



Knowledge assessment and sharing on sustainable agriculture

Main results, gaps in knowledge and challenges in the Latin American platform

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THE LATIN AMERICAN PLATFORM



Latin American agroecosystems

KASSA considered a variety of agroecosystems across tropical, subtropical and temperate locations in Latin America.

In the lowlands of Bolivia (humid tropics) annual rainfall may exceed 1500 mm. Wheat-soybean rotations (and numerous other rotations involving soybean, wheat, rice, maize, sugar cane, cotton, sunflower and sesame) may be found.

Crop and livestock systems are prevailing in the tropical "Cerrados" of Brazil (central plateau, 10 to 20°S latitude, with rainfall of 1200 - 2000 mm per year received over an 8-10 month period). Here, the previous soybean monocropping system is giving way to a rotation of a commercial crop (soybean, maize or rice) followed by cereals (maize, millet, sorghum). A new "Santa Fé" cropping system, which associates a maize crop and a *Brachiaria* pasture, has been developed in a crop x livestock integration offering the possibility of rehabilitating degraded pastures.

In the irrigated horticultural systems located in tropical eastern Brazil, the major crops are tomato, bell pepper, lettuce, and broccoli.

Multiple-cropping agroecosystems are located in southern Brazil (subtropical) and central Argentina (temperate) where abundant and evenly-distributed rainfall makes it possible to grow two - and at times even three - crops per year. Principal crops include soybean, maize, wheat, common beans, tobacco and oats. This region is the very heart of the conservation agriculture revolution in Latin America. Until a few decades ago, much of this region was devoted to coffee and extensive pasture for livestock. In the 1960s government policies in Brazil began to promote a shift to crop-based systems. Farmers responded by taking up the crops being promoted - especially soybean. Soon, however, a crisis emerged in the form of a disquieting increase in soil erosion and land degradation. The causes of this crisis were fairly obvious - a deadly combination of farmers' tillage practices, hilly and rolling land forms, the erodibility of local soils, and high levels of rainfall. Conservation agriculture emerged as a response to this crisis. In more recent times, environmental contamination (nitrate, pesticides) has become a source of concern.

Most social and economic issues in southern Brazil focus on equity. There is a great diversity among farmers in regard to farm size, ethnic background, and the source of farm power (mechanical or animal traction). It is felt important that all farm families should have access to conservation agriculture practices, regardless of farm size or ethnic origin.

Conservation Agriculture in the Latin American agroecosystems

There has been substantial adoption of one conservation agriculture practice - no-till - in the lowland humid tropics of Bolivia. This practice is principally used for annual crops; slightly more than half of the 1.6 million ha of cultivated area in Santa Cruz Department is sown using no-till. In most of this no-till area, however, there is little or no complementary use of cover crops neither new crop rotations driven by the principles of conservation agriculture. Adoption rates are higher for larger farmers, though many small farmers have also come to use no-till. No-till implements are either purchased from Brazil or manufactured locally.

In Brazilian Cerrados, data from available publications suggest that adoption of conservation agriculture reached 4 million ha as early as 1997-98. These new systems have been implemented with two or three annual crops in succession - last crop as nutrient pump - under continuous direct seeding, and including conservation of residues.

In rainfed subtropical systems in southern Brazil and temperate central Argentina, no-till covers huge areas. It is indispensable for maintaining soil cover that is seen as essential for erosion control, and is widely used by farmer. Rotations are designed according to market opportunities and economic aspects.

Table 1. Estimates of conservation agriculture adoption rates (% of farmers) in Latin American countries according to the main agro-ecological regions and socio-economic categories of farmers.

		Argentina	Bolivia	Brazil
Tropical	Small-scale	-	40	5
	Large-scale	-	80	40
Subtropical	Small-scale	0	-	50
	Large-scale	55	-	80
Temperate/Central humid	Large-scale	70	-	-
Temperate/Subhumid	Large-scale	50	-	-

Researches undertaken

The main feature of the Latin American platform is that farmers or farmer organisations were responsible for the development and the dissemination of conservation agriculture practices, supported by research. Other entities - the private sector, NGOs, international and national public sector research institutions, universities and others - gradually joined and participated in the innovation system. Research efficiency improves when close cooperation is achieved between research institutions and all other partners, in the context of a broader innovation system, using multidisciplinary approaches and systems thinking. The emergence of farmers groups and networks supported by private and institutional technical assistance, research institutions and the private sector led to innovation networks aiming at the exchange of experiences and up scaling of conservation agriculture in the subtropical and tropical areas.

