Collaborative research on Conservation Agriculture in Bajío, Mexico: continuities and discontinuities of partnerships

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ABSTRACT
Agricultural technologies are debated and contested. Studying the socio-political life of agricultural research can help us to understand why some particular technologies or pathways are favoured (and others not) and eventually why expectations are maintained or not. We studied the 30-year trajectory of practices of Conservation Agriculture in the central region of Mexico. The results of our interviews and literature review show how, over the course of time, Conservation Agriculture (CA) technology has successively changed from being referred to as Conservation Tillage, Direct Seeding, Conservation Agriculture and has now, finally become integrated within Sustainable Intensification. These changes are connected with revamped narratives and the applications of the latest research and development (R&D) paradigms. They were the result of new spaces for CA projects opening up after other spaces had closed, spaces that allowed the researchers, politicians, technicians and farmers to continue to engage in CA in a reconfigured way that fit the various agendas. The opening and closure of spaces for CA projects were the result of researchers being subject to, and taking advantage of, political changes and of politicians seeking new initiatives to support their agendas. This shows how research and politics are mutually dependent and how they generate a discontinuity of project interventions which, paradoxically, represent a continuity of agendas and research processes. As CA is both a complex and flexible technology, it has been possible to make it fit to accommodate the changing agendas of different actors.

KEYWORDS
Conservation agriculture; agricultural technology; research; policy; agricultural research; food security; climate change; boundary object; Mexico

1. Introduction
Much agricultural scientific knowledge is brought to farmers through projects that promote agricultural technologies (Byerlee, de Janvry, & Sadoulet, 2009; Johnston & Mellor, 1961; Thompson & Scoones, 2009). These projects and technologies are usually intended to increase agricultural productivity and improve farmers’ livelihoods (Benton, 2016; The World Bank, 2008). When their potential is being assessed variables such as the potential yield increase, cost–benefit ratio, access to inputs and the knowledge that farmers need to adopt the technology are generally taken into consideration. However, these interventions often have mixed outcomes, some of which are not foreseen. Moreover, the impacts of technology-driven interventions continue to be subject to claims and counter-claims about their benefits and drawbacks, more recently in the case of Conservation Agriculture (CA) (e.g. Andersson & Giller, 2012; Ramírez-López, Désirée Beuchelt, & Velasco-Misael, 2013), the System of Rice Intensification (Glover, 2011), Climate Smart Agriculture (CSA) (Newell & Taylor, 2018), GMOs (Zerbe, 2004) and ICTs (Brown & Grant, 2010; Thompson, 2004). In the literature, three important arguments emerge from these discussions around the impact of the applications of these technologies: one size does not fit all (Gatere et al., 2013; Ramalingam, 2013); technologies alone are not sufficient to
solve the ‘problem’ (however defined) (Douthwaite, Keatinge, & Park, 2001; Glover, Venot, & Maat, 2016) and the importance of understanding the local contexts where interventions are implemented in order to reduce unintended negative outcomes (Ferguson, 1990; Li, 2007).

Sumberg, Thompson, and Woodhouse (2013) place these contested technologies in the wider and changing context of agricultural research which is increasingly shaped by the neoliberal project, the environmental agenda and the call for more participatory approaches. These influences result in increasingly contested goals, motivations, and agendas of agricultural research. This points to the inherently political nature of agricultural research and the need to understand the politics of knowledge and research. Giller, Andersson, Sumberg, and Thompson (2017) speak of the need to view agricultural research through a lens of ‘political agronomy’ that can shed light on the way agricultural research is framed, and how this influences decisions to finance and implement different projects and approaches. This can help us to understand why particular technologies or pathways are favoured (or not), and why expectations are maintained (or not).

What is generally labelled as Conservation Agriculture is a prominent example of such a contested technology. Figures indicate that at least 105 million of ha in the world use zero tillage which is considered a component of CA, claiming its positive impacts to mitigate climate change (Hobbs & Govaerts, 2010) and in increasing crop yields (Hobbs, Sayre, & Gupta, 2008). Research indicates that farmers in northern Mexico can reduce the water demands by 29% and increase crop yields by 10% by using CA vs conventional tillage systems (Hobbs et al., 2008). On the other hand, some authors have shown how the adoption of CA by farmers is influenced by local socio-economic complexities (Baudron, Andersson, Corbeels, & Giller, 2012; Ekboir, 2003; Erenstein, Sayre, Wall, Helin, & Dixon, 2012) and others have addressed the political nature of CA interventions (Andersson & Giller, 2012). Whitfield et al. (2015) have argued that the promotion of CA technology has been more a response to changing international development agendas rather than to any empirical evidence about its benefits. Westagen, Nyanga, Chibambwa, Guillen-Royo, and Banik (2018) describe how the framing of political agendas influences the way farmers eventually practice CA in their fields. In this paper, we examine these claims about CA in the context of Mexico. We have analysed different CA projects in a central region of Mexico over a time span of 30 years. We studied the way actors participating in the projects needed to find a ‘fit’ within a dynamic political landscape and had to do so repeatedly to achieve continuity. This search for continuity in the face of the discontinuity of projects affected not only researchers but also politicians, technicians, and farmers.

