

How and Why the Brazilian Zero Tillage Explosion Occurred

John N. Landers*

ABSTRACT

A complex institutional framework underpinned the exponential expansion of Zero Tillage (ZT) in Brazil to 8.7 million hectares in 1997/8, preponderantly in the medium/large mechanized farm sector. Expansion was predicated on (i) farm-tested and cost-effective technology, (ii) awareness of benefits, (iii) technical training (iv) removal of serious soil physical and chemical constraints and problem weeds, (v) availability of cover crop seeds, (vi) credit or small grants for small farmers and (vii) enabling legislation for community management of micro-catchments. Farmer organizations led the formation of the National Federation for Direct Planting into Crop Residues (FEBRAPDP) in 1992, which has acted as a country-wide facilitator for ZT adoption. Farmer-to-farmer contact with integrated support from private sector, NGOs, government, and some international agencies were the prime factors in dissemination. Farmer involvement has led to substantial improvements in the delivery of agricultural services and government support has been essential in the small farm sector. ZT is based on permanent soil cover with crop residues, pre-plant desiccation of weeds, crop rotations including cover crops, specialized planters/drills, maximization of biological activity and enhanced management capabilities of the farmer, leading to environmental responsibility. Besides reducing soil erosion losses by up to 90%, and substantially improving rainfall infiltration rates, ZT generates a series of direct and indirect benefits both to the farmer and society (Landers, 1996). The downstream gains to society, mostly generated by the farmers' own resources, merit greater public investment in dissemination of ZT. This is the gateway to sustainable intensification of natural resources management. But recognition of society's co-responsibility for natural resource degradation and the ZT farmers' role in reversing this is crucial to this achievement and not yet effective.

INTRODUCTION

Zero tillage (ZT) in Brazil is a story of farmer-led technological evolution and integration. Through persistence and collaboration, all challenges to its sustainability in the humid sub-tropics and humid wet-dry tropics of Brazil have so far been resolved. Results in the humid tropics are promising. This paper presents an analysis of the principles, impacts, dissemination and adoption of this new technology. From 1972, the ZT area grew to 8.7 million hectares (Figure

1), over 20% of the area of annual summer crops in 1997/8. The reasons behind this growth will be examined.

HISTORICAL BACKGROUND

The early development of ZT was spurred by excessive erosion losses and credit restrictions. Continuous ZT at farm level started in 1972, in Rolândia, Paraná State (PR). In response to the practical needs of farmers for ready-to-go technology, farmer organization to develop and promote the new system started in 1979 with the Earthworm Club, in the Ponta Grossa region, Paraná State, evolving to the ABC Foundation in 1984 (Borges, 1993). The Friends of the Land Clubs (CAT) movement started in Rio Grande do Sul State (RS) in 1982 (Borges, 1993) and today there are 43 clubs in the CONCAT. In 1992, FEBRAPDP and APDC were formed independently, with immediate affiliation of the latter to FEBRAPDP, followed by the formation of state associations and an expansion of CATs into the rest of Brazil.

Although isolated tests began from 1969 onwards in southern Brazil (Borges, 1993), research trials began in PR in 1971, with the support of GTZ (Derpsch, 1998), from which derived the first publication on MiT (Ramos, 1976). This work, plus interchanges with scientists from the USA and the signing of a 1976 research agreement between ICI do Brazil and IAPAR renewed in 1981, were fundamental in consolidating early research efforts. A state-of-the-art publication followed (IAPAR, 1981) and the Embrapa Wheat Center, Passo Fundo, RS, imported planters/drills from the USA in 1975, which formed the basis for the modern Brazilian machines (Herbert Bartz, personal communication, 1999), accompanied by research on cover crops, rotations, plant pathology, and other aspects of ZT. Later, adaptive research was carried out by farmer-owned foundations, of which the two most important were the ABC Foundation, Castro, PR and FUNDACEP Foundation, Cruz Alta, RS, followed by many others.

In 1977, the Embrapa Soybean Center promoted the first research meeting on ZT in Londrina, PR (IAPAR, 1981) and farmer- and agronomist-organized technical meetings, with private sector and increasing official support, proliferated from 1981 onwards, starting with three national events in Ponta Grossa, PR (1981, 1983 and 1985), continued in Cruz Alta, RS (1994), in Goiânia, Goiás State (1996) and in Brasília, Federal District (1998), the last three promoted by FEBRAPDP and organized by CAT Cruz Alta RS and APDC. In the 90's, a number of ZT scientific events, and many other local events, stimulated adoption, research and

*Federação Brasileira de Plantio Direto na Palha Non-Government Organization Representing FEBRAPDP (Federação Brasileira de Plantio Direto na Palha). Home address: MUDB, Conjunto 9, Lote 5, cep 71680-090 – Brasília - DF, Brazil. john.landlers@apis.com.br

