

# Conservation Technologies and the Plant Science Industry

Managing Natural Resources  
Sustainably





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June 2004

# The Plant Science Industry

Committed to sustainable agriculture through innovative technologies



The plant science industry, represented by CropLife International, supports sustainable agriculture through innovative science based solutions for reliable supply of food and fibre for all. The increasing emphasis of technologies developed by the industry is to promote sustainable use of natural resources, protect the environment, enhance economic viability of farms and rural livelihoods, and contribute to improved quality of life for farmers and the society generally. Successful adoption of sustainable agricultural practices by farmers would be a major contribution towards fulfilling

the overall objectives of sustainable development, a key part of Agenda 21 signed by 100 heads of state and governments in Rio de Janeiro in 1992 and reaffirmed by the 2002 World Summit on Sustainable Development held in Johannesburg.

The CropLife members work with a network of qualified personnel and partner organizations to test, analyse, and disseminate innovative products and techniques to meet differing needs and priorities of farming communities in the industrialised and the developing countries. To ensure that innovative solutions are responsive to the socio-economic circumstances of farmers, the industry undertakes local adaptive work and provides technical service to ensure safe and effective use of its products.

In helping to produce safe and affordable food for all, the industry actively promotes dialogue and cooperative programs with international organizations, governments, NGOs and other stakeholders. It shares knowledge and, where appropriate, contributes to the formulation of international and national policies, regulations and guidelines for sustainable agricultural growth. It works in close cooperation with farmers around the world in product development and testing and draws on their cumulative knowledge to enhance the relevance, cost-effectiveness and safety of recommended solutions.



# Agricultural Growth, Natural Resource Base Sustainability, and the Environment

The evolving paradigm

As the new century begins, the world faces enormous challenges in meeting food and fibre needs of the growing population with rising incomes. It is estimated that by 2025 the global population will be approximately 7.9 billion, increasing worldwide cereal and meat demands by 46 and 56 % respectively<sup>1</sup>. Because prospects for further expansion of agricultural land and irrigated areas are limited, increased food demand will need to be met primarily through sustainable intensification of existing cultivable land.

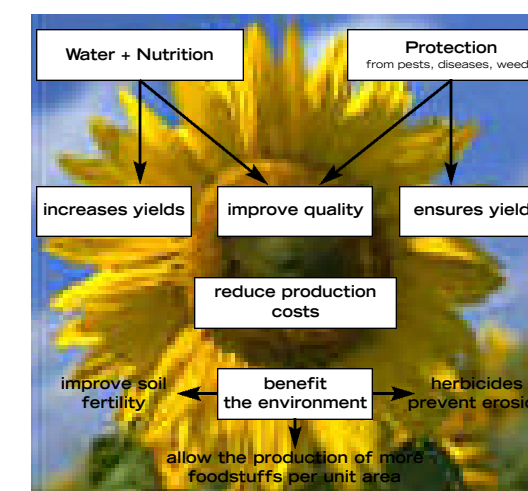
Over the years many industrialized and developing countries have achieved impressive rates of agricultural growth. For example, Asia transformed its agriculture by doubling rice and wheat production during 1970 to 1995 by intensification using Green Revolution technologies<sup>2</sup> and expansion of area. Over the same period, higher farm incomes and accelerated growth of the rural non-farm economy, led to doubling of real per capita rural incomes and significant lowering of poverty levels<sup>3</sup>. However, there were also some negative sides to this revolution. The regional disparities in income growth increased and inappropriate use of applied inputs (fertilizers, crop protection products, irrigation) in some locations resulted in environmental damage<sup>4</sup>. While the continued search and application of science based innovations remains critical to meeting the future food and fibre demand, further intensification of agriculture to increase productivity, especially in countries that need it most, must be achieved in ways that are sustainable and safe to the environment, producers and consumers.

More people means less land per person

	Population growth		
	World population (billion)	Arable land & permanent crops (billion ha)	Farmland per person (ha)
1950	2.5	1.3	0.5
1975	4.0	1.4	0.4
2000	6.0	1.5	0.3
2020	7.5	1.5	0.2

Source: International Food Policy Research Institute, 2002

Plants need adequate water, nutrition and protection



Source: Food for All. 1996 publication of IFA/GCPF

The growing concern for sustainability can be seen as a positive response to limits and problems of both low-input, traditional agriculture and intensive modern agriculture relying on high levels of applied inputs. The move to sustainable agriculture relies on practices that help to maintain ecological equilibrium and encourage natural regenerative processes, such as nitrogen fixation, nutrient cycling, soil regeneration, and protection of natural enemies of pests and diseases, as well as the targeted use of inputs. The agricultural systems relying on such approaches are not only able to support high productivity, but also preserve biodiversity and safeguard the environment. The conservation technologies for improved productivity being promoted by the plant science industry are making it possible to achieve these objectives.

<sup>1</sup> Rosegrant, M W, X Cai and S A Cline (2002). World water and food to 2025: Dealing with scarcity. International Food Policy Research Institute, Washington DC, USA.

<sup>2</sup> In 1968, William Gaud, the administrator for the US Agency for International Development (USAID), coined the term "Green Revolution" to describe the agricultural growth in Asia resulting from wide-scale adoption by farmers of new varieties, irrigation, fertilizers, and crop protection inputs.

<sup>3,4</sup> Rosegrant and Hazell. Transforming the rural Asian economy: The unfinished revolution. Published for the Asian Development Bank by the Oxford University Press. 2000

# Conservation Technologies and Sustainable Agriculture

## What are the characteristics of conservation technologies?

Traditional farming normally involves intensive soil tillage as the main starting operation to eliminate weeds and to prepare seedbeds. In the past, intensive tillage was also associated with increased fertility due to mineralization of soil nutrients. However, in the longer term, excessive tillage reduces soil organic matter content and exposes soil to wind and water erosion leading to lower productivity. Consequently, traditional agriculture has increasingly relied on applied inputs such as fertilizers, as well as crop protection products to maintain or to increase productivity.