In **Argentina**, there were some special research programs oriented to promote no-till principles among small-scale farmers, but the largest experience had been developed within large-scale/market-oriented mechanised agriculture.

In **Bolivia**, research on conservation agriculture technologies began in the 1980s. Research and development activity has emphasized participatory approach to develop workable no-till practices.

A good deal of innovative research has been conducted on conservation agriculture practices in **Brazil** where experiments with the no-tillage systems at farmer level were established as an initiative of farmers, supported by research. Research activities in public institutions such as IAPAR and EMBRAPA were also established with some financial support of the private sector.

Main Results

Multiple-cropping in high rainfall environments in southern Brazil and central Argentina

The introduction of conservation agriculture has reduced erosion and production costs, increased yields, and fostered more diverse systems. Without conservation agriculture, multiple-cropping of annual crops would have been impossible as higher net benefits per ha. Abundant and evenly distributed rainfall has allowed adequate production of crop residues for soil cover. For most farmers, residues are neither scarce nor excessive. Potentially important problems with weeds, pests and diseases have been managed through technical recommendations of integrated strategies mainly crop rotations. Despite neutral to unfavourable macroeconomic and sectorial policy environments, the successful track record of conservation agriculture appears to have overcome the "socio-cultural barrier problem", and there is now in place an effective innovation system, with research institutions as partners. Equity concerns have resulted in efforts to make conservation agriculture available to a greater number and range of small - scale farmers.

In the case of small - scale farmers in southern Brazil, the introduction of conservation agriculture reduced drudgery and labour requirements for crop production. This was one of the factors that contributed to the incorporation of other economic activities into the farming systems. For instance, in the State of Paraná (Brazil), 27% of the farms have already incorporated non agricultural activities such as home employees, hotel workers, clubs, shops, hospitals, schools, and industries for processing of agricultural products (dairy, meat, fruits).

Southern Brazilian farmers, by keeping the soil covered with a straw layer and sowing directly with minimal soil disturbance, reduce soil erosion and the water runoff, soil sediments and organic matter to rivers and small streams.

Cropping systems in the Cerrados of Brazil

Despite the presence of acid soils, conservation agriculture allowed multiple cropping where previously only monocropping was possible. Crop rotations play an important role in strategies for integrated weed, pest and disease management. Soil cover is provided by crop residues combined with biomass from cover crops, e.g., millet, *Brachiaria*.

When conservation agriculture leads to permanent increases in Soil Organic Carbon -SOC, carbon can be said to have been sequestered in the soil. Several studies measured increased SOC levels attributable to the introduction of conservation agriculture. The further noted that the effect of conservation agriculture on Carbon stocks was especially strong “when additional cover crops, especially grasses and legumes, are used in order to increase the total photosynthetic production during the year and provide high levels of biomass returned to the soil”.

Table 2. Chemical attributes at the original soil and at the sediments produced for intense rainfall in an area with no tillage management system, showing the enrichment of the eroded sediment.

Attributes	Concentration	
	Soil ¹	Sediment
pH in H ₂ O	6.4	6.6
Ca (mmolc/dm ³)	34.0	44.0
Mg (mmolc/dm ³)	56.0	60.0
P (mg/dm ³)	34.0	72.0
K (mg/dm ³)	270.0	609.0
Organic matter (%)	2.9	7.3

¹ From 0 to 10 cm depth.
Source: Denardin *et al.* (2004).

Gaps in knowledge

Despite the large dissemination of conservation agriculture in Latin America, there are still gaps in knowledge regarding the development and the adaptation of conservation agriculture technologies:

- In many parts of Argentina, Bolivia and Brazil, small scale farmers are often confronted with a scarcity of crop residues, which are used as fodder for livestock or –as it is the case in Bolivia- they are sold for cash rather than used for soil cover. Residue scarcity can emerge when biomass production is relatively low too. The crop-livestock integration may be achieved through increasing residue availability by introducing multipurpose cover crops, rotational grazing, the use of fodder banks, silage, etc;
- Certain crops, e.g., cotton and tobacco, are rarely grown under conservation agriculture because of crop peculiarity, pest and disease issues. Technology development for these crops, adaptation or breeding of species aiming at cropping systems’ diversification for different agroecological conditions, and development of cash and cover crops more tolerant to abiotic stress and compatible to different farming systems is needed;
- In Argentina, conservation agriculture is not really suitable for some temperate sub-humid and subtropical regions where “monozonic” rainfall patterns and deficient water balances limit biomass production, crop development and final yield;
- In Bolivia, weed competition continues to be an issue. Farmers have yet to introduce cover crops or rotations as part of integrated pest, disease and weed control strategies, but availability of information remains an issue for some farmers, e.g., small-scale farmers with limited Spanish-language capacity.