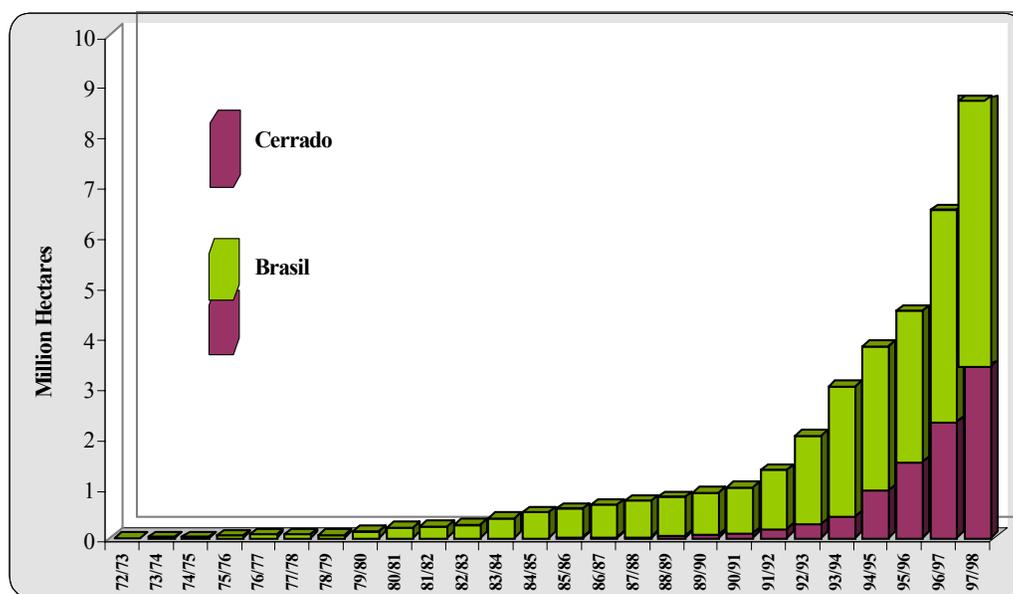


Figure 1. Expansion of the zero tillage area in Brazil and in the “Cerrado” region (tropical wet/dry savannahs) Sources: Brazil - FEBRAPDP and Cerrado - APDC

Table 1. The phases of zero tillage development in Brazil.

PIIONEER PHASE	Sub-tropical (mechanized)	Sub-tropic. Small	Tropics (mechanized)
On-farm technology development by few farmers Little expansion. Beginnings of research. No extension Private sector support. Testing of cover crops. Beginning of ZT farmer organisation and dissemination events.	1972-1984	1985-1991	1981-1986
CONSOLIDATION PHASE			
Improvements in technology, better planters, more weed control and cover crop options. Early fertiliser lime recommendation under ZT. Costs approaching CT expansion slow, little extension and formal teaching.	1985-1990	1992-1996	1987-1992
MASS ACTION PHASE			
Costs below CT. Increasing adoption by extension in teaching curricula. Technology refinements and wide range of research recommendations. Incentives limited to small/medium farmers. Significant private sector support. Rapid expansion – NGO network with private and public sector.	1991-2000	1997-2010	1993-2000
DOMINANT PHASE			
ZT as the norm. Full research priority to avoid second generation problems. NGO network active in on-farm R&D and professional ZT training. Widespread adoption by extensionists and teaching establishments. Incentives to intensification in Zero Tillage	2001 - 2100	2010 – 2100	2001 - 2100

on-farm development by farmers. ZT development is reviewed in Table 1.

From 1981 onwards, there was a northward technology transfer of the basic principles of ZT, through migrating farmers and technical interchanges, from sub-tropical to tropical Brazil. But the agronomics of a warm, dry tropical winter versus a cold wet sub-tropical one, with frost, had to be worked out (Landers Ed.; 1994). The major desiccant herbicide firms, Monsanto, Zeneca, BASF, Dow Agrosiences, and others carried out extensive field trials and demonstrations, accelerating these in the 90’s. In 1992, the ZT Promotion Group was formed, now with ten major

input and machinery firms, specifically to promote ZT, chiefly through farmer organizations, with foundations, co-operatives and CATs increasingly involved in on-farm research/development and technology transfer. Notable contributions to tropical ZT technology have been from on-farm programs undertaken by CIRAD–CA (Centro de Cooperacin Internacional Reserche Agronomy per le Developpament – Culturas Annulles) and its various collaborators (Séguy et al. 1998b), Sementes Bandeirantes (millet and pigeon pea breeding), Manah S.A. (Vasconcelos and Landers, 1993), Monsanto and other private sector efforts.

By about 1992, there was enough small farmer technology proven on-farm for extension services in RS, SC (Santa Catarina State), PR to begin technology transfer to the small farm sector, as evidenced by the first and third Latin American meetings on ZT in small farms. A FEBRAPDP/IAPAR/EMATER-PR (Empresa de Assistência Técnica e Extensão Rural do Paraná) initiative in 1992 distributed 30 animal traction planters to small farmers; the results were so good that between 1993 and 1996 nearly 2000 animal traction planters were sold by 7 different manufacturers in PR, SC and RS (Darolt, 1998).

Although at first lagging on farmers' initiatives, the public research and development effort on ZT, comprising Embrapa centers, universities and state research organizations, has now become a driving force.

TECHNICAL, ECONOMIC AND SOCIAL ASPECTS OF ZERO TILLAGE

In Brazil, CT (Conventional Tillage), predominantly with offset disks and disk plows, leaves the soil surface exposed to heavy rains and insolation, while the use of incorporated pre-plant, selective herbicides in soybeans encouraged excessive tillage to promote herbicide efficiency. The window of ideal moisture conditions for tillage was too small for the farmer's equipment capacity, leading to soil preparation under unfavourable conditions for structure maintenance. With CT, water-stable soil aggregates, and infiltration rates decline (Freitas, 1994), as shown in Figure 2, while Fabrizio et al. (1999) showed an infiltration rate of 8.5 times CT on a dystrophic tropical red latosol after 5 years of ZT, following 10 of CT. Rapid organic matter decline in tropical soils under CT has been shown by Silva et al. (1994). The effects of ZT in reversing the degradation of soils caused by CT have become evident. Sá (1993) showed long-term organic matter gains under ZT on subtropical soils

and Bayer et al. corroborated this showing higher levels of total carbon under ZT (Figure 3).

