Economic aspects of Conservation Agriculture (1)

Adoption of Conservation Agriculture

Unfortunately, short-term solutions and immediate benefits always attract farmers and the full technical and economic advantages of conservation agriculture can be seen only in the medium- long-term run, when its principles (no-tillage, permanent cover crop and crop rotation) are well established within the farming system.

In fact, if the two systems (conventional and conservation agriculture) are applied in two plots with the same agro-ecological and fertility conditions, no great differences in productivity during the first years are to be expected. However, after cultivating the same crops in the same areas for several years, the differences between the two systems become more evident.

CA requires a new way of thinking from all concerned. Along with this "new way of thinking agriculture", there is already enough technical and agronomic evidence that could positively influence farmers contemplating the adoption of CA principles. It is, however, important to demonstrate to farmers that the technical and agronomic aspects are directly related to the management and economic ones and, therefore, any technical and agronomic improvements obtained by applying CA principles need to be quantified in monetary and economic terms.

Before analysing the farm management and economic aspects of CA, it is illuminating to divide the adoption/adaptation process into four theoretical phases. This theoretical division, represented in Figure 1, facilitates the reasoning when analysing the farm activities and the impacts of new technologies in the production process.

- First Phase - Improvement of tillage techniques: During this first phase, no increase in farm output is foreseen. But decreases in: labour; time; draught animal or motorised power (reduction of production costs) would occur. An increase in agro-chemical use, especially to control weeds might be required. Furthermore, there may be an increase in family expenses to compensate a probable (but not certain!) reduction of production in comparison with the conventional agriculture;
- Second Phase - Improvement of soil conditions and fertility. Decreases in labour, time and draught animal and motorised power (reduction of production costs). Increases in yields and consequently increase in net farm income;
- Third Phase - Diversification of cropping pattern. Increased and more stable yields. Increased net farm income and soil fertility.
- Fourth Phase - The integrated farming system is functioning smoothly. Stability in production and productivity. The full technical and economic advantages of conservation agriculture can be appreciated by the farmer.

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(1) The majority of these notes are based on information extracted from:
FAO. 2004. Conservation of natural resources for sustainable agriculture: training modules. FAO Land and Water Digital Media Series CD-ROM 27. FAO, Rome. Original references are given in the CD-ROM.

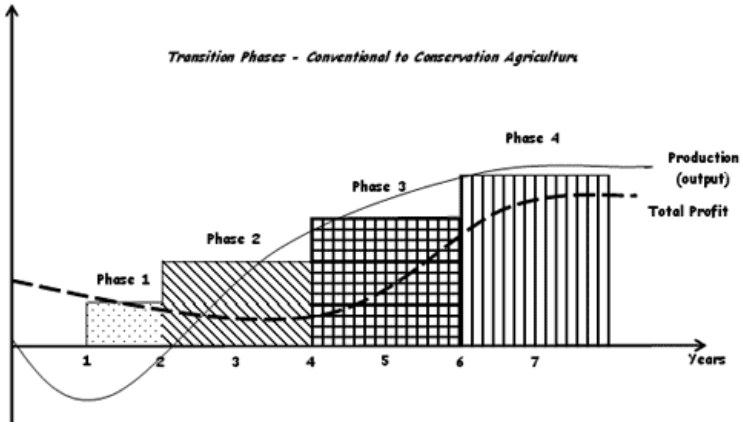

Figure 1. The transition phases of CA adoption

Technological changes

Because of the opportunities for increased outputs, reduction in production costs and higher income levels which a technological change to CA can offer, it is useful to take into consideration the process of adoption / adaptation and diffusion of technical innovations. The economic potential of conservation agriculture, in terms of costs of production, profit, yield, soil conservation, etc. is very important. However, unfamiliarity with conservation agriculture practices might make the initial impact on yield and input usage uncertain. It should not be forgotten that the adoption / adaptation decision must take place in an uncertain environment (subject to the vagaries of nature and the market). Farmers' attitudes to risk and, in particular, their strategies for risk aversion must also be taken into consideration.

There are four requirements **(2)** for the adoption of CA practices:

1. It must bring the farmer a visible and immediate benefit, economic or otherwise.
2. The benefit must be substantial enough to convince the farmers to change their ongoing practices.
3. For the technology to be disseminated, the costs incurred must be able to be covered by the farmer.
4. The introduction of CA should be followed up by an extension service for a long period of time.

The potential conservation agriculture adopter / adapter may be confronted with constraints in terms of purchasing power; access to credit and information; and poor communications links with product and input markets. In this regard, the availability of inputs in the quantity and at the time required may prove to be important considerations in the adoption / adaptation process.