Conservation Agriculture has known a variation of labels since 1943 to describe a technology package that gives a central place to minimal soil disturbance (Kassam, Friedrich, Shaxson, & Pretty, 2009). The FAO definition of Conservation Agriculture refers to the combination of three core elements (minimum soil disturbance, crop residues mulching and crop rotation) (FAO, 2008; Kassam, Friedrich, & Derpsch, 2019). Other authors use the CA term to portray how it is widely used to fit different sets of practices and somehow justify it is promotion whether it fits or not the three principles (e.g. Andersson & D’Souza, 2014; Kassam et al., 2009). We use Conservation Agriculture (CA) technology as an umbrella term to cover a varying, confusing and complex set of practices around minimum soil tillage, in this case for the technology-interventions over a period of 30 years in Mexico, presented in this paper. We use the term CA as a ‘boundary object’ (BO) to show how different actors re-arrange themselves around a shared idea (Ewenstein & Whyte, 2009; Mollinga, 2010; Star & Griesemer, 1989), i.e. CA, while having different definitions, practices and/or interests.

Our entry point of the study is the MasAgro programme (the Sustainable Modernization of Traditional Agriculture), a joint effort of the International Maize and Wheat Improvement Center (CIMMYT) and over 150 partners, that was funded by the Mexican Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA). It was launched in 2010 to support the use of sustainable technologies, CA among them, in maize and wheat production, (Camacho-Villa et al., 2016). From there we trace back 30 years of CA-related interventions. We distinguish three groups of projects that introduced CA, in Jalisco, Guanajuato and Michoacán respectively, which we label as phase 1, 2 and 3 of the CA technology.
2. Data collection and study site

Our historical case study (Gerring, 2006) focuses on three states in the region of Bajío, in Mexico: Guanajuato, Jalisco and Michoacán (Figure 1). Administratively, Mexico is a federal republic composed of 32 states.

The data were collected between October 2014 and October 2016. Three main data sources and types of analysis were used:

(1) Content analysis of literature and policy documents on projects framed around CA technology within the Bajío region, such as project reports and evaluations, articles published in scientific journals, media notes in magazines, newspapers and, websites. Additionally, we accessed the CIMMYT repository, the Web of Science, Scopus and Google Scholar to consult the scientific publications that resulted from these projects.2

(2) A total of 35 semi-structured interviews with key actors to construct a time-line events of the evolution of CA technology and the key actors who participated in each of the different interventions. These interviewees included project leaders, technicians, scientists, government officers and farmers implementing CA. The initial sample of potential interviewees was identified through participation in a workshop for MasAgro collaborators and farmers organized in October 2014 with the aim of historically retracing actors’ experiences of CA, tracking backwards from the MasAgro intervention to their initial encounter with the CA technology. This workshop yielded the names of key CA actors within the region. Additional key actors were identified through the initial interviews (using ‘the snowball approach’) and further consultation of the literature.

(3) Participatory observation from attending workshops, training events and field demonstrations involving farmers and technicians participating in the MasAgro project in Michoacán and Hub Bajío. A total of six workshops was organized between November 2014 and September 2015. Two of these were aimed at technicians, collaborators and farmers and two workshops at farmers in Indaparapeo, Michoacán (where MasAgro project has an experimental platform). One workshop was aimed at collaborators and the last was done with farmers from Indaparapeo who were not participating in the MasAgro project.

3. A brief history of the Conservation Agriculture technology

Technologies based on ‘Conservation Agriculture’ were known to the Egyptians and Incas (Derpsch, n.d.) although such practices were first formally documented in the USA by Faulkner (1943). Since then CA technology has been tried out in, and adapted to, a wide range of contexts. In the late 1970s several research institutions working on international development such as CIRAD (the French Agricultural Research Centre for International Development) and CIMMYT were running projects based on CA in tropical conditions in developing countries, Mexico among them (FAO, 2008; Friedrich, Derpsch, & Kassam, 2012). In Brazil, CA was promoted as a response to serious soil erosion in the 1980s (Ekboir, 2003). By the end of the 1980s, successful experiences with CA in Brazil and Argentina caught the attention of agricultural researches world-wide (Derpsch, n.d.).