Using ZT technology, pre-plant herbicides eliminate all soil movement, leaving protective crop (and weed) residues on the surface. Specialized ZT planters/drills slot the seed and fertilizer into the soil, through the relatively undisturbed cover. Principal crops under ZT in medium-to-large mechanized farms are Soybeans (*Glycine max* (L.) Merrill.), corn (*Zea mays* L.), edible beans (*Phaseolus vulgaris* L.), spring wheat (*Triticum aestivum* L. emend. Fiori et Paol.), irrigated and upland rice (*Oryza sativa* L.) and on a lesser scale, cotton (*Gossypium hirsutum* L.) (Séguy et al. 1998a). Generally on smaller farms, tobacco (*Nicotiana tabacum* L.), onions (*Allium cepa* L.) tomatoes (*Lycopersicon esculentum* Miller nom. cons.) and tree crops are transplanted with ZT or MiT. Principal cover crops in the sub-tropics are black oats (*Avena strigosa* Schreber), Italian rye grass (*Lolium italicum* Lam.), hairy vetch (*Vicia vellosa*, Roth) mucuna (*Mucuna pruriens* Piper et Tracy, Holland), corn spurrey (*Spergula* sp), forage turnip (*Raphanus sativus* L.), and three lupin species (*Lupinus albus*, L., *L. luteus*, L. and *L. angustifolia*, L.). In the tropics, cover crops are limited to millet (*Pennisetum americanum* (L.) Leake), sorghum (*Sorghum bicolor* (L.) Moench.) and forage turnip, while pigeon pea (*Cajanus cajan* L. Millsp.) is used in pasture renovation. Over-seeding is used with millet, black oats and sorghum into soybean, planting up to 20 days pre-harvest.

Related soil management technologies practiced in Brazil on a lesser scale are: (i) strip till (ST) with animal traction, (ii) MiT followed by ZT in irrigated rice (Mello, 1994), (iii) mechanized MiT with a chisel plow or sub-soiler plus planter attachments and trash disc or (iv) MiT with a closed levelling disc over broadcast cover crop seeds. ST in the plant year followed by ZT has been initiated recently

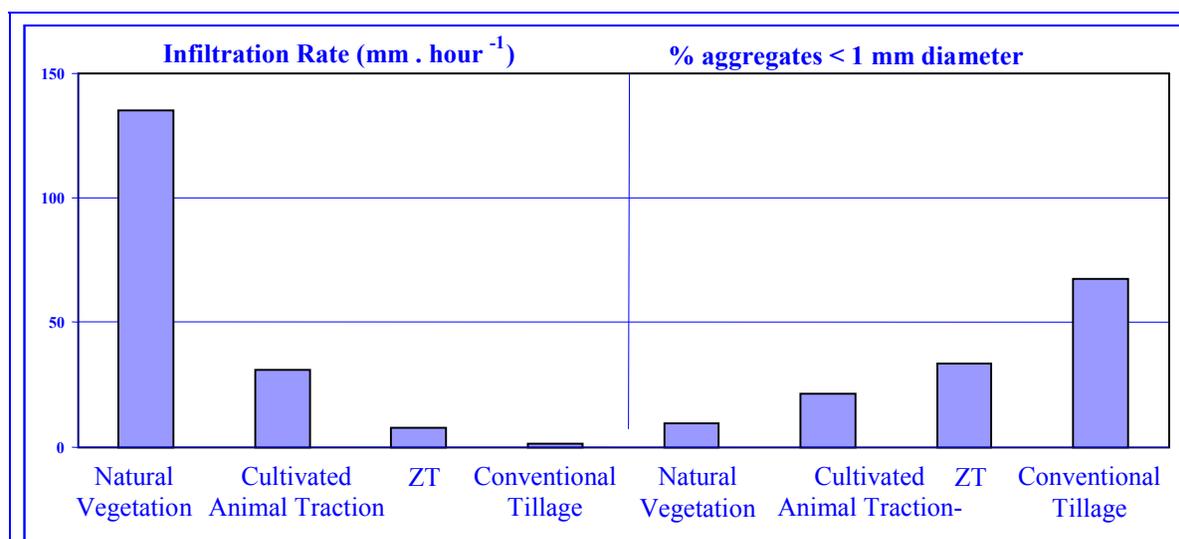


Figure 2. Infiltration rate and percentage of water-stable aggregates <1-mm diameter under different soil use and management systems. Source: Freitas, P.L. in Landers Ed., 1994.

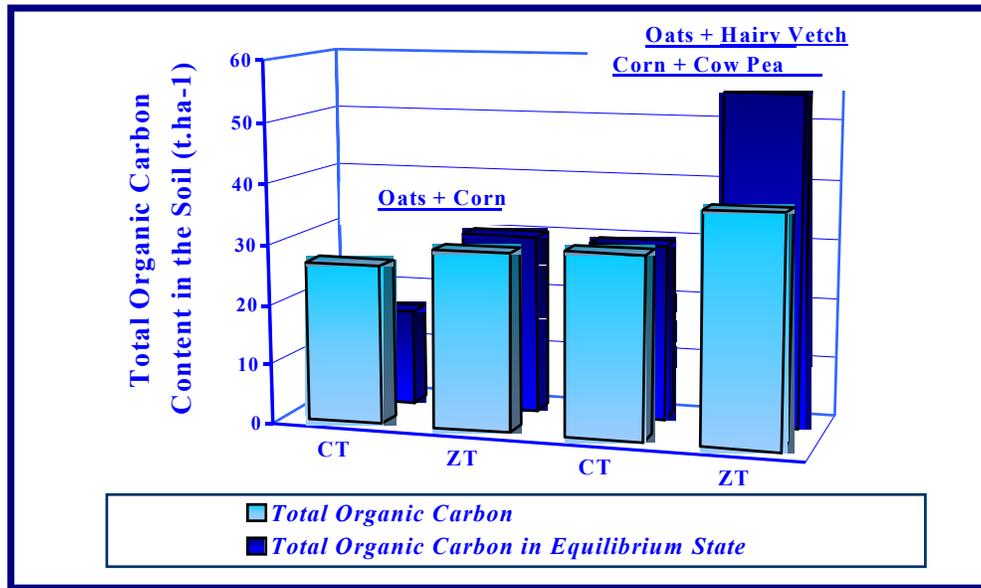


Figure 3. Combined effect of soil tillage and crop rotation on soil organic carbon content.
Source : based on Bayer et al., (1996).