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(2) FAO, 2005. Conservation agriculture for soil moisture. Briefing notes: Production systems management, Rome. FAO. 4 p.

Managing changes in input use

In principle, the cost of some inputs (e.g. for seed purchase) should not differ in conservation agriculture compared to conventional tillage. However, differences are often observed and can be explained through:

- In conservation agriculture less seed is needed because the losses in the field are reduced. However, sometimes more seed is needed because the plant density in conservation agriculture is optimal and might be higher than under traditional dibble stick planting. So, in effect, seed use remains about the same.
- In conservation agriculture cover crops play an important role and if the seeds for cover crops are not produced on-farm, the farmer needs to buy them elsewhere.
- As with the cost of seeds, fertilizer costs are initially considered to be the same under conservation agriculture compared to conventional tillage. However, as the organic matter of the soil increases under conservation agriculture, so will the soil fertility and moisture content. Both aspects lead to an increased fertilizer efficiency, which will reduce fertilizer need in the long run.
- Farmers who are used to applying herbicides under conventional system will also use them under conservation agriculture. Experience shows that in these cases herbicide costs will reduce over time as the permanent soil cover exerts its weed-controlling function. Herbicides are important, but farmers using conventional tillage methods use similar amounts of herbicides as no-tillage farmers.

Those farmers, who have never used herbicides because they are simply not available or very expensive, are likely to adopt alternative practices for weed control, like the use of knife rollers.

When conservation agriculture is practised correctly, pest and disease incidence will be lower compared to conventional tillage due to crop rotation and the use of cover crops. Consequently, the cost for treatment will also be reduced.

Labour The positive impact of conservation agriculture on the distribution of labour during the production cycle and, even more important, the reduction in labour requirement is the main reason for the adoption of CA in Latin America, especially for farmers who rely fully on family labour.

Besides the reduction in the total time required, conservation agriculture techniques would also reduce the number of activities needed for the production cycle, as shown in the example in Table 1.

Table 1. - Mechanised operations and the time required (hours/ha) for each of them under different bean production systems in Brazil.

Operation	Conservation agriculture	Conventional tillage
Knife roller	0.89	-
Direct seeding	0.76	-
Spraying	1.2	0.6
Harvest	0.93	0.93
Ploughing/disking	-	1.37
Levelling	-	1.38
Conventional planting	-	0.89
Ridging	-	1
Total	3.78	6.17

Especially in areas where family labour is becoming a constraint, because of migration, HIV-Aids, etc., conservation agriculture could be a good option for farmers. The reduction in on-farm labour requirement allows farmers to:

- Extend the cultivated area.
- Hire themselves out in off-farm employment.
- Diversify their activities, including processing of agricultural products.
- Reduce the cultivated area due to increased yields and allow more marginal areas to recuperate.

Table 2 gives an example of a simple overview of the labour requirements, using animal and motorised traction in land preparation activities. In particular, the illustration shows in the case of animal traction, the reduction in labour can reach as much as 86%. The time required to prepare the land using a tractor is reduced by 58% under conservation agriculture.

Table 2. The time requirements for land preparation activities under conventional tillage and conservation agriculture (hours/ha).

Conventional tillage		Conservation agriculture	
Operations	Time required (hours ha^{-1})	Operations	Time required (hours ha^{-1})
Tractor		**Tractor**	
Ploughing	1.5	Knife roller	0.9
Harrowing (2x)	1.4	Spraying	0.3
Total	**2.9**	**Total**	**1.2**
Animal Traction		**Animal Traction**	
Ploughing	25	Knife roller	3
Harrowing (2x)	5	Spraying	1.5
Furrowing	3		
Total	**33**	**Total**	**4.5**

Machinery and Equipment

In the majority of the farms where conservation agriculture is practised, fewer operations are executed in the field. For this reason farmers need less equipment and the costs of both labour (see above) and fuel are reduced. In addition, the number of implements can be reduced; ploughs and harrows are no longer required. In the case of tractor-powered farming, the size of the tractor can also be reduced: for ploughing a heavier tractor is needed compared to direct seeding and spraying.

Likewise, in animal draught systems, fewer animals are needed, or different types of animals can be used: instead of one pair of oxen, a pair of donkeys might be sufficient.

Fewer field operations result in less wear and tear of the equipment, which in turn will have a longer life span and the costs for maintenance and repair are reduced considerably.

Table 3 gives one example of an estimation of machinery and fuel costs for soya and maize crops under conventional tillage and conservation agriculture. The costs for lime and fertilizer application, insecticide spraying, harvest and internal transport are not included in the calculation, as they did not differ between the two systems.

Table 3 - Estimation of costs for machinery and fuel in a maize soybean rotation in Brazil.