According to Farooq and Siddique (2015) and Kassam et al. (2019), the term Conservation Agriculture (CA) has no clear origin. It was popularized in the International Congress on Conservation Agriculture in 2001 (Kassam et al., 2009). The FAO (2019) indicates that the CA combines three major components: (a) Minimum soil disturbance refers to low disturbance no-tillage and direct seeding; (b) Permanent soil organic cover with at least 30% of the ground covered after sowing and (c) Crop rotation with at least three different crops. The potential benefits of CA include:

- improved soil water retention and drainage, as soil porosity is increased;
- less soil erosion and water losses, as mulching reduces evaporation and increases organic matter;
- increased water and nutrient availability, as a result of the higher organic matter content of the soil;
- a reduction of labour and capital requirements, because of reduced tillage (FAO (2019)).

Among the frequently reported myths of CA are an increase in weeds and the need for more herbicides (at least initially) and for specialized machinery to sow and incorporate mulch, the competition for biomass to be used as mulch or fodder, and the delayed yield impact (Andersson & Giller, 2012). In many situations these disadvantages may outweigh the benefits listed above (Andersson & Giller, 2012).

Interest in CA experienced a revival, based on its potential for delivering a more sustainable and
environmentally friendly type of agriculture. CA practices have been described with a range of labels: zero, no or minimal tillage, strip-till, direct seeding, conservation tillage, conservation agriculture, blue agriculture and direct seeding mulch-based cropping systems (Kassam et al., 2009). More recently due to CA’s popularity, a new paradigm emerged from the CA concept, i.e. Sustainable Intensification (Giller et al., 2015; Kassam, Friedrich, Derpsch, & Kienzle, 2015; The Montpellier Panel, 2013).

4. Conservation Agriculture in the Bajío region, Mexico

In Mexico, CIRAD and CIMMYT researchers started CA experiments in Veracruz in 1975 under the name of Conservation Tillage (Martínez Ruiz, 2006). CA was high on the research agenda of CIRAD and CIMMYT, and their researchers were studying CA in various parts of the world. The label, Conservation Tillage, emphasized the value of the technology in combating soil erosion and coping with conditions where water was a limiting production factor.

Since then CA has been practiced and studied in Mexico in one form or another, under different labels and being promoted by a variety of actors. Towards the end of the ’70s, the Mexican Trust Fund for Agriculture (FIRA), CIMMYT and the National Institute for Forestry, Agriculture and Livestock Research (INIFAP) trained technicians to take the technology from Veracruz to other regions of the country (Aquino-Mercado, Peña, & Ortíz-Monasterio, 2008; Martínez Ruíz, 2006), including the Bajío region.

Conservation Agriculture was introduced to Bajío, the area of our study, by CIRAD-CIMMYT researchers in 1987. Bajío is one of the most fertile and productive agricultural regions in Mexico. It lies 200 km away from Mexico City (Figure 1). Most of the region has access to irrigation and the climate allows two cropping seasons through the year. Maize is partly commercial under irrigated regimes and a staple crop in rain-fed/semi-irrigated regimes. The features of CA as practiced in farmers’ fields varied from one intervention to the other and are summarized in Table 1.

4.1. The first introduction: conservation tillage technology in Jalisco (1987–1999)

4.1.1. On farm CT research in Jalisco (1987–1992)

With the first promising on-station research results from Veracruz, Mexico, and encouraged by other research in
the world, CIRAD and CIMMYT researchers aimed to adapt CA to local conditions. They identified Ciudad Guzmán, Jalisco, as representative of the typical varied situation in many rain-fed areas in Mexico where Conservation Tillage (CT) could address problems with soil erosion and increase water-limited maize productivity (Erenstein, 1999). From 1987 to 1992, they carried out experiments in farmers' fields to adapt CT to local conditions, applying the On Farm Research (OFR) approach (Hildebrand & Poey, 1985; Lockeretz, 1987), studying the effects of frequency and timing of tillage activities and amount of crop residue on maize yields.

The scientific publications from this research showed that the CT treatments gave significantly higher yields (almost double) when using one or two mechanized tillages (Erenstein, 1996; Van Nieuwkoop, 1993). Researchers considered more research was needed to study the effect of the practices on production costs.

### 4.1.2. Farming systems CT research (1994–1999)

In 1993–1994, INIFAP developed an interest in promoting CT in Mexico, presenting CT as a technology that could increase the competitiveness of Mexican

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**Table 1.** The characteristics of the conservation agriculture interventions, sites, context, and practices.

