted intensive use of fertilizers, pesticides and improved seeds. It is now noted that Sustainable Intensification (SI) of Rwanda's rain-fed (80%) and labor-intensive (deep tillage twice a year) agriculture requires an agroecological approach to increase the availability of soil organic matter. An agroecological approach will build organic matter providing water and plant nutrient use efficiency and liming materials for raising soil pH to a minimum of 5.5 and supply calcium and magnesium to the acidic and basic cation depleted soils of Rwanda (Steiner, 1998; Rutunga and Neel, 2006; Rushemuka et al, 2014a, b). Indeed, close to half of Rwanda's arable land in the middle and high altitude regions (1600-2500 m) is composed with acidic soils (pH < 5.5) with low Cation Exchange Capacity (CEC) due to the prevalent kaolinite clay and low content of soil organic carbon (1% TOC on average). In this acidic region, food insecurity and crop yield gap are mainly related to soil acidity, soil nutrient depletion, low content of soil in organic matter and erosion. Effort towards the adoption of Conservation Agriculture-based Sustainable Intensification (CASI) practices is refrained by the lack of attention paid to agroecological solutions by policymakers and the low capacity of farmers to invest in these sustainable intensifying technologies.

Half of all soils in the low altitude (900-1600 m), eastern part of Rwanda, are characterized with scarce rainfall and relatively high temperature. In this region, food insecurity and yield gap are related to frequent crop failure related to dry spells. The sensitivity of crops to water shortage is exacerbated by low content of soils in organic matter. Climate change and variability creates disincentives for farmers to adopt the CIP proposed crop priority such as maize as it experiences frequent crop failure. The adoption of agroecological-sensitive technologies is also refrained by a key emphasis on intensive use of inputs with little understanding of the production environment, seasonal growing variations and a lack of agroecological solution development by policymakers.

In the CIP (MINAGRI, 2007), manure and lime were not given sufficient attention resulting in low adoption of the promoted technology package in the acidic soils (mainly in the south and west) and in the low altitude and semi-humid region (in the east). Since 2015, lime has been taken into consideration in the acidic region. Farmers in all regions know the importance of manure for crop productivity. Thus, the problem is obtaining enough manure for the household farm. The CIP has rectified the situation by including manure as a component of its technology package. The big gap is still the production of organic matter as the farm manure is no longer sufficient and crop residues are, as a priority used for feeding livestock. The lack of permanent source of organic matter constitutes a serious threat to sustainable agriculture intensification.

The objective of this policy brief is to communicate lessons learned from the Sustainable Intensification of Maize-Legumes in Eastern and Southern Africa (SIMLESA) project that introduced Conservation Agriculture-based Sustainable Intensification (CASI) in Rwanda. The lessons advocate the integration of an agroecological component to the CIP.

What solutions were identified from research?

In 2012, the SIMLESA project, coordinated by the International Maize and Wheat Improvement Center (CIMMYT) in cooperation with the Rwandan government, introduced Conservation Agriculture (CA) on-farm trials in three different agro-ecological zones to evaluate and promote sustainable intensification. The experimental design was a split plot comparing Conservation Agriculture (CA) against conventional Tillage Agriculture (TA) as the main factor and measuring different levels of inputs as treatments as the secondary factor. SIMLESA activities were implemented in three sites located in three Agro-Ecological Zones (AEZ) summarized in the table 1.

