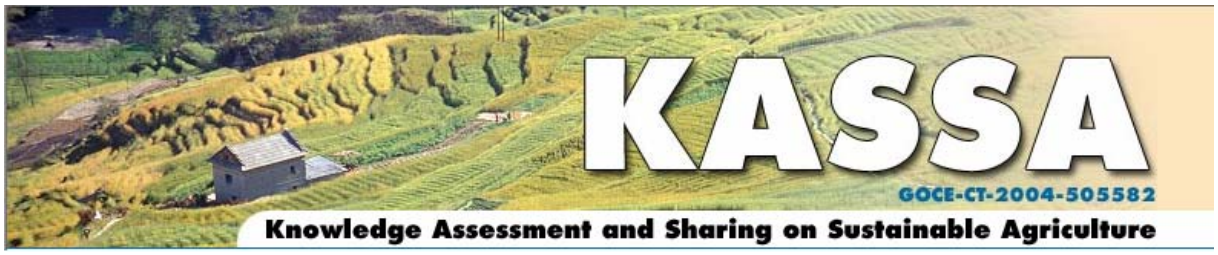

Knowledge assessment and sharing on sustainable agriculture

Main results, gaps in knowledge and challenges in the Asian platform

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ACKNOWLEDGMENTS

The research reported here has been carried out in the context of KASSA project (Knowledge Assessment and Sharing on Sustainable Agriculture) a European Commission – funded project (DG-Research - Contract no. GOCE-CT-2004-505582) under the FP6 programme: "*Integrating and strengthening the European Research Area*"; Thematic priority "Sustainable Development, Global Change and Ecosystems", Sub-priority "Global Change and ecosystems".

KASSA has been coordinated by CIRAD.
It worked between 1 September 2004 and 28 February 2006.
The KASSA Consortium assembled 28 contractors from 18 countries.
KASSA has been implemented through four regional "platforms": Europe, the Mediterranean, Asia and Latin America.
http://kassa.cirad.fr

Partners of the Asian platform:

24- RWC-CIMMYT, India;
27- CASA, India;
28- VASI, Vietnam.

Scientific advice has been provided by:

Michel Griffon (CIRAD, France);
Ren Wang (IRRI, Philippines);
Jaromir Kubat (VURV, Czech Republic);
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This document is the deliverable D5.4 of the workpackage 4.

THE ASIAN PLATFORM

Asian agroecosystems

KASSA focused on rice-wheat and related agro-ecosystems in the Indo-Gangetic Plains, intensive rice-based systems in the river valleys and sloping land systems on hillsides in northern Vietnam.

Rice-wheat systems in the Indo-Gangetic-Plains are a major source of food grains for hundreds of millions of rural and urban poor in South Asia. They are the backbone of national food security for the countries located in the Plains. They directly or indirectly provide employment for most inhabitants of the Plains. They have major effects on the availability and quality of water resources for rural and urban areas.

The ecological and environmental issues in the Indo-Gangetic-Plains have recently received a great deal of attention. In the western transects, issues include groundwater depletion, poor drainage and soil salinization, water pollution from nitrogen fertilizers, air pollution from the burning of rice straw and other residues, low levels of agrobiodiversity, and depletion of soil fertility. Water scarcity and aquatic ecosystem destruction are also problems. In the eastern transects, issues include seasonal flooding and arsenic contamination of groundwater. High intensity monsoon rains concentrated in a span of about 100 days cause heavy soil losses with adverse on site and off site impacts.

Social and economic issues and problems are bewildering in their number and complexity. The central issue is that of poverty. Of the three quarters of a billion people living in the Plains, about a third live in absolute poverty, with incomes of less than one US dollar per day. As usual, poverty opens the door to other problems: hunger, malnutrition, and disease.

Irrigated agro-ecosystems in northern Vietnam are extraordinarily intensive, with two rice crops and an additional winter crop all sown and harvested in a single calendar year. These systems are central to addressing the issue of food security in the context of a rapidly increasing population. Land productivity must continue to increase (note that per capita agricultural land availability fell from 1318 m^2 in 1980 to 914 m^2 in 2003). At present, however, yields are said to have reached a plateau. It is clear that new sources of productivity growth must be identified. But the Vietnamese are very aware that this must be achieved in ways that preserve the resource base.