| Project /Technology label | Conservation tillage (1987–1992/1994–1999) | Direct seeding (2000–2009) | Conservation agriculture /Sustainable intensification (2005–2017) |
|---------------------------|---------------------------------------------|-----------------------------|---------------------------------------------------------------|
| Site of implementation    | Jalisco (Ciudad Guzmán and San Gabriel)     | Guanajuato (Irrigation District 011) | Michoacán (Rural Development District 092) |
| Cropping season and main crops | Spring-summer (S-S): maize                  | Spring-summer (S-S): maize and sorghum Fall-Winter (F-W): wheat and barley | Spring-summer (S-S): maize and sorghum Fall-Winter (F-W): Wheat and barley |
| Irrigation regime         | Rain-fed (400–1000 mm/year)                 | S-S: 38% irrigated at least once and the rest rain-fed F-W: 100% rain-fed | S-S: 85% irrigated at least once, the rest rain-fed F-W: 100% rain-fed |
| Approach to take CA to the farmers | Researcher controlled experimentation (on farm research and farming systems research) | Farmer controlled (innovation systems) | Farmer controlled (innovation systems/sustainable intensification) |
| Crop soil coverage        | At least 30%, still studies on adaptation were performed | At least 30% | At least 30% |
| Tillage practices         | One or two tillage activities through the cropping season. No ploughing. | S-S, direct seeding, and no ploughing F-W, one or two tillage activities as required to incorporate the crop residues unless beds need remaking by opening the furrows. |
| Crop rotation             | Not an explicit part of the package.        | Not an explicit part of the package. |
| Economic benefits         | Not analysed                                | Reduction of production costs. 11<sup>b</sup> ton/ha | Reduction of production costs. 7.7<sup>c</sup> ton/ha |
| Maize yields with traditional tillage practices | 1.25<sup>a</sup> tons/ha                   | Reduction of production costs. 11<sup>b</sup> ton/ha | Reduction of production costs. 7.7<sup>c</sup> ton/ha |
| Maize yields with CA practices | 2.2<sup>a</sup> tons/ha                    | 11<sup>b</sup> ton/ha | 7.6–9.9<sup>d</sup> ton/ha |
| Maize production cost using conventional tillage | $2,240<sup>a</sup> MNX<sup>+<</sup> | $9,490<sup>b</sup> MNX<sup>+</sup> | $11,950<sup>c</sup> MNX<sup>+</sup> |
| Maize production cost using CA | $2,207<sup>a</sup> MNX<sup>+</sup> | $6,550<sup>b</sup> MNX<sup>+</sup> | $9,821<sup>c</sup> MNX<sup>+</sup> |
| No. Farmers involved      | 25<sup>e</sup>                             | Up to 67<sup>f</sup> | Up to 100<sup>g</sup> |

<sup>a</sup>Erenstein (1999, pp. 6, 26).  
<sup>b</sup>SERpro_SC (2007, pp. 44–55).  
<sup>c</sup>CIMMYT (2016). BEM, data base of MasAgro project.  
<sup>d</sup>Fundación Produce Michoacán A.C. (2011, pp. 73–75) and (CIMMYT, 2016). BEM, data base of MasAgro project.  
<sup>e</sup>Based on oral testimonies.  
<sup>f</sup>SERpro_SC (2007, pp. 24).  
<sup>g</sup>Fundación Produce Michoacán A.C. (2011, p. 62) and oral testimonies, data from the first intervention in Michoacán.  
<sup>+</sup>MNX = Mexican pesos.
maize farmers in the international market. This argument was well received by politicians in Jalisco who were concerned about the impact of NAFTA\(^3\) (North American Free Trade Agreement) on farmers in their state, the signing of which (in 1994) opened up Mexican markets for maize imports. This provided favourable conditions for further CT research and resulted in a second project starting in 1994, funded by the Mexican Government and implemented by INIFAP, CIRAD and CIMMYT. One component of the project was to test CT in 25 different INIFAP research stations throughout the country. The other component was to continue the research activities in Ciudad Guzmán in Jalisco. The research was fitted to the Farming System Research (FSR) approach and included economic analysis at field level (Damhofer, Gibbon, & Dedieu, 2012). San Gabriel was added as a new experimental site. At this stage, competition for crop residues between livestock and mulch was noted.

The shift to the Farming System Research (FSR) approach was crucial. NAFTA marked the beginning of the era of neoliberalism in which the government took a back seat and encouraged ‘free market’ competition. The assumption was that if FSR were successful then farmers would take it over and begin to articulate their research needs and pay for technical assistance (Gates, 1996). Thus, the FSR approach also aligned well with the political agenda of the time.

With the emergence of neoliberalism, and the deregulation of the national markets and international trade, agricultural policy focused on private sector initiatives and enhancing competitiveness. New mechanisms to fund agricultural research were established, similar to those in other countries under neoliberal agricultural regimes (Gates, 1996). In 1996, the Fundaciones Produce became the central funding institutions for agricultural research in each state in Mexico (Ekboir, Dutrénit, Martínez, Torres Vargas, & Vera Cruz, 2006). One of the outcomes of these changes was that there were less funds for the CT project and by 1997 only the research activities in Ciudad Guzman continued, at a lower level than before.