While the negative effects of tillage operations have been known for sometime<sup>5</sup>, it was only after the discovery of broad spectrum herbicides that leave no residues in soil to harm the subsequent crop planted that the idea of using herbicides as an aid to eliminate tillage made major progress. The worldwide research efforts starting in the 60s involving the private sector (the plant science industry and manufacturers of farm implements), the public institutions and enterprising farmers led to development of crop establishment techniques that used herbicides either to fully eliminate or minimize the need for tillage operations. Under the new techniques -- no-till, zero-till, minimum-till, ridge-till, mulch-till -- seed was sown directly into the previous crop's stubble with little or no intermediate tillage. Later, crop rotation and maintenance of permanent or semi-permanent groundcover (of live cover crop or crop residue mulch) were included as an integral part of this approach, now commonly known as conservation tillage<sup>6</sup>. Over time, these practices have proved to be equally suitable for small, medium, and large farms that use either hand, animal or tractor driven implements for tillage operations.

Conservation tillage protects the upper soil layer from wind and water erosion and loss of ground moisture. It also improves soil biodiversity, such as bacteria, insects, and fungi. The abundance of soil organisms helps decomposition of mulch and its incorporation into soil as humus, contributing to stabilization of soil structure and enhancement of soil fertility. Maintenance of mulch is estimated to increase soil organic matter content by about 1 % every 10 years<sup>7</sup>.

Although conservation tillage provides many benefits, there are also areas of concern that generate resistance to change from conventional farming. Weed management during the change-over period requires special care. Management of diseases and insect pest problems can be an area for concern. Experience shows that combining of Integrated Crop and Pest Management (ICM and IPM)<sup>8</sup> approaches with conservation tillage is an effective way of addressing these problems and enhancing sustainability.

Sustainable practices, collectively described as conservation technologies, are applicable in wide range of situations covering farm, non-farm and urban locations. However, the main focus of this paper is on benefits associated with conservation tillage technologies, the key elements of which include:

- Minimum disturbance of soil, where needed with the help of herbicides used as aid to cultivation
- Maintenance of mulch consisting of either a live cover crop or dead crop residue
- Sound crop rotations
- Need-based matching of conservation tillage with ICM/IPM practices

## How do conservation technologies fit into sustainable agriculture?

Conservation technologies are at the heart of sustainable agriculture, providing dynamic solutions to problems encountered in increasing food production without damaging the ecosystem or depleting natural resources for future generations. A farming system based on conservation technologies is not low-output agriculture. It provides comparable yields to intensive conventional farming relying on high external inputs, but in a sustainable manner.

### Comparison of conventional farming with the characteristics of conservation technologies

Problem Area	Conventional Farming	Conservation Technologies
Nutrient deficiency	Corrected with inorganic fertilizers	Relies on integrated nutrient management through biological regeneration, plus targeted use of organic or inorganic fertilizer. Where appropriate includes integration of livestock production for nutrient recycling.
Water deficiency	Corrected with irrigation	Emphasises management of soil organic matter (use of cover crops and mulch) for efficient capture of rainfall, soil moisture conservation and targeted irrigation.
Erosion control	Corrected with physical barriers	Erosion minimized through reduced or no-till practices along with retention of cover crops/residue in arable agriculture and vegetation management in non-crop situations.
Soil structure deficiencies and compaction	Corrected with intensive tillage which further decreases biological oxidation and soil carbon	Soil restoration using cover crops, residue management, crop rotation, and minimum/zero tillage.
Pest management	Calendar or need-based spraying of crop protection products	Site-specific management of insects, weeds, diseases and other pests using IPM approaches which are economic, environmentally safe, and socially acceptable.
Environmental degradation	Corrective measures involve variations in intensive tillage and associated management practices, which provide limited protection against soil erosion and secondary damage through silting and contamination of surface and groundwater from leaching and run-off of applied chemicals.	Prevented using conservation tillage technologies that reduce soil erosion, water run-off from farms and emission of green house gases.
Loss of biodiversity and wildlife habitat	Loss of on-farm biodiversity and wildlife due to intensive soil cultivation, planting of similar biotypes over large areas and applied inputs during crop growth. Higher productivity through intensification can slow spread of agriculture to fragile and marginal areas.	Additional cover provided by crop mulch encourages micro fauna and flora diversity and other wildlife species. Sustainable increases in productivity from existing areas avoid spread of agriculture to marginal areas.

<sup>5</sup> Faulkner, E H (1943). Plowman's folly. University of Oklahoma Press, Norman, OK.

<sup>6</sup> Conservation tillage is any tillage and planting system that covers more than 30% of the soil surface with crop residue after planting to reduce soil erosion by water. Where wind erosion is a primary concern, conservation tillage includes any system that maintains at least 450 kg/ha of flat small-grain residue equivalent on the surface throughout the critical wind erosion period. No-till, minimum-till, ridge-till, and mulch-till are types of conservation tillage (Conservation Tillage Information Centre, 2002).

<sup>7</sup> Thomas, G T (1990). Labranza cero, resultados, en EEUU y observaciones en campos Argentinos. Rosario Argentina. AAPRESID.

<sup>8</sup> Integrated Crop Management (ICM): There are many definitions of ICM. For the purposes of this document it has been defined as 'management of crop production on the whole farm in a way that maintains and enhances the environment for wildlife and people while at the same time producing economic yields of high quality'. Integrated Pest Management (IPM). A FAO and the plant science industry accepted definition of IPM means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasises the growth of a healthy crop with the least possible disruption to agroecosystems and encourages natural pest control mechanisms.