in sugar cane (*Saccharum officinalis* L.) coffee (*Coffea arabica* L.) and other tree crops. Examples of new, cost-efficient, practices are: (i) fertilization of the cover crop to reduce main crop planting time, (ii) surface application of lime and fertilizer, (iii) on-farm fertilizer calibration (iv) heavy cover crops to reduce or eliminate post-emergent herbicide requirements, (v) Baculovirus biological control of caterpillars (Herbert Bartz, on 500ha in Rolândia PR, Brazil, has not used aerial-applied insecticides since 1983), (vi) increase of cropping intensity with second cropping (wet-dry tropical region), (vii) reductions in water use under irrigation, (viii) reductions in herbicide and insecticide applications through higher application precision and selective use, and. (viii) use of legume cover crops to supply nitrogen.

Within the concept of ZT as a system, research was necessary on biological and rotational controls to counter enhanced susceptibility to certain diseases (Reis, 1995) and pests (Gassen, 1995), clearly focused crop selection for climatic adaptation (especially for the tropics) and new diseases (Spehar, 1995), new alternatives for cover and cash crops to improve rotations (Derpsch et al 1991; Calegari, 1998; Neto, 1995); revision of fertilizer and lime recommendations (Anghinoni, 1995; Pöttker, 1995; Rizardi, 1995; Sá, 1993); soil physical conditions were studied by Blancaneaux, Ed. (1998), Ruedell (1994), Castro et al. (1987). Planter design improvements were led by the guillotine disk cleaner, a principle invented by a farmer in RS. Animal-drawn and manual jab planters/drills, sprayers and small Argentine rolls were adapted for small farmers (Casão Junior, R. et al., 1985, Ribeiro et al., 1993), weed control methods and mechanisms were developed and herbicides tested (Almeida, in IAPAR, 1981; Velloso, 1993; Neto, 1995, Embrapa Soja, 2000). Muzilli et al.(1994)

demonstrated a wheat yield increase of 25.7% when corn, a heavy residue generator, substituted soybeans in succession with this crop; this rose to a 37.5% yield advantage when soybeans alternated with corn in summer. The effects on corn and soybean yields under the latter system were increases of 24.4% and 24.3% respectively. In terms of disease resistance for ZT conditions,

Erosion Losses

As the agricultural frontier expanded outside the traditional areas of eutrophic soils with higher clay contents and lower erodibility, to more fragile podsolics, oxisols, quartz sands and cambisols of the new frontiers, soil degradation and erosion became serious limiting factors to sustainability. Contour banks and terraces merely checked overland flows, caused serious gullyng when they overtopped and did not prevent rills and sheet erosion on the exposed soil between the contours.

ZT has a marked influence in reducing erosion and increasing rainfall infiltration in both the sub-tropics and tropics (Table 2). Results of soil loss estimates with the USLE (Universal Soil Loss Equation) in the São Francisco valley (Chaves, et al., 1995), with very limited adoption of ZT, show erosion losses (correlated with sediment levels) varying from 2- 10 metric ton ha⁻¹ yr⁻¹ in the slope class 0-2 per cent, rising to 10-18 metric ton/ha/yr for slopes of 2-6 per cent. On clayey eutrophic soils, the reduction in soil loss with ZT was logarithmic, indicating a reduction in erosion susceptibility with time (Hernani, *et al.*, 1996). This can explain why farmers tend to remove contour banks against the advice of soil conservationists (Bertol, 1995) in order to plant in straight lines, without dead-ends. This is financially attractive, but probably underestimates the risks (with e.g. a 50-year storm). This question merits a reevaluation of

Table 2. Relative soil and water losses – zero tillage vs. conventional tillage.

Description	Soil Losses (metric ton/ha/year)			Water Losses (mm/ha/year)		
	CT	ZT	(% gain ZT/CT)	CT	ZT	(% gain ZT/CT)
Paraná State (1) (Ave of 12 yrs)	Sub-tropics					
Soybean/Wheat succession	26.4	3.3	87.5	666	225	66.2
Minas Gerais State (2) (11 mths.)	Tropics					
Soybeans	4.8	0.9	81.2	206	120	41.7
Corn	3 to 3.4	2.4	20 to 29	252 to 318	171	32 to 41

Sources: (1) Merten, 1996. (2) Santana, 1994

erosion factors as related to crop residue cover in land use capability classifications. For example, Ruedell (1994) cites erosion losses of 13.7-ton ha⁻¹ from bare soil and zero with 2.2 metric ton ha⁻¹ of dry matter as crop residues.

Benefits of ZT to the farmer

IAPAR (1981) showed that direct costs of ZT were 9.8 % and 7.8% higher than CT, in soybeans and corn respectively, but by the mid '90.s there were significant cost savings with ZT over CT, amounting to a reduction in costs of 19.8 % in a 2 year soybean/wheat/corn/oats rotation and 12.9 % for corn in PR (Guerra, 1997). And while the pioneers in the 70's and early 80's suffered yield penalties (Bartz, 1994), Bragagnolo et al. (1997) showed gains in 4-year average yields (1990-1993) on 120 micro-catchments in PR of (i) 60-65% in edible beans, (ii) 87% in corn, (iii) 26% in soybeans and (iv) 61% in wheat. These differences are principally due to ZT adoption and the higher management levels that going *through the ZT gateway* entrains.