4.1.3. The state of Conservation Agriculture after ‘phase 1’

When the last funding dried up in 1999, 25 farmers were hosting on-farm trials with a range of treatments (Table 1). This second project period generated 16 publications, around half of which were project reports and the rest scientific articles published after the project finished. The results showed that that the adoption of CT was constrained by several factors, of which access to specialized machinery for sowing, tillage and the incorporation of mulch was perhaps the most important. The need for expertise on the management of pests, weeds and mulch were also flagged as issues. In addition, because CT only had an impact on yields after several seasons, farmers lacked the incentive to adopt CT practices. The researchers concluded that Ciudad Guzman was not a ‘promising environment’ as envisioned initially.

4.2. The second introduction: direct seeding technology in Guanajuato (2000–2009)

4.2.1. The emergence of the DS project

The experiences in Jalisco had made it obvious that farmers needed access to machinery in order for a new CA project to be feasible. An initial exploratory study identified suitable sites in the states of Guanajuato and Querétaro, where the political climate was also favourable. The new president of Mexico as well as the Minister of Agriculture were both from Guanajuato.\(^4\) While PAN (the incoming government) favoured market liberalization, it had also campaigned against the previous government’s unmet promises to support maize farmers to adjust to NAFTA.\(^5\) This led PAN politicians in Guanajuato launch the state Agricultural Development Plan 2000–2006 (SERpro_SC, 2007) prioritizing access to water for maize producers who had been under increased competition for irrigation water with the industrial sector within the state.

In 2000 Chapingo Autonomous University organized a conference on Conservation Tillage, that allowed politicians, interested researchers and the private sector to meet, which led to a plan for a new CA initiative that was seen as having the potential to reduce competition for water resources between industry and agriculture and increase maize yields and productivity (SERpro_SC, 2007). Globally, CA was continuing to capture the attention of researchers and private sector partners, the later of whom had an interest promoting the machinery and herbicides needed to promote CA.

4.2.2. ASOSID: the formation of the multi-stakeholder platform

It took another two years of lobbying and negotiations to get the project proposal approved by the local Minister of Agriculture (SDAyR) in Guanajuato. CA was now labelled as ‘Direct Seeding’ (DS), a reference to
the experience of Monsanto in Argentina where well-organized farmers were using DS and financing their own technical assistance, a model that resonated with researchers, the Ministry and the private sector.

By 2002 Innovation System (IS) thinking, in which multi-stakeholder platforms and involving various actors as active participants plays a central role, had entered the scientific domain (Hall, 2007; Triomphe, 2012). Wishing to pioneer IS, the CIRAD-CIMMYT researchers took up the role of broker: bringing together the various stakeholders and coordinating the process. Some farmers from the Irrigation District 011 (DR011), mostly commercial ones with some access to machinery, were invited to participate. These farmers were conveniently close to the access to machinery, were invited to participate. Some farmers from the Irrigation District 011 (DR011), mostly commercial ones with some access to machinery, were invited to participate. These farmers were conveniently close to the access to machinery, were invited to participate.

By the end of 2005, with the Guanajuato-state elections coming up, political interest in supporting ASOSID was waning. When the new government took power in the following year, it reduced financial support to ASOSID which, effectively, meant the end of the DS initiative in Guanajuato. ASOSID’s president, the more recently hired technicians, and FIRA had already abandoned ASOSID. Only some of the technicians who were the first to be hired, and the farmers continued.

4.2.3. The disintegration of ASOSID
Soon after the project started the first differences in perspectives and expectations of the actors emerged. From the beginning some questioned the role and intentions of Monsanto and when a former Monsanto employee became the first president of ASOSID in 2003 this added to the tension. Another issue was the scale of the project’s activities. The CIRAD-CIMMYT researchers wanted to work with a limited number of farming groups to establish a collective learning culture. The government wanted a large impact and expected the 23,000 farmers of the DR011 to use DS by 2006. Tensions over these two issues led to all the researchers leaving the project in 2003.

4.2.4. The state of Conservation Agriculture after ‘phase 2’
An evaluation study from 2007 shows that 67 farmers were involved in ASOSID at the end of the project. We found only one report referring to the DS project and ASOSID (SERpro_SC, 2007) and a literature search yielded three scientific publications which briefly mention ASOSID and DS in Guanajuato. The results show that DS required one tillage in winter and superficial ploughing to incorporate crop residues in the spring-summer. DS did not significantly increase yields but did reduce tillage costs by around a third (see Table 1).

4.3. The third introduction: Conservation Agriculture in Michoacán (2005–2017)
4.3.1. The first CA project in Michoacán (2006–2008)
In Michoacán, the neighbouring state to Guanajuato, government officials within FUPROMICH had heard about DS technology and the ASOSID platform and arranged for a group of around 20 farmers from the Rural Development District (DDR092) to visit the DR011 farmers to see DS practices in the field. They liked the project and, at a public meeting, challenged the government officials to instigate a similar programme in their area by enouncing ‘Yes, sure, we like the project we visited. But now, what are you going to do so we can learn to apply the direct seeding...’
technology as well? Consequently, the CA technology fitted the political agenda of FUPROMICH’s leaders (for much the same reasons as it had appealed to those in Guanajuato) so they took up the challenge and hired five former ASOSID technicians from Guanajuato (that later constituted an organization called ‘AGRODESA’) to work under the guidance of researchers from INIFAP-Michoacán. This initiative included a crop rotation with a legume in order to improve the soil and was labelled as the CA project (Fundación Produce Michoacán A.C., 2011).