# Conservation

## Tillage Technologies Conservation Tillage Technologies for the 21st Century and Beyond

Conservation technologies are now being practiced over large areas under different eco-systems in different parts of the world. Their adoption has provided a number of benefits, including more efficient use of available water, reduction in soil erosion, improvement in soil health and increased yields. In addition, they are helping to address other environmental concerns related to air and water quality, emission of greenhouse gases, and protection of wildlife habitat and biodiversity. Conservation technologies are vital to the long-term sustainability of agriculture.

### Total area under minimum and zero-tillage in different countries

Country	Area under Minimum and Zero Tillage, 1999/2000 (ha)
U.S.A.	21,120,000
Brazil	13,470,000
Argentina	9,250,000
Australia	8,640,000
Canada	4,080,000
Paraguay	960,000
Bolivia	350,000
India/Pakistan <sup>a</sup>	300,000
Venezuela	150,000
Chile	100,000
Colombia	70,000
Mexico <sup>b</sup>	50,000
Uruguay	50,000
Ghana <sup>c</sup>	50,000
Others	1,000,000
<b>Total</b>	<b>59,640,000</b>

<sup>a</sup> Hobbs and Gupta, 2002;

<sup>b</sup> CIMMYT estimate;

<sup>c</sup> Ekboir, Boo, and Donkyi, 2001

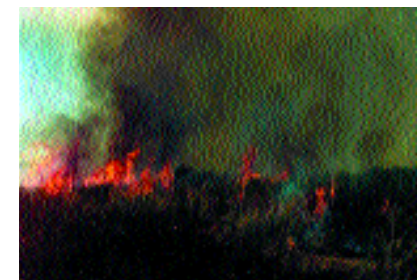
All other data from Derpsch, 2001

In 1985 the Weed Science Society of America published a monograph that reviewed the progress of limited tillage systems with emphasis on weed control practices under different crops around the world<sup>9</sup>. Since that time a lot more information, especially on the long-term benefits of these systems has become available. At the same time new research and/or technologies have enabled introduction to production systems in new areas. The studies presented here have been summarised from the published literature or collected for this report. They provide examples where members of the plant science industry have worked with researchers and farming communities to assist in the development and dissemination of location-specific technologies that are contributing to sustainable intensification of agriculture in different parts of the world.



<sup>9</sup> Wiese, A F (ed.) (1985). Weed control in limited tillage systems. Published under the monograph series of Weed Science Society of America. Champaign, Il., USA

### The Brazil experience<sup>10</sup>



Starting in the 1960s, Brazil saw rapid expansion of agricultural frontiers and intensification of production systems, including greater emphasis on soybean production either as a single crop or in rotation with wheat. In many areas these crops replaced livestock and coffee production. These changes over the last three decades, combined with heavy rains, hilly terrain, and intensive tillage, led to serious erosion problems over vast areas. Searching for more environmentally friendly and economically viable production systems, farmers, development agencies, and researchers started to work

with reduced tillage systems, mainly in the southern region near Parana.

In the early 1970s, the plant science industry started supporting this work using herbicides for weed control prior to direct drilling of soybeans. The resulting network of scientists, manufacturers of farm implements, and innovative farmers soon became a hub of research that developed the first no-till package for Brazil. Based on lessons learned and the continued support of pioneering farmers, more research groups, farmer cooperatives and clubs were organized to address early weaknesses and to expand research and development activities. These groups, with help from national and international public as well private organizations, ensured that conservation tillage became an important part of Brazilian agriculture.

Effective weed control using herbicides, with crop residue remaining on the soil surface, availability of appropriate farm machinery and effective extension has made it possible for zero-tillage farming to be widely practiced for the production of a number of crops, including soybean, maize, wheat, cotton, in both sub-tropical and tropical parts of the country. Innovative systems have also been developed for regeneration of pastures for better integration of crop-livestock production systems, as well as the use of herbicides as an aid to harvesting of sugarcane to enhance labour productivity and to reduce pollution caused by burning of case foliage prior to harvesting. Farmers adopting zero-tillage systems are reporting higher yields, improved income, erosion control and savings in time and labour. Combinations of sound crop rotations and use of cover crops has further enhanced productivity, soil erosion control and plant nutrition. In addition, these practices provide more cost effective management of weed population.

### The Paraguay experience<sup>11</sup>

The introduction of soybean and wheat to southern and eastern Paraguay in the 1970s using conventional mechanised soil-preparation practices contributed to soil degradation and erosion with long-term consequences for the sustainability of commercial agriculture. However, learning from experiences of the neighbouring southern Brazilian states of Parana, Santa Catarina, and Rio Grande do Sul, conservation tillage techniques were developed to overcome the negative impact of mechanised tillage and intensive high-input crop management practices. As a result of continued research and development work involving both public and private organizations, large, medium, and small-scale farmers now practice conservation tillage techniques on almost 1 million hectares involving reduced or zero tillage, mulch management, and crop rotations. The most commonly followed rotations in southern and eastern Paraguay vary in length from three to five years and involve crops such as oats, wheat, soybean, maize and sunflower. The shorter turn-around time between crops under conservation tillage has also broadened options of crops that can be grown within a cropping year.