Table 1 SIMLESA intervention sites and their characteristics

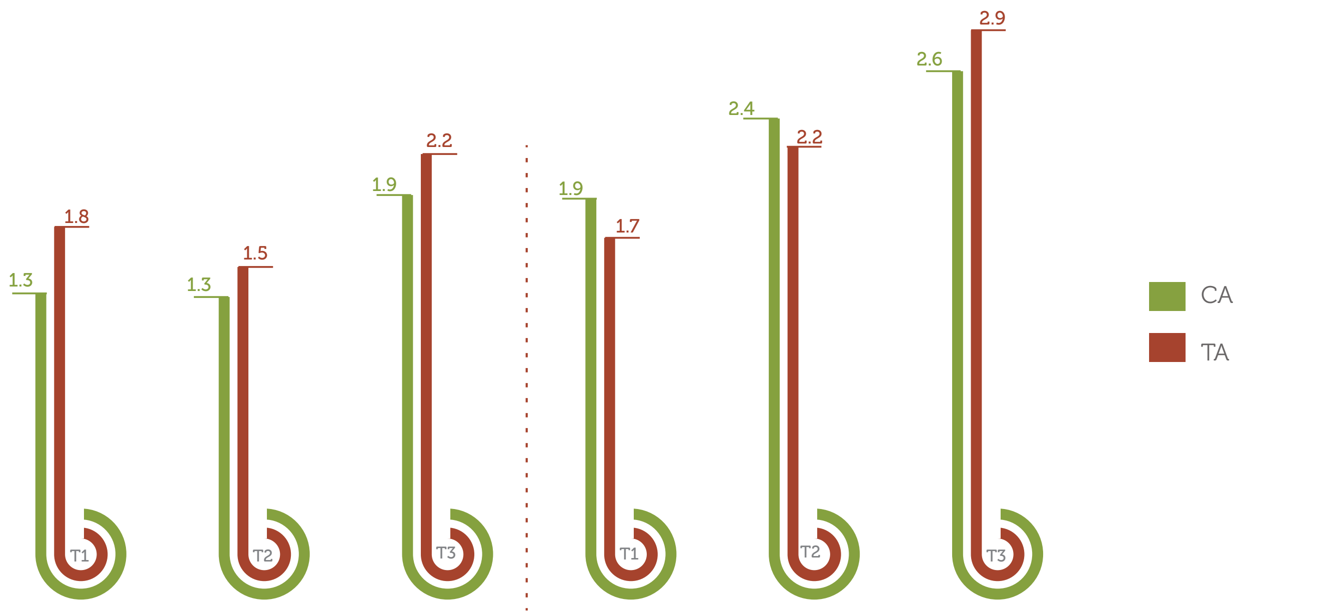
Site	Agro Ecological Zone	District	Altitude (m)	Rainfall mm/ year	Topography	Fertility status
Gashora	Semi-arid lands of Bugesera	Bugesera	1000-1400	900	Flat	Very good
Runda	Central Plateau	Kamonyi	1400-1800	1200	Hilly	good
Cyuve	Volcanic lands of Birunga	Musanze	>2000	>2000	Flat	Excellent

The results of CA compared to TA varied depending on location and growing season conditions.

For instance, in Kamonyi the first season was superior to the second for both maize (figure 1) and bean (figure 2). The level of inputs also contributed significantly. On all experimentation plots over the two seasons, T3 outperformed T2 and T2 outperformed T1 (Figure 1, 2, 3, 4,5,6). During the 2017A season, TA was statistically higher than CA across all treatments. However, there was no observable difference between CA and TA in the following season. The superiority of TA over CA in the first season could be a result of inefficient implementation of CA technologies and the fact that the soil remained poor in soil organic matter and nitrogen.

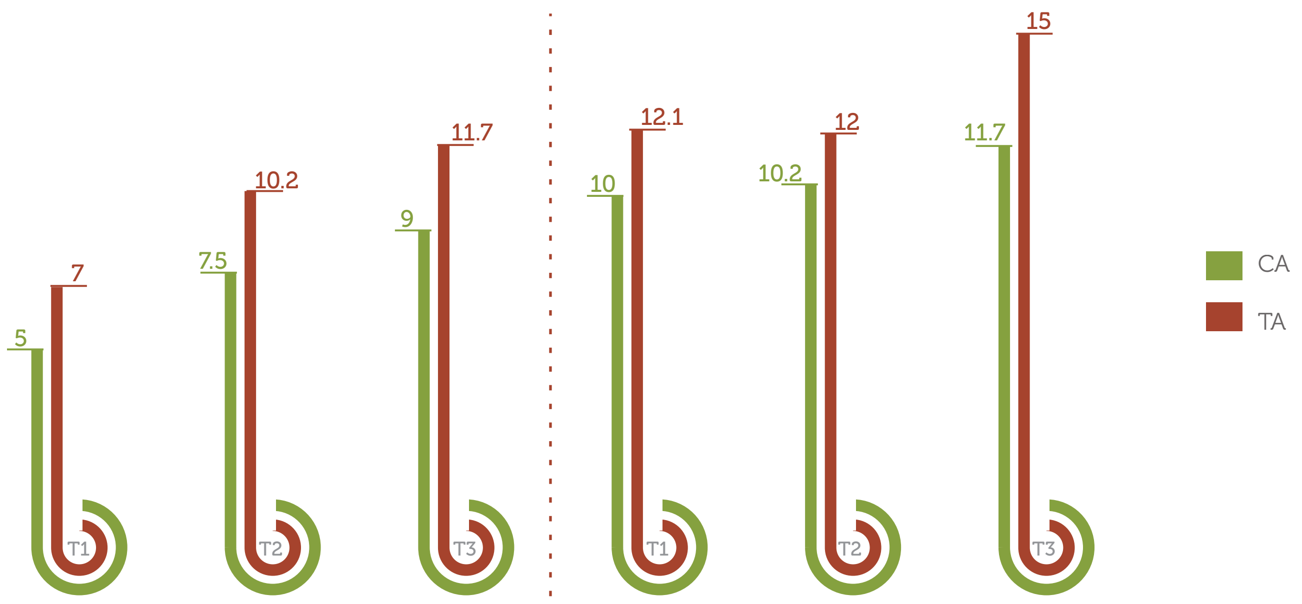
During the second growing season, the difference between TA and CA was reduced. More appropriate application of the techniques by farmers and some improvement of soil properties under CA could explain the reduced performance margin in comparison to the previous season. The difference between CA and the varied treatments were not significant where manure had the same effect irrespective of the additional amendments (manure combined with fertilizers and manure combined with fertilizers and bio-fertilizers). An apparent significant difference was observed in T3 of 2017B where yields under TA were significantly higher than those under CA.