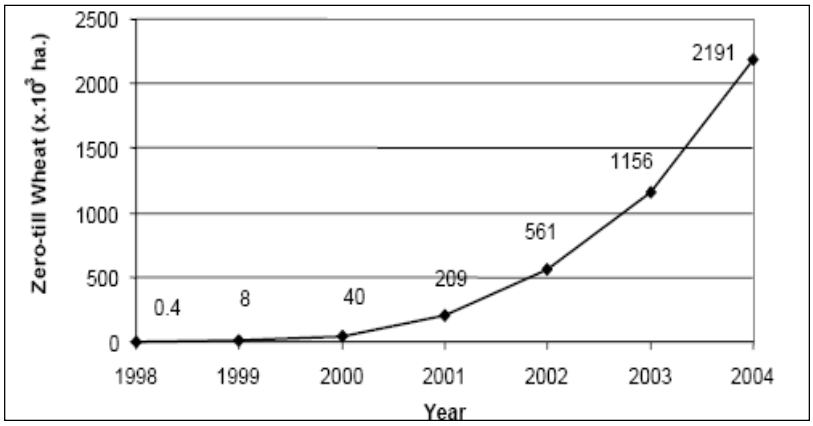
In the hillside systems of northern Vietnam, slopes are typically steeper, population pressure on resources is more intense, and generalized issues of poverty are of greater importance; cropping intensity is actually lower. Livestock are allowed to graze on crop residues. Sometimes these systems employ shifting cultivation, where a particular field is used for a few years until soil fertility has declined and weed pressure has increased. At that time, the field is abandoned and the farm family moves to a new field. The major issue of hillside “shifting agriculture” agro-ecosystems is soil erosion and land degradation.

Conservation Agriculture in the Asian agroecosystems

Information on irrigated conservation agriculture was the principle focus of the Asian platform. Drawing on information from Vietnam as well as from the Indo-Gangetic-Plains, the Platform described the unique situation of conservation agriculture in agro-ecosystems based on puddled rice culture, with recurring transitions between aerobic and anaerobic growing conditions.

Conservation agriculture practices, in the **Indo-Gangetic Plains** referred to as "**resource conserving technologies**" or RCTs, have over the past eight years or so begun to revolutionise irrigated agriculture in South Asia. The practice that has most widely adopted is zero tillage[1] wheat after puddled rice. Area under this technology now exceeds 2 million ha, up from virtually zero in the late 1990s. The swift adoption of this practice is an indication of its very high levels of near-term profitability to farmers – achieved through cost reductions as well as yield gains.

Table 1. Adoption of wheat zero-till after puddled rice in the Indo-Gangetic Plains, 1998-99 to 2004-05 (m ha)



Some early adoption is also being seen for several complementary technologies, among them zero till direct-sown rice, double-zero till of rice and following crops in bed and furrow systems, intercropping of wheat with other crops in bed and furrow systems, and laser levelling of irrigated fields. Apart from laser levelling, however, the area covered by these practices remains small.

Research leading to this "**no-till revolution**" featured a fruitful partnership among national public-sector research programs, local universities, international research centres, private sector implement manufacturers, state-level extension agencies, NGOs, and farmer groups.

The development of conservation agriculture practices is just beginning in the intensively-cropped rice-based lowland agro-ecosystems in **river valleys in northern Vietnam**. As in South Asia, the search for ways to operationalize the principles of conservation agriculture is complicated by the prevalence of puddled rice culture. Direct dry seeding of rice and co-culturing techniques of rice with green manure crops are practices that result in unacceptably low rice yields.

In the **hillside systems in northern Vietnam**, two group of conservation agriculture technologies were examined for these systems. The first group focuses on residue management, mulching, and soil cover through mulch (dry, living, in-situ, or imported); mini-terraces; "soil-cooking" in which dry residues are placed in shallow trenches, partly covered, then burned to rehabilitate highly degraded lands. The second group of conservation agriculture practices focuses on no-till establishment of crops after upland rice.

Researches undertaken

In **India** and **Pakistan**, experiments have been conducted in the national agricultural research systems at experimental sites as well farmers' fields. A number of studies had been incorporated that deals with socio-economic conditions of the farmers.

In **Vietnam**, a research program "Agricultural Systems in Mountainous Regions of North Vietnam" has been started since 1997. Mulch based direct sowing has been used in different types of soils and with different experiment designs. The research sites are located in a Northern mountainous province, and results have been tested in other districts.

Main Results

In the Indo-Gangetic-Plains, a dynamic innovation system, itself a product of interaction and partnership among international research centres, public-sector national research centres, local universities, farmer groups, and private sector implement manufacturers – with central facilitation provided by the Rice-Wheat Consortium – RWC has been successful in developing, adapting and introducing no-till, direct-sown wheat after puddled rice. Public sector policy support and credit/ subsidy programs are in place. Private sector implement manufacturers once again are involved in the process.

[1] Zero tillage, no-till and direct sowing refer to the same technology i.e. sowing in no ploughed soil and without seed bed preparation.

The use of no-till to establish wheat after puddled rice results in very substantial cost savings – especially for smallholder farmers who rent in tillage and crop establishment services. The team found that no-till reduced fuel costs for wheat crop establishment by $36-47 per ha in Pakistan, and about $50 per ha in Haryana State, India. But they also found that no-till led to lower fuel costs for the pumping of irrigation water.