<sup>10</sup> based on - Derpsch, R (2001). Frontiers in conservation tillage and advances in conservation practice. <http://www.rolf-derpsch.com/notill.htm#21> - Ekboir J M, K Boa and A A Dankyi (2002). Impact of no-till technologies in Ghana. CIMMYT Economic Program Working Paper. CIMMYT, Mexico. - Pieri C, G Evers, J Landers, P O'Connell and E Terry (2002). No-till farming for sustainable rural development. Agriculture and Rural Development Department Working Paper. The World Bank, Washington DC, USA - Saturnino H M and J N Lander (2002). The environment and zero tillage. Associacao de Planto directo no Cerrado, Brasilia. - World Bank (1998a). Implementation Completion Report, Brazil, Land Management I Project, Parana. ESSD Sector Management Unit, LAC, World Bank, Washington DC, USA. - World Bank (1998b). Implementation Completion Report, Brazil, Land Management II, Santa Catrina Project. ESSD Sector Management Unit LAC, World Bank, Washington DC, USA.

<sup>11</sup> based on - Sorrenson, W J (1997). Paraguay: Financial and economic implications of no-tillage and crop rotations compared to conventional cropping systems. FAO Investment Center Occasional Paper Series No. 9. Food and Agriculture Organization of the United Nation, Invest Centre, Rome, Italy. - Ekboir J M, K Boa and A A Dankyi (2002). Impact of no-till technologies in Ghana. CIMMYT Economic Program Working Paper. CIMMYT, Mexico.

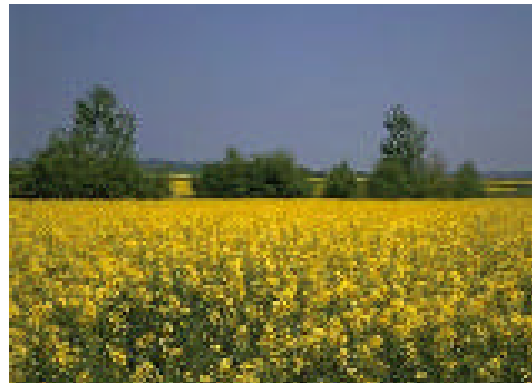
### The Canada experience<sup>12</sup>



With the availability of improved herbicides and suitable farm implements such as direct drills in Canada, it was possible to control weeds and successfully plant a crop without tillage. By about 1975, many pioneer farmers had become serious about converting to zero tillage, experimented with different approaches, and provided invaluable feedback to university researchers, the plant science industry, and machinery manufacturers for continued improvement of technological options. Starting with a handful of farmers, over the last three to four decades conservation tillage has grown and is now

practiced on more than four million hectares covering a range of crops including wheat, maize and canola. The advantages of conservation tillage have been demonstrated by continuous no-till cropping on numerous farms. These advantages include erosion prevention, moisture management, higher productivity, and lower costs of production, including reduced fuel costs.

### Europe: The UK experience with the Soil Management Initiative (SMI)<sup>13</sup>



Based on experiences of farmers operating under different soil, crop and climate situations across the UK, SMI work has confirmed several major benefits of conservation tillage systems, mostly involving reduced cultivation and crop residue management, reported from other member countries of the European Conservation Agriculture Federation (ECAAF)<sup>14</sup>.

It is estimated that in the UK some 1.5 m ha, representing nearly 30% of agricultural land is now under conservation agriculture. Well thought out strategies for crop residue management, weed control and crop protection involving improved farm implements, herbicide technologies and rotations (of crops of herbicides

and of drilling dates) systems, conservation tillage (no-tillage or minimum tillage) practices combined with crop residue management were needed for success. Although the success is confined to combinable crops (e.g. cereals, rape), the current status is a significant advance over the situation in the 70s when limited progress was possible with a focus only on promoting no-till systems.

A major benefit of the programme is reduced soil degradation due to erosion and compaction - previously losses of 2.3 million tonnes per year across the UK have been reported with 44% of arable land being vulnerable<sup>15</sup>. Other benefits of conservation agriculture have included: (a) savings in crop establishment costs and energy use; (b) improved soil quality, resulting from improved soil fertility, increased organic matter, improved water permeability, improved bulk density and aggregate stability; (c) improved water quality due to reduced water run-off and sediments leaving fields with pesticide and nutrient residues; (d) reduced CO<sub>2</sub> emission due to improved retention in crop residue and soil as well as reduced use of fuel; (e) increased biodiversity due to improved soil conditions for soil organisms and habitat for bird species; and (f) higher yields.

<sup>12</sup> based on - Coutts G R and R K Smith (1991). Zero-tillage production manual. Manitoba and North Dakota Farmers Association, Brandon, Manitoba, Canada.

<sup>13</sup> Based on - Soil Management Initiative (SMI) publication 'A guide to managing crop establishment', 2003. and 'Improved soil management for agronomic and environmental gain'. SMI is an independent organization that promotes the adoption of cultivation systems designed to protect and enhance soil quality, and to minimize soil erosion and water pollution, whilst maintaining or enhancing farm economic returns.

<sup>14</sup> ECAAF is a network of leading European academics, scientists and farmers to promote farming practices collectively known as conservation agriculture to improve and maintain agrarian soil and its biodiversity. It brings together fourteen national associations in Belgium, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Ireland, Portugal, Slovakia, Spain, Switzerland and the UK.

<sup>15</sup> Code of good agricultural practice for the protection of soil, MAAF, UK, 1998.

### The South Asia experience with the Rice-Wheat Systems of the Indo-Gangetic plains

Nearly half of the total land area of the Indo-Gangetic plains -- Bangladesh, India, Nepal, and Pakistan -- of South Asia, over 400 million hectares, is devoted to feeding and providing livelihoods for 1.8 billion people<sup>16</sup>. Rice and wheat are the staple food crops and contribute more than 80 % of the total cereal production in these countries. This system is fundamental to employment, income, and livelihoods for hundreds of millions of rural and urban poor of South Asia<sup>17</sup>.