Figure 1. Maize yield (cobs and grains) in Kamonyi with: T1=manure only; T2= manure + fertilizers; T3= Manure + fertilizers + bio-fertilizers.



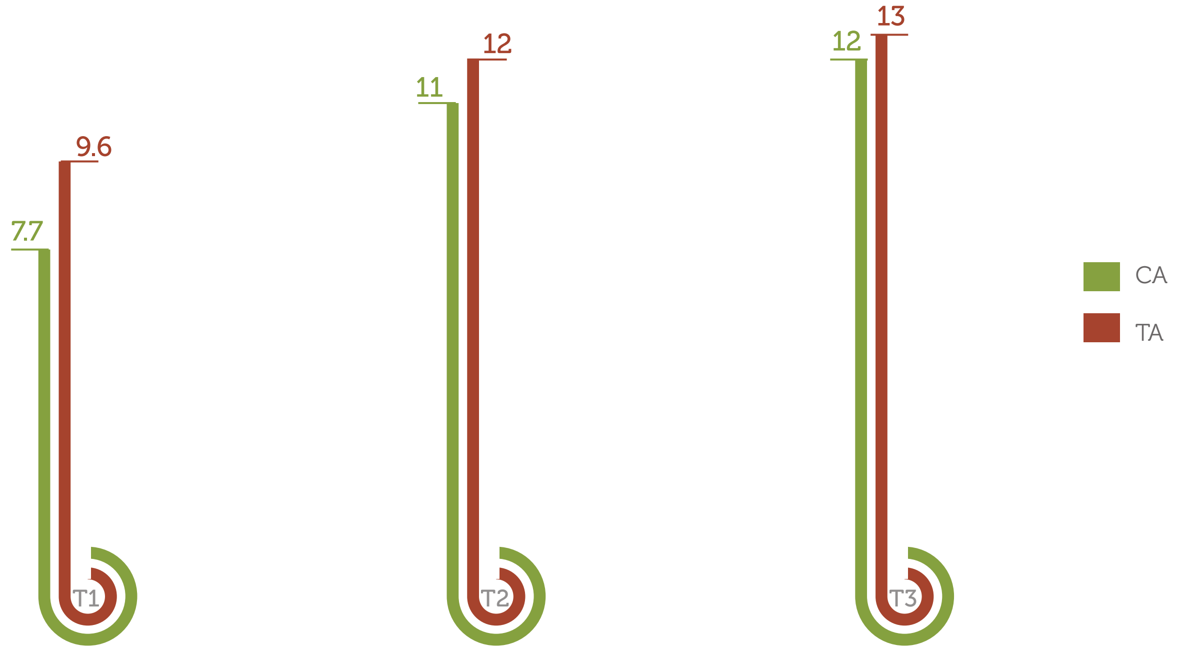
It can be seen from figure 2 that in general, there was no significant difference between CA and TA. The beneficial effect of CA over TA become apparent in the second growing season. This was due to the residual effect from mulching in the previous season and because farmers had practised the CA techniques (e.g. mulching and timely weed control) with more rigor than in the first season.