Mello (1995) demonstrated the viability of ZT soybeans seeded into native pasture in RS with a 2700 kg ha⁻¹ yield; profits of US\$400 ha⁻¹ year⁻¹ were also reported for a soybean/wheat rotation with oats for winter forage and Broch (1998) showed similar results for crop x pasture rotations in the tropics. Financial analysis of a large mechanized dryland operation, planting 2 years soybean and one year of corn, without second cropping, indicated internal rates of return of 15% for ZT as compared to 5% for CT, in spite of little difference in direct costs at that time; fewer tractor drivers reduced total payroll costs by 30% (Landers, Teixeira and Milhomem, 1994). Medium term reductions in machinery replacement costs are generated by lower machinery investment with ZT, estimated at 47% less by Gentil (1995). An average reduction of 44% in tractor hp ha⁻¹, with dryland indices for ZT ranging from 0.26 to 0.40 hp ha⁻¹ and 0.32 to 0.54 hp ha⁻¹ for irrigated conditions, were reported in the wet-dry tropics (Landers, Ed., 1994). Mello (1995) measured reductions from 1.6 hp ha⁻¹ with CT to 0.85 hp ha⁻¹ for ZT in the humid sub-tropics.

In soybeans, for droughts over 25 days, enhanced drought resistance under ZT generates yield increases of up to 25%, or more, over CT (CAT Bom Jesus, GO, private communication, 1999). Reductions in water use of 25% were measured for an erect edible bean variety under irrigation and with a thick mulch versus no mulch (Stone and Moreira, 1998), corroborating farmer reports of improved water economy and yield advantages for ZT.

Additional benefits from adopting ZT are (i) earlier planting, (ii) greater efficiency and lower maintenance costs of machinery, (iii) more time for management decisions and technical upgrading, (iv) less dusty and muddy work environment, (v) more time for the family, (vi) less stress and (vii) greater satisfaction derived from caring for the environment. In a survey of small farmer ZT adoption, Darolt and Wall (1999) indicated the following benefits perceived by small farmers in South Brazil: (i) lower labor demand and less drudgery, (ii) ability to plant at the right time, (iii) better yields, (iv) control of erosion, (v) enterprise diversification and (vi) a future on the land for their grandchildren.

Economic Implications of ZT for society

With adverse agricultural and credit policies, coupled to unstable economic and climatic environments, adopting and creating more efficient ZT technology has been the Brazilian farmer's response to economic survival. The adoption of this technology is the gateway to full sustainability in modern Brazilian agriculture. Reinforcing this, Bale et al., (1997) in a World Bank dissemination note based on Landers (1996), stated: "*Direct drilling (i.e.ZT) is a practice with no substantial negative effects*"

The major part of ZT area adopted in Brazil was implemented with farmers' own resources. In Table 3 is a summary of benefits and economies for society as a whole, resulting from this. These benefits are so considerable that ZT merits policies of financial stimuli, which should not be classified as subsidies. So far in Brazil, these have been limited. Financial incentives for sustainable intensification of land use within existing frontiers can mitigate clearing of virgin land, using ZT as a strategy to regenerate degraded pastures through integration of crops and livestock. Society, which is benefiting from low costs of farm products, has a historical and ongoing co-responsibility to pay for preservation of natural resources. In Brazil, the fact that over one fifth of annual crops is under ZT has gone unnoticed by the urban society, much of whose effluents is discharged untreated into rivers or the sea.

ADOPTION AND TECHNOLOGY TRANSFER IN ZT

ZT is the GATEWAY to a fundamental change in base values, representing a qualitative leap in Brazilian agriculture, where the farmer progresses towards higher profits and greater environmental responsibility (Figure 4).

Table 3. Benefits Generated for Society by Adoption of zero tillage.

Reduction of silting in reservoirs, lakes and watercourses proportional to 70-90% less erosion (Chaves H.M.L in Saturnino and Landers, 1997) - a very conservative estimate of the annual value for the Cerrado region was given as 33 million US dollars per year (Landers, 1996);
Consequent reduction in the pollution and eutrophication of surface waters by agricultural chemicals carried in erosion runoff (Sorrenson and Montoya, 1984);
Substantial reduction in treatment costs of municipal water drawn from surface sources (Braganolo and Parchen, 1991);
Considerable reductions in maintenance costs of rural roads;
Reduced wear on hydro-electric turbines from the passage of cleaner water;
Flooding risks are reduced by 30-60% greater rainfall infiltration (Chaves,H.M.L in Saturnino and Landers, 1997) and delay to overland flows by surface residues, increasing times of concentration;
By the same token, aquifer recharge is enhanced, improving groundwater reserves and dry season flows in springs and streams;
Reductions in diesel fuel of 50 to 70%, or more, (Gentil <i>et al.</i> , 1993) and proportional reductions in greenhouse gas emissions;
ZT per se has a major impact in reducing carbon dioxide emissions when compared to Conventional Tillage, by immobilising carbon in incremental soil organic matter and surface residues (Derpsch,1997)
It is axiomatic that, by promoting high-yielding sustainable agriculture and increasing pasture carrying-capacity, through rotation with annual crops, ZT takes pressure off the demand for agricultural frontier expansion by deforestation;
Provision of winter feed (crop and weed seeds not incorporated) and shelter, lower soil temperatures and reduced water pollution levels increases populations of terrestrial, soil and aquatic fauna; a high-yielding, prosperous and sustainable agriculture ensures lower food costs and improved food security for the population as a whole.