There are also gaps in knowledge regarding the assessment of the socio-economic, agronomic and environmental impacts of conservation agriculture:

- During the transition period, expenditures in inputs for fertilization, weed, pest and disease control may offset gains from diminished labour and machinery demands. Development of conservation agriculture systems less dependant on external inputs is needed;
- In Argentina, as in Brazil, many areas are susceptible to erosion. Here, however, it is felt unwise to rely entirely and exclusively on conservation agriculture practices for erosion control. Indeed, conservation agriculture practices have resulted in a concentration of nutrients near the soil surface. And, there is evidences (see table 2) showing that intensive rainfall events can lead to unexpectedly high rates of nutrient loss at certain locations in farmers’ fields. No-tillage needs to be supported by complementary conservation techniques, like terracing, contour planting, aerial planting, strip cropping...
- The impact assessment of the use of external inputs in conservation agriculture on soil and water quality

and on biodiversity has not been addressed in the past. Issues of concern include pesticide use, fertilizer use, water pollution from leaching and/ or run-off of pesticides and nutrients. Information based on scientific data from direct in-field measures regarding pesticides in conservation agriculture systems are considered as insufficient in the Latin American literature: in some situations conservation agriculture increased pesticide lixiviation and reduced pesticide runoff and in others the results were the contrary;

- New studies could help to know more about dynamics of soil nutrients in agro-ecosystems (e.g. increase of efficiency of liming and fertilization); dynamics of soil organic matter; definition of soil quality indicators; and, genesis, diagnosis, and mitigation of soil compaction in conservation agriculture areas. For farmers, soil compaction seems to be more evident under soil moisture stress associated to high clay and low organic matter content or in soils with high silt content;
- Herbicide-resistant genetic modified –GM- soybeans are largely used in Argentina and Southern Brazil. The impact assessment of the adoption of GM crops under conservation agriculture practices is necessary.

Challenges

Latin America is at the very heart of conservation agriculture. According to the figures published by the 3rd world congress on conservation agriculture (2005), Argentina and Brazil are totalising 44% of the world surface under no-tillage: 23 600 000 ha in Brazil and 18 269 000 ha in Argentina. The natural potential of the region, the dynamism of the innovation systems in place and the driving force of the market may continue to spread the no-till technology. However, despite of this large adoption and the long practical history there are still challenging issues.

The lack of crop rotations is considered as one of the most important challenging issues. Crop rotations are the core of sustainable conservation agriculture systems; they are associated to biomass production and are part of strategies of integrated weed and pest management. But their adoption is constrained both by agro-ecological and socio-economic factors. They are of low profitability and not economically viable under an economic context where prices are market-driven and there is virtually no policy that favours the use of crop rotations. In Argentina, the lack of equally profitable alternatives seriously restricts the implementation of a proper agronomic rotational strategy and mono-cropping situation (soybean) is heavily promoted.

In this situation, conservation agriculture systems remain dependant on external chemical inputs: pesticides, fertilizers, liming... and, less knowledge have been generated regarding:

- The dynamics of soil organic matter and soil nutrients in the agroecosystems, the efficiency of liming and fertilization; the soil quality and water quality. The potential of these agroecosystems for carbon sequestration, GHGs emissions...;
- Soil induced changes and biodiversity behaviour, especially dynamics of pests, weeds and diseases generated by the introduction of conservation agriculture;
- The behaviour of the pollutants and their risk for the environment, food chain and health.
- Herbicide-resistant genetic modified soybeans which are being largely used in Argentina and Brazil. This adoption by farmers - although it is an important indicator- has been the only evidence of its benefits. Yet there is no scientific data available addressing the economic, social and environmental impacts of this technology in the short, medium and long term.

Hence, the lack of impact assessment is the other challenging issue. To assess the socio-economic, agronomic and environmental impacts of the use of conservation agriculture practices and their external inputs may help understanding theses systems and improving their sustainability.