Figure 2 Bean yield (grain) in Kamonyi with: T1=manure only; T2= manure + fertilizers; T3= Manure + fertilizers + bio-fertilizers.



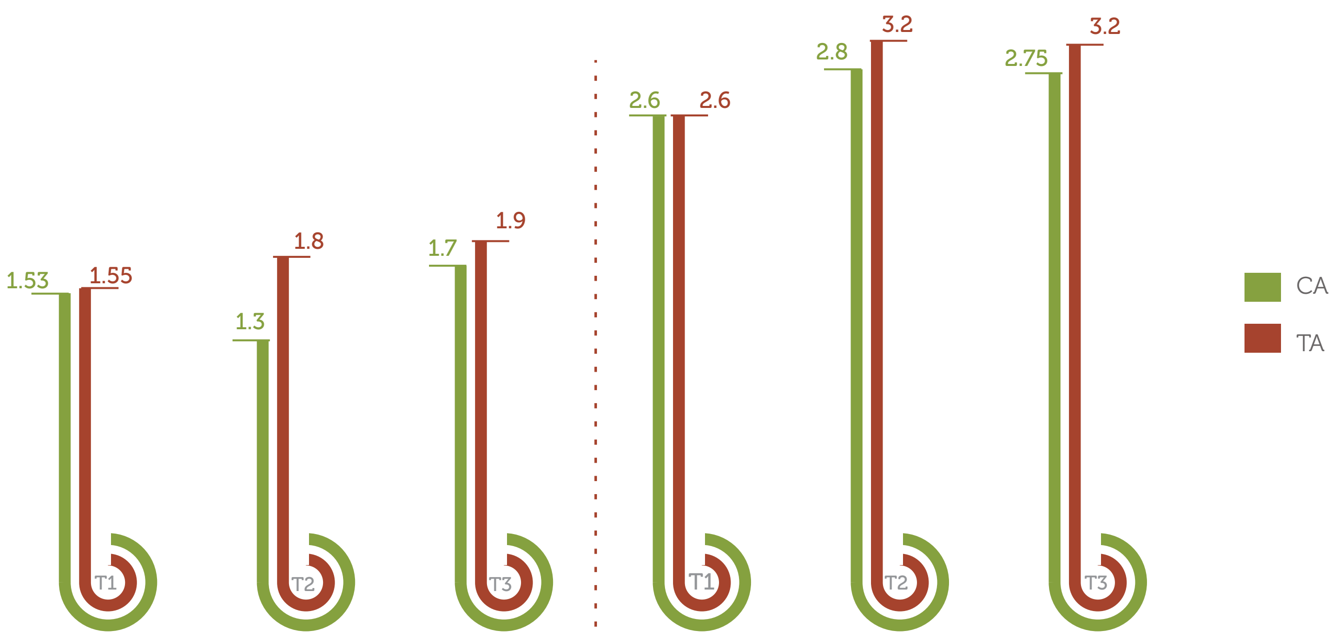
In Bugesera, the difference between growing season conditions had a dramatic effect. The 2017A season was dry and caused a total crop failure. However, due to improved conditions crop yields were obtained for 2017B. Results show that there was no significant difference between CA and TA (figure 3). A significant difference was observed between T1 and the rest of treatments (T2 and T3) for maize (figure 3). Hence, the idea of including soil fertility management as a fourth principle of CA (Bernard et al. 2014). The significant improvement in yields with fertilizers application was explained by the depleted soils on the Bugesera site, which required amendments for maize production. However, the effect of bio-fertilizer was not statistically significant.

Figure 3 Maize yield (cobs and grains) in Bugesera with: T1=manure only; T2= manure + fertilizers; T3= Manure + fertilizers + bio-fertilizers.