Source: Adapted from Landers Ed., 1994 .

General pre-conditions for adoption are: (i) farm-tested technology and specialized planters/drills, (ii) awareness of benefits, (iii) technical training (iv) removal of serious soil physical and chemical constraints and problem weeds, (v) availability of cover crop seeds. (IAPAR, 1993) and (vi) enabling legislation for community management of micro-catchments. The principal mechanisms involved in the adoption of ZT are partially confounded. In all cases, farmer-to-farmer contact and field demonstrations have been the most effective; for medium/large mechanized farmers, private sector and NGO actions pre-dominated, while for small farmers, state extension services were most important. There is also a social conscience in the ZT movement, shown by technology transfer from large to small farmers, from south to north (last two national ZT meetings in the tropics) and from adopters to non-adopters. State extension and on-farm research is becoming more effective in the World Bank projects of South Brazil, where the principle of participatory planning on a micro-catchment basis has been introduced, as shown in Table 4. The three World Bank projects in RS, SC and PR states are examples of *de facto* agrarian reform; through appropriate ZT technology transfer and the investments required for intensification, the small farm has been made a viable unit. Small farm ZT adoption and on-farm research is only incipient in the rest of Brazil.

Darolt and Wall (1999) indicated the acquisition of specialized equipment, such as planters, drills, mini-Argentine rolls and sprayers, as a capital barrier to small farmer adoption of ZT, well addressed by World Bank projects in RS, SC and PR. Other constraints indicated were

the control of weeds during the adoption phase and adjusting to a more complex management system (including use of technology). In 1993, insufficient or no technical information was given by 74% of respondents as a reason for not adopting mechanized ZT in the tropics (Landers, Ed., 1994), underlining the importance of all forms of technology transfer. In the medium to large (mechanized) farm sector, private sector mechanisms, drawing on both official and private sector research and development results, have largely carried out technology transfer.

In this process, the involvement of agribusiness and farmer NGOs was fundamental, while isolated efforts by researchers or farmers did not cause notable impact until this dimension was added. Recent public/private sector partnerships have also been successful in southern Brazil, such as the METAS project in RS, in part responsible for the 2.8 million ha under ZT in that state in 1997/8 (Denardin, 1997 and EMATER-RS, 1998) and the PROPALHA project in SC, initiated in 1998.

RESEARCH AND DEVELOPMENT

ZT represented a breakthrough in erosion control, which encouraged further development of the technology and also promoted a farming system/interdisciplinary research approach, with more work on-farm. The principles of farmer-led innovation and technology demand has been the most efficient route to workable and profitable farming practices in ZT. Agronomic research in ZT is especially important in the post-adoption phase, when a new biological balance evolves (Gassen and Gassen, 1996). At the 6th National ZT event in 1996, the president of Embrapa

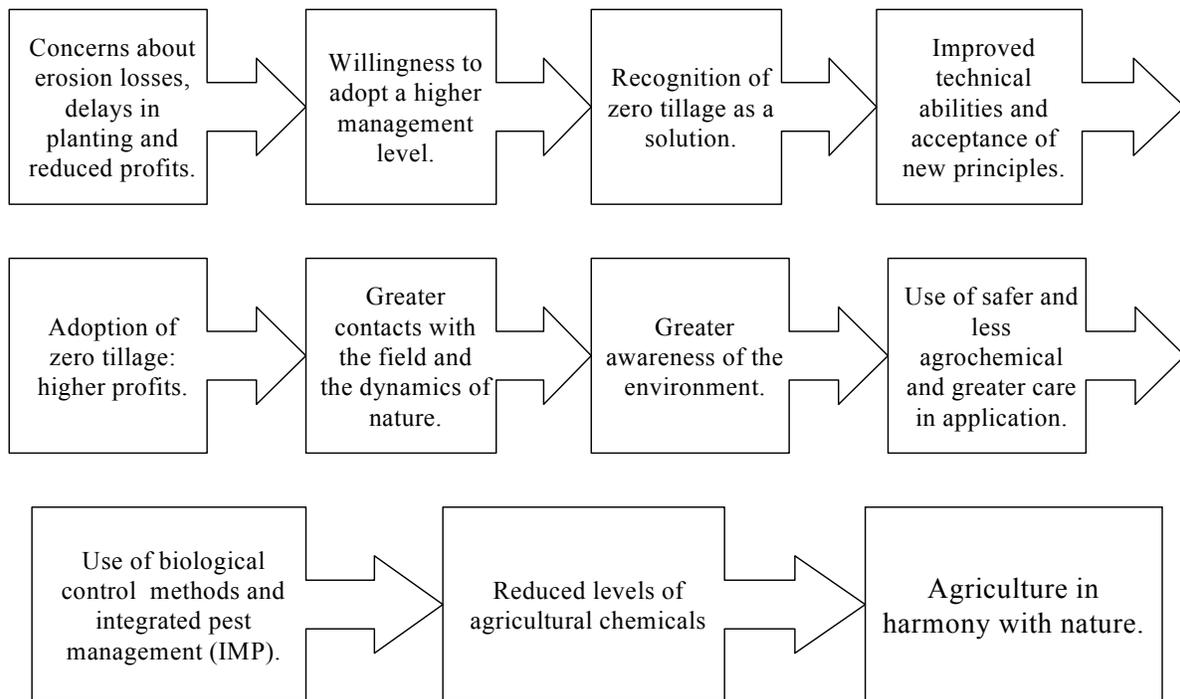


Figure 4: A management route to lower use of agricultural chemicals. Source: Landers, 1996.