The initiative was officially launched in 2006, with an emphasis on adapting CA to local conditions, rather than on research. Each of the 100 participating farmers committed himself to have ‘an experimental field’ of one hectare under CA for at least three years, as previous experience had shown that CA would have no immediate effects on yields. The five AGRODESA technicians lived in the farming communities, so they could readily attend to farmers’ requests for support and the INIFAP researchers could be called upon when needed. The farmers would ideally need seven different pieces of machinery to implement the CA package: a tractor, a laser leveller, a mulch slasher, a sower, a threshing machine, a baler and a tractor sprayer and FUPROMICH negotiated state subsidies for small groups (of three to four farmers) to purchase at least two different machines for CA, which they could then share.

4.3.2. The follow up project (2008 –2010)
Two years later, in 2008, the PRD party came into power in Michoacán and reduced FUPROMICH’s budget. Nevertheless, the new state government was still attracted by the CA technology and decided to fund a project under their ‘Sistema Producto Maíz’ initiative that targeted maize-farmers in both the irrigated and the rain-fed regions of Michoacán and coordinated by the Chapingo Autonomous University. The AGRODESA technicians accepted the invitation to implement the project on condition that they could continue to work with their model of working with farmer-groups. This allowed them to continue their work with the five DDR092 farming communities and they proposed that one of the former FUPROMICH officials become their administrative coordinator.

4.3.3. The state of Conservation Agriculture after ‘phase 3’
Since the project now also targeted rain-fed maize production and included a legume rotation element, the project was now working with increasingly diverse agro-ecological and socio-economic contexts. While the project’s emphasis was on extension, rather than research, there were also knowledge gaps to fill, such as how to accommodate the practice of making beds on hill slopes. In the irrigated areas, occasional soil tillage was needed in the later years to facilitate irrigation. Reported results showed zero to significantly positive effects on maize yields, and a 20% reduction in costs of tillage (Table 1). Up to 100 farmers had been participating in the two years of the project. We found no project reports or scientific papers relating to the project that describe the use of machinery or the adoption of CA practices.

4.4. The incorporation into MasAgro
4.4.1. The encounter with MasAgro
In 2010 a new government official took over the responsibility for the CA ‘Sistema Producto Maíz’ project, and cut the project’s budget, leaving AGRODESA with just enough funds to sustain its work in Indaparapeo, one of the five initial farming communities of the DDR092. In that same year, some of these farmers and an AGRODESA technician visited an agricultural fair in Sinaloa state where they attended a public presentation by the leader of the MasAgro project that showed the places in Mexico where MasAgro was working on CA. The farmers from Indaparapeo asked: What about us? Why aren’t we on your map? We’re also doing CA! Come and see what we are doing. This public challenging of politicians and researchers once again proved to be a very effective way for farmers to get their voices heard and led to the project in Indaparapeo becoming part of MasAgro, of which it remains a part to this day (CIMMYT, 2018). In a MasAgro-reflection meeting in 2014 the Indaparapeo farmers recalled their long-standing experience with CA technology, saying that MasAgro is only from yesterday, we have been doing CA for a long time.

The MasAgro project today, like many other CA-labelled interventions, fits the broader concept and strategy of SI (CIMMYT, 2017; Curiel, 2016). As with the other CA-like interventions we have described, MasAgro is framed around food security, reducing maize imports (symbolic of national sovereignty) and climate change. Three events were key to the Mexican government establishing the MasAgro project in 2010. First, there was the price increase of maize on the world market due to the biofuel boom
in the US (Ogle, 2013). Mexico, importing yellow maize for poultry and industrial uses, now saw rising prices for white maize as well as it had partially replaced the use of yellow maize. This led to the ‘tortilla crisis’ of 2007. Then, in 2009 national maize production was affected by the severest drought in 60 years and the year after by unusually high rainfall (Caballero, 2012; Seager et al., 2009; Tirado & Cotter, 2010).

4.4.2. The state of Conservation Agriculture as at present
MasAgro, at the time of writing, is still functioning after eight years and has expanded to many parts of Mexico. It is based on innovation system thinking, combining research and development with multi-stakeholder approaches (Camacho-Villa et al., 2016). Conservation Agriculture is an important element of the technology menu that the programme offers to Mexican farmers involved with irrigated and rain-fed maize and wheat production. Five journal papers and four working papers have thus far been published on CA-MasAgro. These papers, together with other research on CA in Mexico, show that CA has the potential to increase yields and brings economic benefits to farmers. According to the most recent National Agricultural Census (INEGI and SAGARPA, 2015), there are 9,403,672 ha in Mexico under CA. An extrapolation of these data suggests that 1.3 million farmers (34.2% of the agricultural area in Mexico), may be using one form of CA or another.