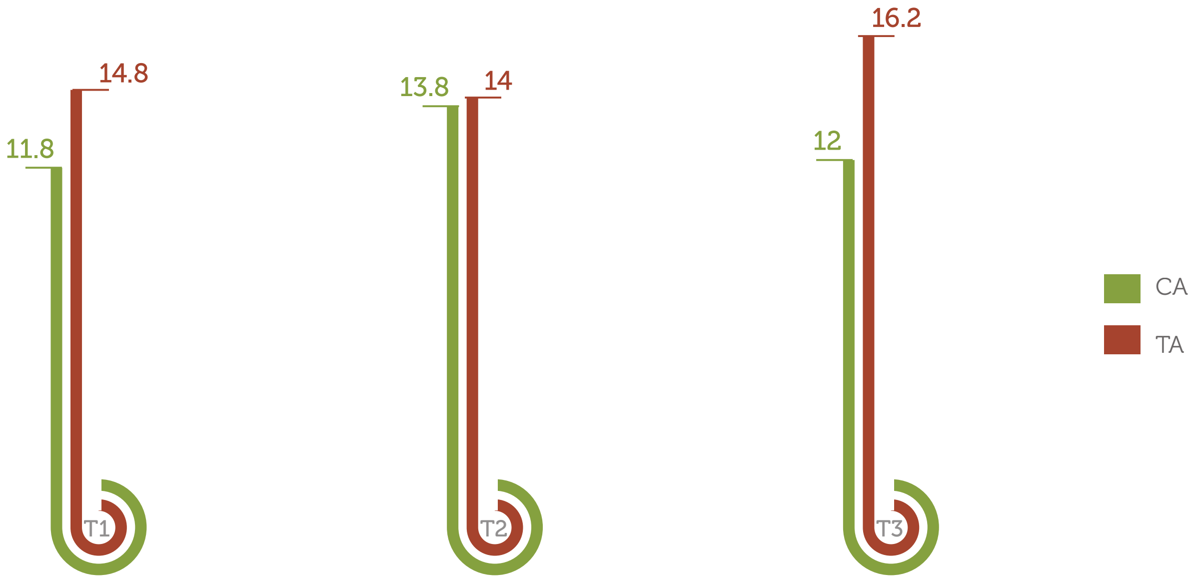
The effect of season conditions was also significant in the bean trials however with less impact (figure 4). The figures show that for bean crops, there is neither a significant difference between CA and TA nor between treatments. Bean production might have been less sensitive to inputs than maize because the crop is less nutrient demanding (Roose and Ndayizigiye, 1997) and the soils in Bugesera were more fertile compared to Runda (Biasa et al., 1990).

Figure 4. Bean yield (grain) in Bugesera. with: T1=manure only; T2= manure + fertilizers; T3= Manure + fertilizers + bio-fertilizers.



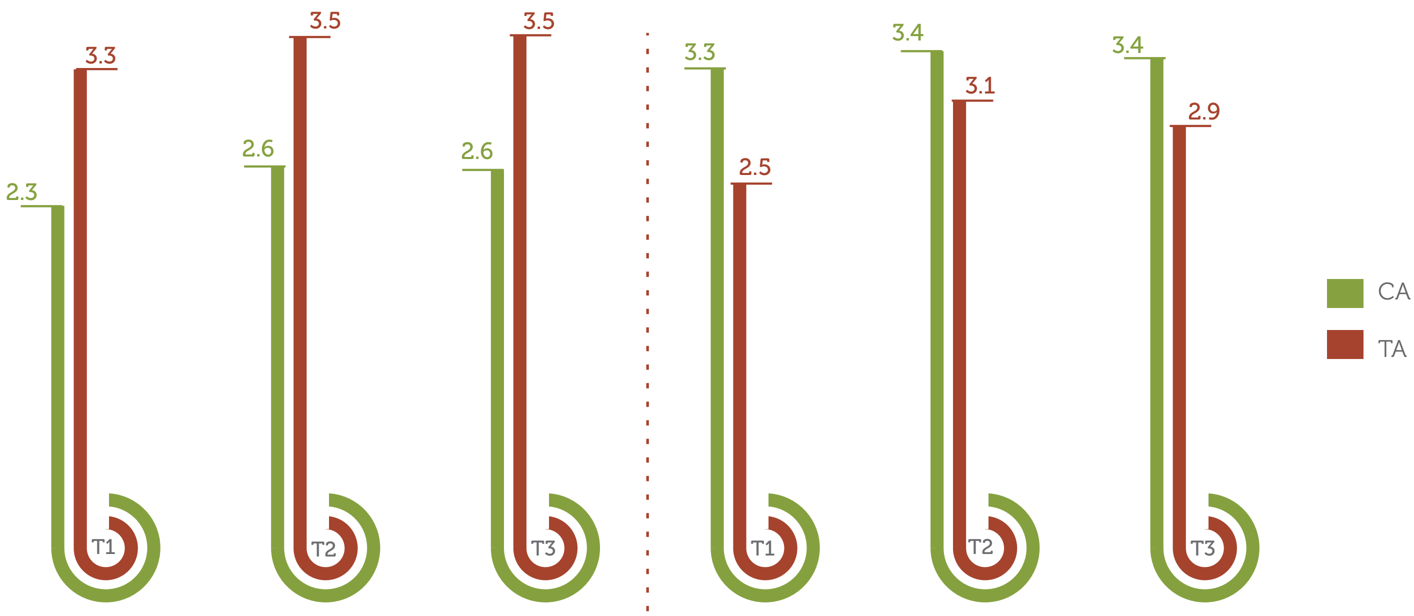
In Musanze, it was observed that the effect of season conditions, CA versus TA and level of inputs were not significant (figure 5). Good rainfall and the rich volcanic soils may have provided adequate water and nutrients to support maize production.