Table 4. Actions in the development and dissemination of zero tillage and community management of other natural resources in a Pilot Micro-catchment in Ribeirão das Pedras, Santa Catarina State, Brazil

<u>1984 / 1985</u>	<u>1986</u>	<u>1987</u>
<ul style="list-style-type: none"> ▪ Field Tours ▪ Founding of watershed management commission 	<ul style="list-style-type: none"> ▪ Green Cover Observation Unit 	<ul style="list-style-type: none"> ▪ Implementation of the first ZT planting using animal draught
<p style="text-align: center;"><u>1988/1989/1990</u></p> <ul style="list-style-type: none"> ▪ Period of experience and adaptation of machines ▪ Development of ZT machines pulled by draught animal or tractor ▪ Improvement of MiT and ZT kits for micro-tractors 	<p style="text-align: center;"><u>1991/1992</u></p> <ul style="list-style-type: none"> ▪ Beginning of ZT planting system ▪ Continued adaptations ▪ 5 % adoption of ZT 	<p style="text-align: center;"><u>1993/1994</u></p> <ul style="list-style-type: none"> ▪ Increase in the ZT area ▪ Acquisition of machines, either individual or in groups ▪ Adoption of ZT in 1995 over 80%

Source: adapted from Freitas, V.H. (1997)

indicated that research had lagged on the farmer and exhorted his researchers to catch up (Portugal, 1997). Today, both the Embrapa Wheat Center (Passo Fundo, RS) and the Embrapa West Regional Center (Dourados, MS) have adopted ZT as the norm for experimentation. Collaboration between farmers, researchers and manufacturers has led to many improvements in planter design (Sattler, 1995, Ribeiro et al., 1993).

The time frame for change was much greater for researchers, academics and extensionists than that of farmers, and farmer practice has often been ahead of research. In economic terms of marginal satisfaction, the farmer sees immediate benefits over and above the cost of change, while the professionals cited see a positive cost in

the effort of change and no foreseeable economic benefits accruing to this extra effort. They must be motivated by non-financial stimuli, which takes longer. Research on second phase problems provoked under ZT conditions is now a priority.

The Institutional Framework for ZT Dissemination

The complex institutional framework, which surrounds the Brazilian farmer, through which actions in support of ZT flow, is shown in Figure 5. This demonstrates an inner circle of organizations in which the farmer has significant control and an outer circle where the farmer has little or no direct control over priorities and actions. FEBRAPDP has been, since 1992, a constant facilitator and promoter of ZT

through its 60 member organizations, more especially the CONCAT in RS and APDC in the Cerrado region. Figure 6 shows how the Brazilian NGO network is organized and linked to other organizations in the Americas.

The Friends of the Land Clubs represent the local units of this NGO network and are cited as a practical bottom-up solution to the adoption and improvement of ZT; their activities are summarized in Table 5. These clubs are farmer-based NGO's focusing solely on ZT practice and promotion.

CONCLUSIONS

The adoption of this technology represents the gateway to full sustainability in modern Brazilian agriculture. The varied mechanisms, wide agrologic base and extent of the Brazilian experience generate useful examples for development of ZT in similar conditions worldwide.

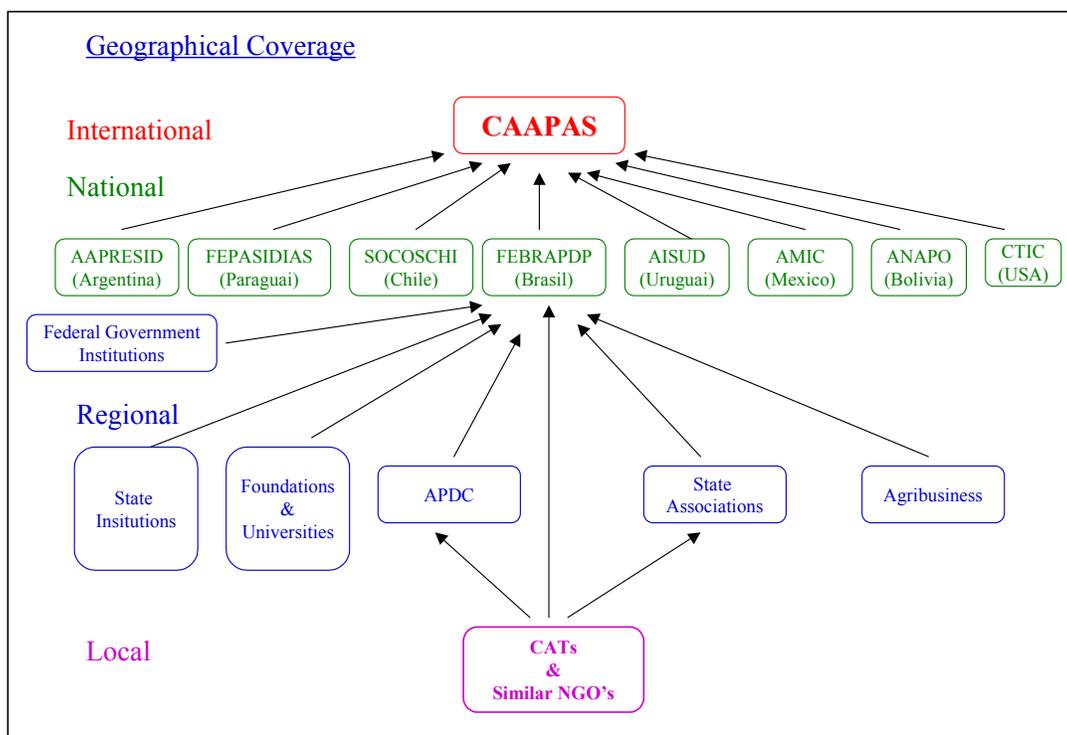


Figure 5. The institutional framework for ZT dissemination in Brazil. Source: Author

Table 5. Activities of Friends of the Land Clubs.