Suitable weather conditions for rice and wheat cultivation, development of short-duration, nitrogen-responsive cultivars, expansion of irrigation, and the ever-increasing demand for food from the rising population were the driving force for increased production through area expansion and intensification of the rice-wheat system during the Green Revolution starting in the early 1960s. In the last four decades, high growth rates for food grain production -- wheat 3.0 %, rice 2.3 % -- have kept pace with population growth.

Evidence is now appearing that further intensification of input use above that already adopted during the Green Revolution will result in lower marginal returns<sup>18</sup>, and the continued intensification of cropping in some situations is leading to degradation of the resource base through salinisation, over-exploitation of groundwater, physical and chemical deterioration of the soil, and pest problems<sup>19</sup>. Results from research and development work to develop conservation tillage systems involving substitution of conventional tillage with zero or minimal tillage for wheat planting in rice-wheat rotation show improved productivity, reduced cost of cultivation, water savings, and lower weed populations. These techniques when combined with integrated approaches to pest control provide options for sustainable intensification and diversification of rice-wheat systems.

### South-East Asia: The Malaysia experience



Rubber and oil palm are two very important crops in the Malaysian economy, occupying 1.6 million and 3.4 million hectares, respectively<sup>20</sup>. These crops are cultivated both by smallholders and large plantations. Under the traditional clean-clearing method of planting and replanting, logged-over forests or old stands of rubber and oil palm are mechanically felled and burned. This approach exposes the soil to erosion and contributes to environmental pollution. The plantation industry has now developed a 'zero-burning' replanting technique under which the old stands of palms are mechanically felled and shredded and left as mulch to decompose in situ. Prior to felling, base lines for new planting

rows, roads, mechanisation paths, and drains are pegged in order to facilitate placement of shredded material as mulch in the future inter-row areas. Planting rows for new crops are cleared and prepared immediately after felling. It is a common practice to terrace steep slopes and make silt pits to reduce soil erosion due to heavy rains during crop growth. At the same time, establishment of creeping leguminous crops to provide rapid ground cover in the inter-row areas provides added protection from soil erosion until the palm oil or rubber canopy is fully developed. In addition, the leguminous species fix nitrogen adding to soil fertility. Besides contributing to a cleaner environment, the 'zero-burning' technique replenishes soil organic matter and improves the physical and chemical properties of the soil. Weed growth in planting rows is kept in check, mostly with post-emergent herbicides.

<sup>16</sup> Gupta, RK, RK Naresh, PR Hobbs, Z Jiaguo, and JK Ladha (2002) Sustainability of post-Green Revolution agriculture: The rice-wheat cropping system of the Indo-Gangetic Plains and China. p. 1-27. In JK Ladha et al. (ed.) Improving the productivity and sustainability of rice-wheat systems: issues and impact. ASA Spec. Publ. 65. ASA, Madison, WI.

<sup>17</sup> FAO (Food and Agricultural Organization) (1999) FAO production book, Vol. 53. FAO, Rome, Italy.

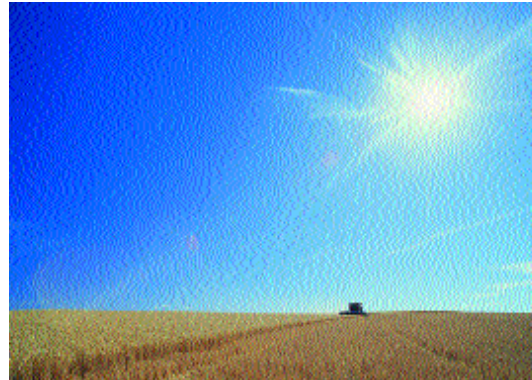
<sup>18</sup> Ladha, JK, KS Fischer, M Hossain, PR Hobbs, and B Hardy (2000). Improving the productivity and sustainability of rice-wheat systems of the Indo-Gangetic Plains: a synthesis of NARS-IRRI partnership research. p. 1-31. Discussion Paper No. 40. International Rice Research Institute, Philippines.

<sup>19</sup> Byerlee, D, and R Murgai. (2001). Sense and sustainability revisited: The limits of total factor productivity measures of sustainable agricultural systems Agricultural Economics 26, 227-36. Byerlee, (1992)

<sup>20</sup> Malaysia Ministry of Agriculture, (2002)

# Impact of Conservation Technologies

## The Australia experience<sup>21</sup>



In Australia many soils in areas dominated by wheat-pasture rotations have low moisture-holding capacity, are nutrient-poor, and are prone to wind erosion. Accordingly, the main focus of conservation tillage technologies in wheat cultivation, which have now been adopted over large areas, has been to conserve moisture and reduce soil erosion. The pasture phase of rotation includes a mixture of grasses and clover. At the time of changeover from the pasture phase, wheat is direct drilled – zero tillage – three to five days after herbicide application to kill off grasses. Planting of wheat without cultivation allows large areas to be covered quickly and crops to be established early,

making full use of moisture from early season rains and shortening the period when soils are exposed to wind erosion. More efficient use of moisture improves productivity reducing overall cost of production. Direct drilling also avoids soil compaction, due to a reduction in tractor passes, which in some situations adds to improved productivity.

## West Africa: The Ghana experience<sup>22</sup>



Even though public institutions in West Africa started research on zero-tillage systems in the 1960s, little progress was made in transferring this knowledge to farmers. It was not until the 1990s, when the national and international research and development institutions, non-government organisations and the private sector formed a partnership to support further participatory research and extension work that information about benefits of conservation tillage began to be appreciated and adopted by farmers. Since the traditional method for maize planting followed by small-scale farmers in Ghana and some other West African countries involves very little cultivation, focus of the

renewed effort was to develop effective weed control and stubble management practices. The partnership program emphasized on-farm demonstration to show the advantage of conservation tillage to farmers. Using participatory approaches, an entire farm-management system was promoted. This included the use of certified seed, organic and inorganic fertilizers, pre- and post-planting weed control, and harvesting techniques that left crop residues in the field. This work was supported by pre-season farmer training, field days, field tours, workshops, and distribution of printed extension material. Some rural banks and district councils also got involved in the promotion work by providing credit to selected farmers. No-till farming has given higher yields both in normal and drier years due to improved land management and moisture retention. From the early 1990s to 2000 it is estimated that more than 100,000 farmers have adopted conservation tillage methods on about 45,000 hectares to cultivate maize and grain legumes.