5. Discussion

5.1. Conservation Agriculture technology as a boundary object
We have analysed different project interventions in the Bajío region over a period of 30 years by considering CA-label as a boundary object. We have shown how CA has moved from one space to another, with the principal actors re-arranging their engagement with it and changing its shape, according to research and political priorities, funding opportunities and the chance to build alliances. The changing labels given to the technology illustrate these changes: ‘Conservation Tillage’ became ‘Direct Seeding’ and then ‘Conservation Agriculture’. Along with the names, there were changes in the narratives and practices. It was initially presented in 1987 as Conservation Tillage: a combination of reduced tillage and the use of crop mulches that would increase maize yields and income of smallholder maize farmers in rain-fed areas. Later it was promoted in order to make maize-farmers internationally more competitive and to use irrigation water more effectively. As time passed CA moved from experimental treatments to technologies that were applied by farmers’, it became increasingly clear that variations in agro-ecological and socio-economic conditions demanded site and farmer-specific adaptations. At this point the difficulties in adapting CA to smallholder farming on rain-fed hilly land became apparent. This led CA researchers to target farmers in irrigated areas, raising the need for farmers to have access to tractors and other specialized machinery. Later, in the 2000s in Guanajuato, CA was rebranded as Direct Seeding: with no tillage at all and (as yet) no crop rotation, although researchers were starting to investigate this. This form of CA required specific machinery for sowing and preparing the mulch. Later, in Michoacán, the package was promoted as Conservation Agriculture and now included crop rotation. Finally, CA in MasAgro gave place to the concept of the Sustainable Intensification package in Mexico.

5.2. Alliances and dependency
In each of the projects, we saw how CA met the agendas of researchers, politicians, technicians, farmers and sometimes agro industry and led these actors to become partners in CA projects. The alliances were relatively easily welded, because there was a flexibility in the wording of CA technology (creating a narrative that justified the project, technology and project label) and in how it was practiced that allowed it to meet the interests of the partners and to achieve their goals.

Researchers from national and international institutes teamed up in their effort to mobilize resources from the federal and state governments to advance their scientific agenda. In addition to labelling and practicing CA with the newest vocabulary, and using emerging insights from agronomic and economic research, they also wove in new approaches to technology development: on-farm research, farming systems research and innovation system thinking with multi-stakeholder platforms. These changes in labels and approaches reflect the efforts that researchers (like us) make to keep ourselves at the frontier of scientific advances; in this case responding to the evolving discussions around CA, both as a specific
technology and in relation to agricultural technology development in general.

For politicians, the change of project labels was a useful way of distinguishing themselves from their predecessors, allowing them to approach the electorate with new priorities, narratives and vocabularies. The ‘moldability’ of the CA technology fitted very well with this picture: the new projects were able to claim different benefits from applying CA, depending on the context. It was adapted to maize and other crops, irrigated and rain-fed regimes, different types of farmers and to a range of environmental, sustainability and socio-economic challenges, such as NAFTA and climate change. This made the CA projects not only relevant for the agricultural sector, but also allowed it to reflect broader political issues and for politicians to show commitment to farmers and broader societal issues. It allowed politicians to legitimately subsidize farmers to acquire machinery, which farmers saw as a strong sign of support from their governments. In other words, the researchers and politicians needed each other and in the CA initiatives they found each other working together repeatedly, in new forms, under different labels and following different narratives. In the last case, Michoacán, the technicians and farmers became important active players. They learned to play the rules of the game and were able make use of opportunities provided by a change of government, the replacement of an important government official or a public presentation by a renowned international scientist. It allowed technicians to find continued funding of their activities and farmers to access inputs and machinery.

### 5.3. Continuities and discontinuities

Because of the relationships between the actors were tied to changes in the political scenery, these alliances had a relatively short lifespan. None of the projects lasted more than five years, with the exception of MasAgro, the only one that sustained changes in government. In each of the other projects, the life cycle was defined by elections and changes in political priorities that either led to the start of a new project or to the reduction of funding of an existing project to the point where it was no longer viable. This dynamic meant discontinuity for the agenda of the researchers and technicians who were always in need of more time to configure the right form for CA or integrate it into a context for specific farmers. After spending considerable time and effort in liaising with farmers, gaining their confidence and setting up participatory working modes, they were forced to look for other spaces and other potential sources for funding. In some instances, such as Michoacán, they were successful and the same technicians were able to continue working with farmers from the same farming community. In other cases, they had to start a new configuration, which happened in Guanajuato, Jalisco and even Michoacán (in the FUPROMICH and Chapingo interventions). This said, it was not so difficult to find farmers interested in participating because CA training came with a range of benefits: inputs, advice and support in getting machinery. Thus, these projects had clearly time-defined boundaries, set by the start and end of funding, which created discontinuities. Yet the boundaries between these interventions were vague and there was continuity in the process of researching and promoting CA technology. Long (2001, p. 34) has highlighted the linkages between a series of interventions, with later ones carrying the history and experience of earlier events and actors. In our case, the researchers were the main drivers of the continuity, taking the legacy of CA from one area to another. In Michoacán, this led to a situation where the MasAgro researchers were able to build on the earlier CA experiences of technicians and farmers, derived from other projects.