No-till wheat turned out to yield more than conventional till wheat, for two reasons: timelier sowing and better stand establishment. On average, based on many monitored zero-till farmer fields in India, yields of zero-till wheat are from 2-400 kg/ha more. At $100 per ton that works out to $20-40 per hectare extra income. Fields monitored in Pakistan showed a 500 kg increase in yield. The returns to investment to wheat no-till are so large that the purchase of a no-till drill pays for itself in one or two seasons.

Improved water productivity (and higher yields through improved water management) is of the greatest interest in water-scarce environments, as the western (drier) transects of the Indo-Gangetic-Plains. The use of no-till, bed and furrow systems, laser levelling and other resource conserving practices have proven their usefulness.

System diversification and intensification has been observed as an outcome of the adoption of wheat no-till in the Indo-Gangetic-Plains. It appears that zero tillage facilitates agro-ecosystem diversification by providing greater flexibility in sowing dates.

The crisis of herbicide-tolerant weeds in wheat in the Indo-Gangetic-Plains was the motivation for launching an emergency program of farmer experimentation with no-till – with spectacular results. The adoption of wheat no-till after rice actually helps control a major problem weed (*Phalaris minor*). Adoption of no-till resulted in a decrease in herbicide use over time because weed germination gradually dwindled.

In sloping hillside systems in Vietnam, soil cover has been found to be very effective in controlling erosion.

Gaps in knowledge

Conservation agriculture has to be extended to rain fed and irrigated areas in system crops with contrasting edaphic requirements.

There is a need for policy analyses to understand how conservation technologies integrate with other technologies, policy instruments and institutional arrangement that promote or deter conservation agriculture. Sound economic analysis combined with farmer assessment of technologies is needed too.

Problems of soil structure and compaction are largely driven by soil puddling for lowland rice cultivation. Residue retention and soil puddling are mutually exclusive. A major opportunity, then, is the continued development of systems that allow residue retention and mechanised establishment of aerobic rice, wheat, legumes and other marketable crops in agronomically sound rotations.

The introduction of conservation agriculture can be constrained by excessive levels of residues, when many farmers deal with large volumes of loose straw by simply burning it. Retention of rice straw on the soil surface tends (in the absence of specialized drills) to hinder the timely sowing of the following wheat crop. Incorporating the straw tends to immobilize soil nitrogen, requiring that farmers apply additional nitrogenous fertilizers if they are to avoid a yield penalty.

The use of conservation agriculture is also constrained when suitable implements are not available. (Implement availability is less of a constraint in unmechanized agro-ecosystems, e.g., those in Vietnam.) Implements might include special drills for direct-sowing into mulch (to prevent burning of straw) without seedbed preparation, harvesters with special tools for optimal straw distribution on the soil surface, and equipment for weed and pest control.

Existing conservation agriculture systems should be refined to be fewer dependants on external inputs. Innovative crop rotations are needed for addressing changes in weed and pest complexes.

Further studies on the role of crop residues in meeting nutrient demands in micaceous and acidic soils, on sensor based technologies (NDVI[2]) for Nitrogen management, and on practices for organic accumulation in soils could help soil fertility management.

Information on wheat no-till is circulating swiftly, but information on other conservation agriculture practices has not yet been widely distributed. Farm advisory services should be improved.

[2] Normalised Difference Vegetation Index

In research on conservation agriculture for the sloping hillsides of Vietnam, the lack of farmer participation was seen as a problem in spite of real erosion-linked problems.

CA practices e.g. no-tillage and surface maintained crop residues results in resource improvement gradually and benefits came about only with time. It is important that evaluation of these systems takes into account its impact on the environment, and improvement in the quality of natural resources.

There is a need to develop cultivars with efficient nutrient translocation systems, and to breed germplasm for heat/ drought/ water logging tolerance.

Challenges

In the Indo-Gangetic Plains, the main challenge will be to widespread development of zero-till wheat in rice-wheat cropping system, as it has been proved a cost-reducing and yield-increasing practice. This could be helped with:

- Modification in existing implements and practices for puddled rice / zero till wheat; these practices have to be profitable at the farm level in the near term, easy to manage, and have low levels of risk; precision land levelling and permanent bed systems should improve water productivity and promote diversification;
- Information dissemination and training of farmers with farm advisory services;
- Development of aerobic rice, wheat, legumes and other marketable crops in agronomically sound rotations;
- Impact assessment of economic, social, biophysical and agroclimatic consequences of further adoption of these two practices.

For sloping land systems on hillsides in Northern Vietnam, researches have proved benefits of mulching in terms of reducing labour, reducing soil erosion, water holding capacity, and soil fertility. A multi-stakeholder innovation system should be implemented through:

- Farmers' participation in adaptive research with communication strategies and training;
- Definition of recommendation domains and their use;
- Continued research on the economic, social, biophysical and agroclimatic consequences of further adoption;
- Continued dialogue with policymakers regarding the social benefits of conservation agriculture, and the consequences of different policies on conservation agriculture adoption.