In countries where conservation technologies have now been in use for sometime there is evidence that agricultural lands maintain productivity providing economic, environmental, and social benefits at farm, local community, national and global levels. The benefits are accrued both by large and small-scale farmers enhancing sources of sustainable livelihoods for rural communities

## Economic impact

Of all the reasons to consider conservation tillage, none is more important to individual farmers than the economic benefits. The profitability of farm operations is an annual concern, which is strongly influenced by the cost of production. Increases in land and labour productivity, leading to an increase in farm income, have been commonly reported benefits of conservation tillage practices.

**Brazil: Comparison of direct immediate benefits in maize and soybean production under no-till (conservation tillage) and conventional tillage**

Farm type	Crop	Yield (kg/ha)			Decrease in Hours/ha/year under No-till (%)		
		Conventional	No-till	Increase (%)	Labour	Equipment Use	Fuel Consumption
Mechanised	Soybean	24,40	31,00	27	-10	-27	-27
	Maize	45,00	58,40	29.8	-51	-19	-19
Animal Traction	Soybean	14,60	20,00	37	-59	-46	-
	Maize	40,00	48,00	20	-55	-66	-

Source: World Bank, 1998 a, 1998 b.

**Paraguay: Annual income and variable and fixed costs in the first and tenth year under conservation-tillage and conventional-cropping systems of a typical large farm (135 ha) in San Pedro and Itapua regions**

Region	Parameter	First Year (US\$)		Tenth Year (US\$)	
		Conventional Cropping	Conservation Tillage	Conventional Cropping	Conservation Tillage
San Pedro	Total farm income	77,031	75,010	68,632	93,762
	Total variable costs	53,484	51,467	53,026	48,166
	Total fixed costs	18,618	14,974	18,618	14,454
	Net farm income	4,929	8,569	-3,013	31,142
Itapua	Total farm income	64,688	63,675	61,454	102,856
	Total variable costs	38,818	36,674	41,792	56,077
	Total fixed costs	18,567	17,229	18,567	13,075
	Net farm income	7,304	9,771	1,095	33,703

Source: Sorreson (1997)

<sup>21</sup> based on Spray Seed <http://www.syngenta.com.au>

<sup>22</sup> based on - Mensah-Bonsu and H G Obeng (1997). Effects of cultural practices on soil erosion and maize production in the semi-deciduous rainforest savannah. Transtioal zone of Ghana. In D J Greenland and R Lal (eds.) Soil and Crop Production in the Humid Tropics. John Wiley, Chichester, UK. Pp. 509-519. - Ekboir J (ed.) (2002). CIMMYT 2000-2001 World Wheat Overview and Outlook: Developing no-tillage packages for small-scale farmers. Mexico, DF. CIMMYT.

Paraguay: Comparative summary of changes between the first and tenth years in net farm income, return on capital, and tractor hours under conservation-tillage and conventional-cropping systems of a typical large farm (135 ha) in San Pedro and Itapua regions

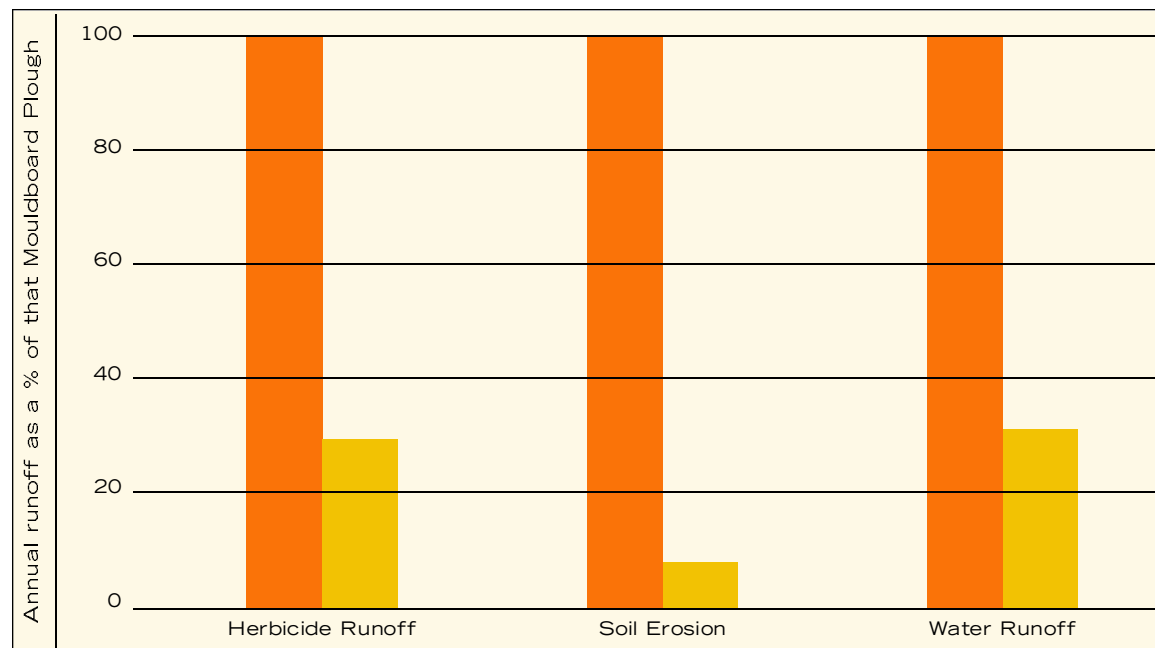
Parameter	San Pedro				Itapua			
	First Year		Tenth Year		First Year		Tenth Year	
	Conventional Cropping	Conservation Tillage	Conventional Cropping	Conservation Tillage	Conventional Cropping	Conservation Tillage	Conventional Cropping	Conservation Tillage
Net Farm Income US\$	4,930	8,570	-3,010	31,140	7,300	9,770	1,100	33,700
Return on Capital (%)	1.8	3.2	-1.1	13.3	1.8	2.4	0.3	8.3
Annual Tractor Hours	1,228	1,177	1,210	776	1,179	981	1,179	786