### 6. Conclusions

We have studied a technology development trajectory that consisted of multiple project interventions creating a lengthy process of apparent discontinuities, underpinned by an invisible continuity of actors organizing themselves around CA projects. By analysing the social life around the technology, we have been able to answer questions relating to who ‘owned’ the intervention, which agendas were being addressed and how the narratives were used to frame support for the interventions. This helps us to explain why particular research activities or technologies prevailed over others (Andersson & Sumberg, 2017).

In each of the cases researchers, politicians, technicians and farmers created spaces for joint CA projects. These actors shared an interest in CA projects, although for different reasons. Researchers need politicians to fund their research. This forces them to present technologies, such as CA, in ways that fit prevailing political agendas. Politicians need to be seen to be serving their constituencies. CA provided
employment for technicians and, in some cases, this benefited farmers through technical advice, machinery or agricultural inputs.

Our study shows how agricultural technology development is not an independent technical process driven by ‘advances’ made by researchers or the impact of a technology on crop yields and farmers’ incomes. In our case, it was the different motivations and agendas of researchers, politicians, technicians and farmers that resulted in a shared interest in CA projects. The fact that CA projects were successful in addressing these diverse agendas may explain the repeated re-invention of project interventions. They are part of a process of ‘musical chairs’, driven by the players, each with their own interests, who came together to ‘play the game’ of sharing a project. Regardless of the project’s performance, our players always found a place to fit in and to keep on playing.

To be able to say something about the actual performance of the projects and technologies, we would need more scientific and published evidence about how CA affected productivity and farmer’s livelihoods. One of the criticisms of CA has been the dogmatic way in which it has been promoted, especially in Africa (Andersson & Giller, 2012). In our case, CA evolved to fit with the SI narrative that is even more flexible and conceptually wider, meaning that more farmers can be linked to the CA/SI narrative not because more farmers changed their practices but rather because what they practice already is being incorporated into wider contours of this concept.

We want to emphasize that this study and reflection on the politics of CA is not intended as a criticism of individual researchers, politicians, technicians or farmers. We ourselves are part of this world and this study has (once again) made us aware of the dynamics in which we are caught and which, at the same time, we maintain. We note, as shown by Camacho-Villa et al. (2016), that the current coordinators of MasAgro also experienced the need for the time, energy and capacity to manoeuvre politically to mobilize resources and pursue continuity.

Notes

1. MasAgro has four components: (1) MasAgro Biodiversity; (2) MasAgro Farmer; (3) MasAgro Maize; and (4) MasAgro Wheat. In this paper we focus on MasAgro Farmer and therefore, when we use the word “MasAgro”, we specifically refer to this project component specifically (For further information: https://www.cimmyt.org/project-profile/sustainable-modernization-of-traditional-agriculture/)

2. The information gathered is stored in Mendeley reference manager and can be accessed from the authors on request.

3. NAFTA is the “free trade agreement between Mexico, the USA and Canada. It eliminated all trade and investment barriers and secure equal treatment for foreign investors in energy, telecommunications, banking and financial services and procurement” (Ramirez, 2003). It promised 15-years of phased trade liberalisation for vulnerable sectors, such a maize and bean producers (Yunez-Naude & Barceinas, 2002).

4. They were from PAN (Partido de Acción Nacional) which in 2000, dislodged PRI (Partido Revolucionario Institucional) after it had enjoyed seventy years in power.

5. By 2000, six years after NAFTA was signed, it was clear that the agreement and the promises to support Mexican farmers were not working out as expected. The Mexican government had agreed to protect maize farmers for a period of 15 years through the establishment of Tariff Rate Quotas (TRQ), market price guarantees and programmes such as PROCAMPO and Alianza Para el Campo. However, the TRQ were not implemented as agreed, resulting in an increase on maize imports (Sweeney, Steigerwald, Davenport, & Eakin, 2013; Sumberg, Thompson, & Woodhouse, 2013; Yunez-Naude & Barceinas, 2002) and a reduction in the prices that Mexican farmers received for maize.

6. Fundación Produce Michoacán (FUPROMICH) and Rural Development District 092 (DDR092).

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