Specification	Soybean				Maize			
	CT		CA		CT		CA	
	Quantity	$US/ha	Quantity	$/ha	Quantity	$/ha	Quantity	$/ha
Maintenance of terraces	0.7 h/ha	2.44	-		0.7 h/ha	2.44	-	
Ploughing	2 h/ha	7.28	-		2 h/ha	7.28	-	
Harrowing (2x)	1.6 h/ha	7.31	-		1.6 h/ha	6.44	-	
Planting	1 h/ha	4.88	1 h/ha	9.74	1 h/ha	3.93	1 h/ha	10.79
Herbicide application	1.6 h/ha	6.79	1.6 h/ha	6.27	0.8 h/ha	3.14	1.6 h/ha	6.27
Total		**28.7**		**16.0**		**23.2**		**17.1**
Fuel	82.3 l/ha	21.30	49.6 l/ha	12.84	86.8 l/ha	22.46	58.7 l/ha	15.18
Lubricants		4.77		2.87		5.14		3.48
Total		**26.1**		**15.7**		**27.6**		**18.7**
Total costs		**54.8**		**31.7**		**50.8**		**35.8**
Total reduction	**$US23.1/ha (=42.2%)**				**$US15/ha (=29.5%)**			

CT: Conventional Tillage. CA: Conservation Agriculture

One interesting and indicative recent development has been the response of rice farmers to conservation agriculture in Southeast Asia. Small holder farmers in Indonesia are realizing 25 percent savings in labour, 65 percent savings in land preparation costs, 28 percent savings in irrigation water per cropping cycle and 2-3 weeks time saving for land preparation. In conventional preparation of paddies, 30 percent of the water is used in the ploughing and puddling process. A substantial amount of this water is lost into the canals during this process resulting in soil and water loss and water pollution. The small farmers in Indonesia rent the equipment to plough and as availability is limited they often have to wait, sometimes missing a cropping cycle. Together with the 2-3 weeks real savings in time to prepare the land for planting conservation agriculture will help move production from the current average of 1.4 crops per year towards a realizable two or even three crops a year. Similar results are being observed in the Philippines, Thailand and India. In North Korea, CA has opened up the possibility of direct seeding rice in order to reduce the inter-crop necessitated by the ploughing and puddling requirement.

Crop yields

In general, conservation agriculture can produce equivalent or higher yields compared to conventional tillage systems (Figure 2). However this trend should not be exaggerated. As we saw in Figure 1, crop yields may fall in the initial phases of CA adoption, and will only rise above conventional tillage figures when the CA system has stabilised. Wherever possible local information should be used and preferred to generalised data.

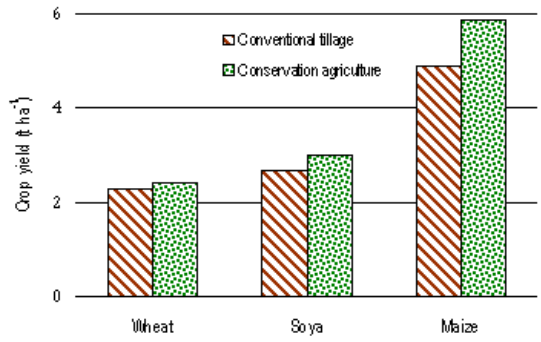

FIGURE 2
Wheat, soy bean and maize yields under conventional tillage and conservation agriculture (averages over a period over 8 years). Brazil

Carbon sequestration

CA does, of course, provide many environmental benefits that may not be of direct interest to the farmer. Here, for example, we are thinking about streams and rivers running free of eroded soil and so not silting up reservoirs or damaging hydro-electric generating turbines. Another major benefit is the reduction of damage

reservoirs of damaging hydro-electric generating turbines. Another major benefit is the reduction of damage done to roads and, indeed marine environments, by reducing runoff and erosion; to say nothing of the costs of domestic water purification.

PLATE 1
Off-site effect of soil erosion: coastal waters are polluted with sediment, posing a problem for local fishermen.
(FAO).

However, CA is currently receiving global focus for its carbon sequestration potential. It has been calculated that the total potential for soil carbon sequestration by agriculture could offset about 40% of the estimated annual increase in CO_2 emissions **(3)**. CA practices that sequester soil organic matter contribute to environmental quality and the development of sustainable agricultural systems. The significance of CA adoption to the amelioration of effects of greenhouse gas emissions on global climate change is now being evaluated. The emergence of carbon credit payments for CA farmers is being considered seriously and could result in a further financial benefit to CA adopters.

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(3) Robbins, M. 2004. Carbon trading, agriculture and poverty. Bangkok, Thailand. World Association of Soil and Water Conservation (WASWC). Special publication 2. 48 p.