Source: Sorreson (1997)

#### Environmental impact

In countries where conservation tillage practices have been widely practiced for many years, e.g., Brazil, Australia, Canada, and United States, considerable information is now available to show environmental benefits of conservation tillage practices, some with global implications. Conservation tillage is reducing water runoff from agricultural land, reducing erosion, reducing CO<sub>2</sub> emissions in to the atmosphere and protecting water quality. These benefits help countries to meet demanding environmental protection regulations.

#### Runoff and erosion in no-till watersheds compared to conventional tillage watersheds.



Legend: ■ Mouldboard Plough ■ No-till  
Source: Fawcett et al. 1994

#### Improved water quality

The US Environment Protection Agency's 1998 National Water Quality Inventory reports sedimentation as the most important pollutant affecting water quality (EPA, 2000). High levels of sedimentation of waterways leads to destruction of aquatic habitat, increased need for water treatment and dredging, and decreased storage capacity of reservoirs. Conservation tillage helps reduce water runoff by up to 70% and sedimentation by around 90% into surface water streams.

#### Increased Soil organic matter, reduced carbon dioxide (greenhouse gas) emission and improved air quality

Maintenance of mulch under conservation tillage systems increases the ability of soil to sequester CO<sub>2</sub> and reduces emission, protecting the atmosphere. In some soils, following several years under a conservation tillage system, organic matter content has been shown to increase by as much as 2000 kg/ha/year<sup>23</sup>. Increased organic matter also improves the nutrient and water holding capacity of the soil. Finally, tillage increases oxidation of soil organic matter content releasing large quantities of CO<sub>2</sub> whereas conservation tillage can reduce CO<sub>2</sub> emission by up to 80%.

#### USA: Carbon dioxide emissions over a 19-day period after tilling wheat stubble with different methods

Tillage method	Cumulative CO <sub>2</sub> Loss (t/ha)
Mouldboard plough	9.13
Disk harrow	3.88
Chisel plough	3.65
No-tillage	1.84

Source: Reicosky, 1998; and Reicosky and Lindstrom, 1995

In an analysis of cropland as a source and sink for atmospheric carbon at the global level, it has been estimated that a considerable part of 55,000 million metric tonnes of historic soil carbon is lost from cultivated soils globally, which is equivalent to about 7% of the current atmospheric inventory and can be sequestered by adoption of management practices such as conservation tillage<sup>24</sup>. Conservation tillage requires considerably less tractor horsepower and fewer trips across fields with tillage equipment. This results in 40 to 50% reduction in fuel usage depending on the number/type of tillage trips, soil structure, and moisture content. For every litre of fuel saved, 0.3 to 0.4 kg of CO<sub>2</sub> is not released into the atmosphere<sup>25</sup>. In the US alone it is estimated that in 2002 total savings from all conservation tillage practices may have reached about 1,200 million litres of fuel<sup>26</sup>. In addition, by reducing wind erosion, conservation tillage also reduces the amount of dust that reaches the atmosphere, which in several countries in Africa, Australia, Asia, North and South America can be an important source of air pollution.

<sup>23</sup> Reicosky D J, M J Lindstrom and S Masielewicz (1994). Conservation Tillage. Swan Lake Research Farm, US Department of Agriculture, Agriculture Research Service, Soil Conservation Laboratory, Morris, Minnesota, USA. August 24, 1994.

<sup>24</sup> Lal R, J M Kimble, R F Follet and C V Cole (1998). The potential of US cropland to sequester carbon and mitigate the green house effect. Ann Arbor Press, Chelsea, MI., USA

<sup>25</sup> Jasa P A, D Skelton, A Jones and E Dickey (1991). Conservation tillage and Planting Systems. Cooperative Extension Service, University of Nebraska-Lincoln, Lincoln, Nebraska, USA.

<sup>26</sup> Fawcett R S and D Towery (2002). Conservation tillage and plant biotechnology: How new technologies can improve the environment by reducing the need to plough. Conservation Technology Information Centre, West Lafayette, IN, USA - Reicosky D J, M J Lindstrom and S Masielewicz (1994). Conservation Tillage. Swan Lake Research Farm, US Department of Agriculture, Agriculture Research Service, Soil Conservation Laboratory, Morris, Minnesota, USA. August 24, 1994. - Reicosky D C and M J Lindstrom (1995). Impact of fall tillage on short-term carbon dioxide-flux. In Soils and Global Change. R Lal, J Kimble, E Levine and B A Stewart (eds.), Lewis Publishers, Chelsea, USA. pp. 177-187.