Figure 5 Maize yield (cobs and grains) in Cyuve with: T1=manure only; T2= manure + fertilizers; T3= Manure + fertilizers + bio-fertilizers.



There was a significant difference between CA and TA in 2016B (figure 6) where bean yields were higher under TA compared to CA. One possible explanation is that farmers were not yet used to practicing CA techniques; mainly mulching and weeding and therefore there was no significant difference between treatments. This was expected since the region's soil was rich enough to provide adequate nutrients to the crop. This is consistent with Rushemuka et al. (2014a) who found that fertile soils (pH > 6.0) can produce a good yield with manure and without any fertilizer in Rwanda. The best result for this season was TA with manure only. Interestingly, the outcomes were reversed in 2017B (figure 6), where the best result was CA with manure only. Yields were consistently higher under CA compared to TA across all treatments, and the difference was significant on the plot with manure. This was consistent with previous studies that found CA benefits improve overtime as soil properties increase (Rodriguez et al., 2017). In TA on the other hand, yields are expected to decrease as the soil is exposed to excessive and degrading tillage. However, the field trials show that the benefits of manure can be minor when CA is practiced where soil organic carbon content is good to secure optimum crop production. This is consistent with Rushemuka et al (2014b) who indicated that in Rwanda 2% of soil organic carbon is enough for optimum crop production, when other factors are provided.

Figure 6. Bean yield (grain) in Musanze. with: T1=manure only; T2= manure + fertilizers; T3= Manure + fertilizers + bio-fertilizers.



What are the opportunities for policy action?

Promote the creation and growth of a strong soil information system.

As crop yields vary with input application levels and environmental conditions in AEZs there is need to record soil property levels and determine technology recommendation zones. This will require policies to encourage a functional Soil Information System (SIS).

Monitor seasonal growing conditions to better advise farmers.

Crop yields vary according to growing season conditions in all AEZ, thus it is important to take climatic/rainfall records each season over a long period to account for the effect of growing season variations on crop yields and to advise farmers on best adaptation mechanisms. For the moment this is not undertaken by MINAGRI nor the RAB. This will require investment in a functional agro-meteorological system.

Promote farmer training in CA techniques for sustainable intensification.

The fact that crop yields increase with proper application of CA technologies means smallholder farmers' need capacity building in best practices. This requires developing CASI manuals and training of extension staff.

Promote policies to encourage agroforestry to boost CA adoption.

A key barrier to CA adoption is the lack of a permanent source of mulching materials (Rodriguez et al., 2017). The integration of agroforestry (e.g. hedgerows along contour lines as a permanent source of mulching materials) and CA would generate organic matter for efficient use of fertilizers and water for sustainable intensification.

Why act now?

Agroecological solutions in terms of increased soil organic matter are required to meet the CIP goal to close the yield gap of staple crops. Agroforestry and CA integration is a potential solution for sustainable intensification in Rwanda. If this is not done, the soil is likely to continue the degradation process leading to increased soil erosion, inefficient use of fertilizers water siltation and pollution and finally to decreased crop productivity, increased poverty and malnutrition.

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Acknowledgements

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