ADOPTION PHASE	MATURE PHASE	ADVANCED PHASE
<ul style="list-style-type: none"> ▪ Basic instruction ▪ Farmer-to-farmer exchanges ▪ Short courses ▪ Lectures, farm visits/field tours ▪ Planter clinics for adoption 	<ul style="list-style-type: none"> ▪ Specialist seminars ▪ Field days ▪ Ad hoc on-farm research/data collection ▪ University links ▪ Field tours ▪ Planter clinics for trouble-shooting ▪ Professionalizatio of rural workers 	<ul style="list-style-type: none"> ▪ Rural leadership courses ▪ Cost accounting ▪ On-farm research partnerships (new crops, varieties fertilizer, trials) ▪ Advances management groups ▪ Field tours

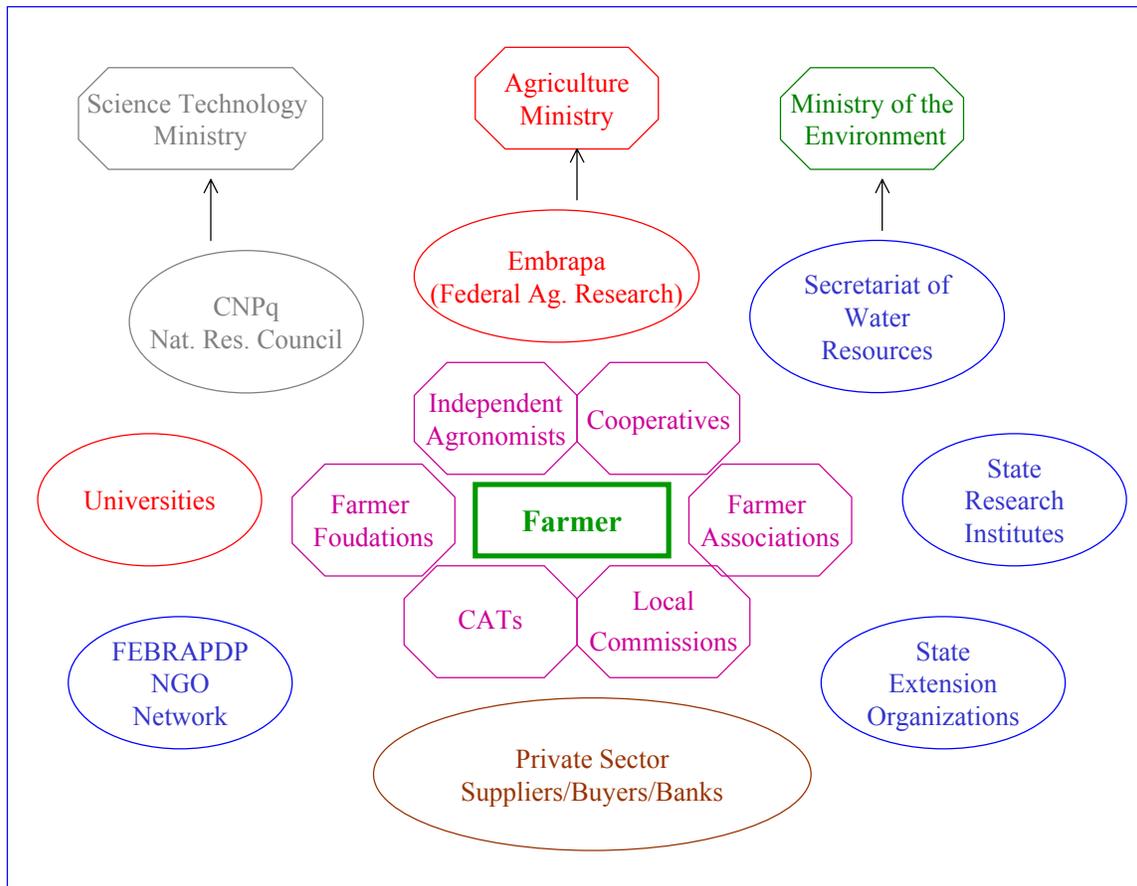


Figure 6. Organization chart of the zero tillage NGO's in Brazil and the Americas.

Note on Terminology

There is an imperative need to change terminology to signal the mindset change engendered by ZT, no-till, no-tillage, direct drilling or seeding and other synonyms. This will underline the spirit of no-return which is required to generate that persistence which has solved all major limitations to ZT in Brazil to date. Thus “green manure crops” which propagates the idea of plowing the crop down would be substituted by “cover crops” and “reduced tillage” “minimum tillage” or “conservation tillage”, which are catch-all terms, embracing and obfuscating ZT, while still admitting turning the soil over (an anti-conservation act because any cultivation oxidizes soil organic matter and reduces soil biological activity and diversity). This generalized usage should be replaced by specifying “ZT” or “direct seeding”. The terms “no-till” and “no-tillage” sound more popular, less technical terms. Direct drilling declassifies itself as a generic term since it does not cover planters. Finally, the very term “soil conservation” omits any mention of crop residues and should be replaced by “crop residue and soil conservation” in that natural order of priority.

There is a complicating factor since both Webster’s and the Oxford English Dictionary define tillage in the wide sense of crop husbandry, including planting weeding and harvest (items tillage, to till.). However ZT has a finite ring to it, indicating a radical change in base values, and while

“direct seeding” is technically correct, it does not cover the case of transplanting into residues, which also is part of ZT. Q.E.D.

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