Planting without ploughing: zero-till wheat takes root

Key fact:

Innovative partnerships among researchers, farmers, and other actors in the agricultural value chain have enabled the adoption of zero-tillage to sow wheat after rice on nearly 2 million hectares in the Indo-Gangetic Plains, increasing farmers' incomes, fostering more sustainable use of soil and water, and providing a platform for cropping diversification and the introduction of other resource-conserving practices.

Agronomist talking to farmer who has adopted zero-tillage *(CIMMYT)*

Summary:

Zero-tillage cultivation is a farming practice that reduces costs while maintaining harvests and protecting the environment. During 1997-2004, an estimated 620,000 farmers in northern India adopted the method to sow wheat after the rice harvest on around 1.76 million hectares of land, with average incomes increasing by US$180-$340 per household per year.

The impact achieved resulted from long-term efforts involving direct promotion and testing with farmers, training and support for national programme champions willing to oppose conventional wisdom about tillage practices and development of affordable, locally-manufactured seed drills. Efforts were led by the Rice-Wheat Consortium (RWC) for the Indo-Gangetic Plains, a partnership involving the national research programmes of Bangladesh, India, Nepal, and Pakistan, and with key technical and logistical support from the International Maize and Wheat Improvement Center (CIMMYT).

Facts & figures[1]

- Zero-tillage wheat cultivation now covers an estimated 1.76 million hectares in India and has been adopted by around 620,000 farmers.
- India was highly successful in developing local manufacturing capacity to adapt and produce zero-tillage drills at a competitive cost. In 2003, the average price of a zero-till drill was US$325 in India, compared with US$559 in Pakistan.
- Specifically, zero tillage:
  - Reduces the number of field operations from an average of seven to one, translating into 8-12 hours per ha saved in tractor time (a 60-90% saving); farmers can save 36 litres of fuel per ha of land, an 80% saving over conventional wheat cultivation.
  - Reduces water usage by about 1 million litres per ha (a saving of 20-35%).
  - Improves soil structure, fertility, and biological properties.
  - Typically reduces the incidence of weeds, primarily due to the earlier emergence of wheat and reduced soil disturbance.
  - Improves the population dynamics of certain wheat pests and diseases.
  - Increases wheat yield by 6-10% and reduced production costs by 5-10%.
- Studies in India suggest that adopting farmers can boost their income by US$97 per hectare of land, and increase annual income by US$180-$340.
- Zero tillage has increased wheat yields by 5-7% for Indian farmers.

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The Indo-Gangetic Plains (IGP), which spread from Pakistan across northern India, southern Nepal, and into Bangladesh, are the breadbasket of the Indian sub-continent and home to more than 300 million people. Farmers in the region typically grow two crops per year: monsoon-season flooded rice and winter season wheat. However, since the 1990s, productivity increases in the rice-wheat rotation have stagnated, owing to land degradation and late planting of wheat, in particular.

Typical farming practices involve up to eight tractor passes to restructure rice paddy soils before planting wheat. Not only is this costly in diesel and associated CO_2 emissions, but the later the wheat is planted, the more likely the crop will suffer from pre-monsoon heat during grain filling, significantly reducing yields. To keep pace with the region's exploding food demands and to adapt to water shortages and climate change, farmers need technologies that can help them improve yields while saving resources, cutting production costs and sustaining environmental quality.

Locally-adapted seed drill *(CIMMYT)*

Zero-tillage - the direct seeding of wheat into unploughed paddies following rice harvest - offers a more sustainable alternative: it involves a single tractor pass, thereby saving fuel, cutting greenhouse gas emissions, and allowing the earlier planting of wheat. The International Maize and Wheat Improvement Centre (CIMMYT) began to introduce this practice throughout the IGP in the 1980s, with efforts increasing with the involvement after 1994 of the Rice-Wheat Consortium (RWC). DFID has supported the work of RWC both directly, and through on-going core assistance to CIMMYT.

Rapid adoption of zero-tillage in the region, especially in India, began in the late-1990s. During 1997-2004, around 620,000 farmers adopted the system and zero-tillage wheat cultivation now covers an estimated 1.76 million of the 14 million hectares of rice-wheat cultivation. This uptake has led to important direct outcomes for farmers and the environment.

Many factors contributed to the successful spread of zero-tillage in the IGP. A key one was the collaborative development and local manufacture of affordable zero-tillage seed drills - which in one pass place wheat seed and fertiliser directly into unploughed land. The process of testing prototype seed drills on farmers' land with farmer participation, developing drills suited to local conditions, and making them available to farmers at an affordable cost, were all vital steps. Seed drills were attractive both for farmers keen to reduce their own cultivation costs and hire themselves out for direct-seeding of neighbours' fields, as well as for profit-minded local manufacturers. Crucial as well were the use of farmer participatory approaches and the involvement of farm implement manufacturers and input suppliers to promote and support zero-tillage against the opposition of tradition-minded farmers, researchers, and policymakers. Finally, the development and spread of this innovation owes much to the conviction and hard work of national research programme champions and extension agents, as well as the continuing high-quality training and support they received through the RWC and CIMMYT.

Apart from reducing cultivation costs, the zero-tillage method increases wheat harvests by 5-7 per cent, largely thanks to timely planting. As a result, in India, it is estimated that zero-tillage has increased incomes by US$97 per hectare, with households typically increasing their annual earnings by US$180-$340. The bulk of this is from reduced costs. Zero-tillage

also has environmental benefits: reducing fossil fuel use and greenhouse gas emissions, improving both fertility and water-holding capacity of the soils, reducing rates of soil erosion, and encouraging rice-wheat farmers to leave crop residues on the soil surface rather than burning them.