**UK: Benefits from soil conservation tillage over conventional tillage**

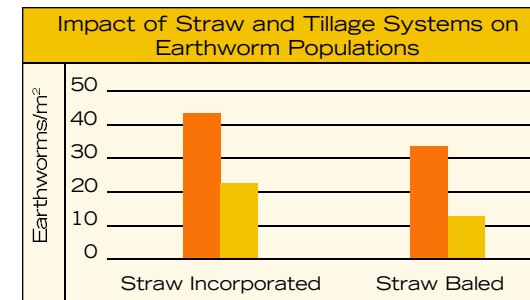
Component	Average Benefit
Establishment costs	Saving £10-40/ha
Energy use for crop establishment	Saving 76 kw/hr/ha
Work rate (250 ha farm)	Saving 52 min/ha
Infiltration rate	43% increase
Soil moisture retention (0.8 cm)	18% increase
Soil bulk density	4% improvement
Number of organisms	44% increase
Earthwork biomass	63% increase
Run-off	48% reduction
Sediment loss	68% reduction
Loss of total phosphate	81% reduction
Loss of available phosphate	73% reduction
Soil Mineral Nitrogen depletion	69% reduction
Total Oxidised Nitrogen emissions	94% reduction
Soluble Phosphate emissions	78% reduction

Source: Soil Management Initiative booklet 'Improved soil management for agronomic and environmental gain'

**Wildlife habitat and biodiversity**



Conservation practices that incorporate about 70% of crop residue in the top soil and leave 30% remaining on the soil surface provide a congenial environment for soil organisms and many bird species, small mammals and reptiles. Similarly, maintenance of tree and other vegetation on farm boundaries creates improved quality habitat for birds. The organisms living in the soil, e.g. earthworms, fungi, bacteria, benefit the most from conservation techniques and, in turn, help to improve the soil structure and natural fertility.



Legend: ■ Reduced Tillage ■ Conventional  
After SMI 2003

Increased production from existing agricultural areas using conservation technologies provides socially responsible opportunities for improved management of natural resources and broadening of biodiversity conservation areas. Active involvement of local communities in this process not only allows two-way knowledge sharing on location specific issues, but also provides an effective stewardship mechanism for long-term sustainability.

**Social impact**



The need for sustainable management of natural resources presents different challenges in the industrialised countries as compared to the developing countries. With its high productivity and excess production, agriculture in industrialised countries needs to find ways of responding to important environmental and food quality issues of concern to the society. Government policies and regulations in these countries are increasingly requiring adoption of technologies that minimise impact of modern agriculture on the natural resource base, restore soil ecosystems and protect the environment and preserves biodiversity on-farm as well as in non-farm situations. Conservation technologies help to address these concerns and optimise land potential to support sustainable agricultural production.

In the developing countries the need is to reduce poverty and reverse other social consequences of low productivity and a deteriorating natural resource base. In many countries farmers have met increasing food demand by expanding agriculture to marginal lands and encroaching forest reserves. In more favoured areas the search for higher productivity has in some situations resulted in excessive use of external inputs and over-exploitation of natural resources, especially land and water, with negative social consequences.

Adoption of conservation technologies has the potential to make agriculture more efficient by reducing labour requirements for land preparation, crop planting and weeding while conserving land and water. Since a number of farm operations are still undertaken manually, conservation tillage reduces drudgery and permit releases of labour for other economic and social needs.

Given the diversity and changing nature of environmental and socio-economic issues in agriculture, it is essential that the farming communities, the public institutions, NGOs and the plant science industry continue to work together to arrive at mutually acceptable goals for production technologies that help to supply safe and affordable food and improved environmental quality.

**Benefits and impacts of Conservation Tillage Technologies**

Farm Level	Community/Watershed Level	Global Level
Savings in labour, power and time through reduced cultivation and weeding requirements	Reduced soil loss and improved water flow and recharge of water table	Reduced soil erosion and improved land quality
Reduced investment in farm implements due to prolonged life and reduced inventory	Improved water quality due to reduced sedimentation and movement of pollutants	Improved carbon balance through reduced carbon emission, lower fuel and energy consumption, and increased carbon sequestration
Reduced erosion and improved soil health	Increased awareness and protection of natural resources	Improved protection of biodiversity at microflora and fauna levels
More stable and higher yields	Reduced costs of maintenance of communal infrastructure, eg rural roads, watershed protection measures	Improved hydrological cycles at river basin/continental level
Reduced cost of production and improved farm income	Improved sustainability of production systems, food security and quality of life for rural communities	Recognition of role of farming communities in providing environmental services for the society
Reduced drudgery and more available time for social needs		

Source: Based on Pieri et al 2002

## Vision Statement

Working together for sustainable agriculture

## Mission Statement

As a global network, CropLife International acts as an ambassador for the plant science industry, encouraging understanding and dialogue whilst promoting sound science and agricultural technology in the context of sustainable development

## Values & Beliefs

### Respect

- We will respect the views and values of others and act with honesty, humility and humanity.
- We will seek the respect of others for our values and beliefs.

### Openness

- Communication will be a fundamental priority in all our activities.
- We will act with openness in all our dealings with stakeholders and actively engage in dialogue, exchanging opinions and facts, in order to increase society's understanding of our industry and our understanding of society.

### Commitment

- We will commit to serve our members and stakeholders operating to the highest possible standards of professionalism ensuring the effective and prudent management of our resources.

### Technology

- We believe in the benefits that technology brings to human development and progress, and to sustainable agriculture.
- We believe in the complementary and synergistic nature of technologies developed and offered by the plant science industry.
- We believe in science as the engine of innovation and the core principle of regulatory decision-making.

### Sustainability

- We are committed to promoting full and effective stewardship (the responsible and ethical management of a plant protection or biotechnology product throughout its life cycle) to the field level, and recognise that the appropriate management and use of our products is an important element underpinning sustainable agriculture.
- We will strive to work together with others to achieve a proper balance between all dimensions/pillars of sustainable development.
- We will strive to maintain a healthy, ethical and viable business environment for the plant science industry.

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