Furthermore, reduced tillage has provided a "platform" for introducing other resource-conserving practices such as: sowing on raised beds; surface seeding in riverain areas; smallholders in the eastern IGP using laser levelling to improve irrigation efficiency; cropping diversification (introducing, for example, pulses and vegetable crops); and supporting conversion to full conservation agriculture by replacing puddled rice cropping with aerobic rice cultivation. Such practices will be crucial for the region, given that by 2050 climate-change induced heat and water stress in irrigated areas may reduce wheat yields by 12 per cent and rice by 10 per cent, while the unsustainable extraction of water for agriculture continues to drain aquifers.

Zero-tillage helps overcome resistance to new practices *(CIMMYT)*

The success of zero-tillage, and the participatory approach through which it was promulgated, has helped overcome resistance to new practices among researchers, policymakers, and farmers. Support for zero-tillage has come from public-private partnerships and the facilitation of both national and international technology transfers, primarily through the RWC. State and local governments have come on board to promote and disseminate the technology, in some cases subsidising seed drills to reduce the cost to farmers.

Adoption of zero-tillage is most widespread in India, where the RWC catalysed the public-private partnerships instrumental to its development and dissemination. So far, adoption has centred on intensive, mechanised farms in the northwest states of Haryana and Punjab. Current efforts are targeting the eastern IGP, where agriculture is less mechanised and poverty more extreme. To this end, research and development is ongoing in eastern Uttar Pradesh and Bihar, as well as in Nepal and Bangladesh.

Testimonials:

- **UP Singh, principal investigator, Banaras Hindu University, Varanasi, India:** “I began as a rice agronomist, but working in the Consortium, my mind was opened to the entire rice-wheat cropping system. Between Varanasi and Ballia, we are establishing demonstration sites every 30 kilometres. Farmers are always wary and unbelieving at first, and ask ‘Without tilling, how can a crop grow?’ Once the innovations catch on in a village, the researchers go to another location and repeat the process.”

- **Arun Joshi, researcher at Banaras Hindu University and CIMMYT-South Asia/RWC partner provides feedback from Uttar Pradesh:** Anil Singh was the first in Karhat village, Uttar Pradesh, to try zero-tillage for sowing wheat when it was introduced in 1997. “When Anil's father-in-law first saw Karhat, he began telling everyone that women shouldn't marry its men, because they wouldn't be able to support a family. When Anil had success with zero-tillage and other farmers adopted the practice, his father-in-law changed his tune completely, and now says that all young ladies should marry men from Karhat!”

Additional case study information

Costs and benefits:[2]

According to a CGIAR science panel report of October 2006, the zero-tillage research and development programme yielded a net present value of US$94 million, equivalent to a benefit-cost ratio of 39 and an internal rate of return of at least 57 per cent. This does not take into account the long term environmental benefits.

DFID contribution to research:

- Attributed funding on natural resources management and core funding to CIMMYT over the years was extremely important in supporting RWC.
- John Gaunt, soil scientist and consultant for DFID, attended and gave advice to RWC meetings.
- DFID funded the RWC review conducted by Ashok Seth.
- DFID provides ongoing core-funding to CIMMYT.

Research milestones:

- Mid-1980s Prototype drill is introduced to Pakistan by CIMMYT, followed by a similar introduction in India in 1989.
- 1991-early 2000s Development of first Indian seed-drill prototype at GB Pant University of Agriculture and Technology in Pantnagar, followed by further development and testing of prototypes by agricultural engineering experts in various Indian universities and by CIMMYT. The spread, testing, and adaptation of seed drills in Pakistan. Eventual involvement of seed drill prototypes by private manufacturers, backed by CIMMYT and RWC-led participatory research programme. Over the same period the RWC and CIMMYT: (1) led widespread farmer piloting and promotion of zero-tillage, providing technical backstopping to refine and adapt the practice; (2) provided extensive training and material support for national programme researchers and extension agents; (3) helped organise travelling field days for South Asian farmers.
- 2003-04 Surveys find that 34.5 per cent of farmers in Haryana state, India, and 19 per cent in Punjab province, Pakistan, use zero-tillage on at least some of their land.
- Ongoing research and development by CIMMYT and national partners in the eastern Gangetic Plains of India, Nepal and Bangladesh.

Photo credits:

CIMMYT: For high res images contact Mike Listman (m.listman@cgiar.org) or Susanna Thorp (s.thorp@wrenmedia.co.uk)

Multi-media material:

Millions Fed: Leaving the plow behind
http://www.youtube.com/watch?v=ysM2EuoVYfI

Links:

CIMMYT: www.cimmyt.org

Main references:

Erenstein, O., (2009) Leaving the plow behind: Zero-tillage rice-wheat cultivation in the Indo-Gangetic Plains, in D.J. Spielman and R. Pandya-Lorch (eds.) (2009) *Millions fed: Proven successes in agricultural development*, IFPRI: Washington DC
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Additional resource material:

CGIAR Science Council, (2006) *When zero means plenty: the impact of zero-tillage in India,* Science Council Brief number 13. http://www.sciencecouncil.cgiar.org/fileadmin/user_upload/sciencecouncil/Impact_Assessment/13_CIMMYT_-Final_l-r.pdf

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[1] Facts and figures sourced from: Erenstein, O., (2009) Leaving the plow behind: Zero-tillage rice-wheat cultivation in the Indo-Gangetic Plains, in D.J. Spielman and R. Pandya-Lorch (eds.) (2009) *Millions fed: Proven successes in agricultural development*, IFPRI: Washington DC

[2] CGIAR Science Council, (2006) *When zero means plenty: the impact of zero-tillage in India,* Science Council Brief number 13

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