Weed pest no longer a bottleneck in raising rice-wheat productivity

RIU

Validated RNRRS Output.

Thousands of farmers in rice–wheat areas of the Indo-Gangetic Plains now practice reduced tillage to control the weed Phalaris minor. This pest was a major bottleneck in raising yields. Previously, farmers didn't understand how long the weed seeds survived in the soil and what caused them to start growing. Now, they've stopped ploughing their fields because they know that this encourages the weed seeds to germinate. Farmers in Haryana State and Punjab, India, successfully used low tillage to control Phalaris. The technique has already spread throughout the Indo-Gangetic Plains in India, Pakistan, Nepal and Bangladesh. Besides curbing the weed, low tillage also reduces erosion, improves soil fertility and lowers input costs—fuel, farm machinery and labour.

Project Ref: **CPP72:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **SAC, UK**
Source: **Crop Protection Programme**

Document Contents:

Description

CPP72

Research into Use
NR International
Park House
Bradbourne Lane
Aylesford
Kent
ME20 6SN
UK

Geographical regions included:

Bangladesh, India, Nepal, Pakistan,

Target Audiences for this content:

Crop farmers,

A. Description of the research output(s)

1. Working title

Minimising the economic and sociological impact of *Phalaris minor* in rice/wheat ecosystems.

2. Name of relevant RNRRS Programmes(s)

Crop Protection Programme

3. Provide R numbers

R7331. SAC, Edinburgh, EH9 3JG, UK; CCS Haryana Agricultural University, Hisar, 125004, India

4. Describe the RNRRS output or cluster of outputs

The project was conducted from 01/01/1999 to 31/12/2001, and extended to June 2002. The project provided strategic support to a suit of research and demonstration work coordinated by CCS Haryana Agricultural University, Hisar (CCSHAU) and supported by Australian (ACIAR) and international (World Bank, CIMMYT, IRRI) funding.

The *Phalaris minor* weed epidemic posed a major threat to the wheat production in the **Indo-Gangetic plains**. The epidemic was driven by a range of biophysical, sociological and economic factors, and the development of appropriate weed control strategies was confounded by the interaction between these factors. CCSHAU had identified a lack of skills in their institute to assess some of these individual factors and their interaction, which constrained their ability to design resilient, integrated weed management systems. Therefore, the project included the following components: (A) knowledge/skill transfer for local scientists in response to locally identified gaps; (B) provision of biophysical and socio-economic information on the drivers of the *Phalaris minor* epidemic in order to formulate recommendations to farmers for **integrated weed management** strategies.

(A) **Knowledge transfer.** The following training workshops were held at CCSHAU: (1) **Sampling** and **multivariate analyses** in surveys of weed populations, 13-15 December 1999; (2) **Simulation** of ecological processes, 11-14 December 2000. (3) Utility of DFID-funded research for control of *Phalaris minor*, 18-20 March 2002. From July to September 2001, Dr RP Sarahan (CCSHAU) received training in molecular ecology at SAC. Each workshop organised by the project was attended by approximately 30 researchers and students from the faculty and post-graduate school at CCSHAU with smaller numbers from the agricultural universities of Ludhiana and Pantnagar. Furthermore, skills to assess the drivers of the weed epidemic were transferred during research activities that resulted in the scientific outputs (B). Especially new methods to conduct and analyse socio-economic surveys of farmers and to quantitatively assess seed longevity and the dynamics of weed seedbanks were relevant to CCSHAU.

(B) Science outputs. To date, the project has generated 3 refereed papers (with 2 more in preparation), 2 conference proceedings papers, 4 conference abstracts/posters and several popular and newsletter articles. The highlights were (1) a clear demonstration of the links between the evolution of the *Phalaris minor* epidemic and the **socio-economic structure** in the farming population; (2) greatly improved understanding of the **seed biology** of *Phalaris minor* in **rice/wheat** rotations and how it is affected by tillage regime; (3) provision of strong evidence that *Phalaris minor* has a high **outcrossing potential**, which has implications for the design of long-term management strategies; (4) development of a lifecycle simulation model of *Phalaris minor*, integrating existing and newly collected information on *Phalaris minor* biology.

5. What is the type of output(s) being described here?

Product	***Technology***	***Service***	***Process or Methodology***	***Policy***	***Other Please specify***
	x		*x*		*x*

A main output is knowledge of the socio-ecological system under investigation

6. What is the main commodity (ies) upon which the output(s) focused?

Wheat. Yes, the methodology used to investigate the socio-ecology of the systems is generic and could be applied to any commodity and any production system.

7. What production system(s) does/could the output(s) focus upon?

Semi-Arid	***High potential***	***Hillsides***	***Forest-Agriculture***	***Peri-urban***	***Land water***	***Tropical moist forest***	***Cross-cutting***
	x						*x*

8. What farming system(s) does the output(s) focus upon?

Smallholder rainfed humid	***Irrigated***	***Wetland rice based***	***Smallholder rainfed highland***	***Smallholder rainfed dry/cold***	***Dualistic***	***Coastal artisanal fishing***
	x					

*9. How could value be added to the output or additional constraints faced by poor people addressed by clustering this output with research outputs from other sources (RNRRS and non RNRRS)? (**max. 300 words**).*

Please specify what other outputs your output(s) could be clustered. At this point you should make reference to the circulated list of RNRRS outputs for which proformas are currently being prepared.

In all suggestions for clustering made here, the motivation is that R7331 covered only a limited part of the food production system whereas the ability of poor people to manage whole systems is often constrained by interactions between different parts of the system. Therefore, clustering R7331 with other projects dealing with similar issues and in related production systems may allow better identification of bottlenecks to technology adoption or to increasing the security of livelihoods. The outputs from R7331 would have added value if they were clustered with other work on weed management in (sub)tropical production systems within the RNRRS programme and also work on characterisation of production constraints in rice and wheat in south-east Asia. Specifically within the RNRRS/CPP clustering the outputs of R7331 with the following projects may add value to all of them: R8409, R8233, R7377; R8412, R8234, R7471; R7473. Because of feedbacks between *Phalaris minor* control and provision of forage for grazing animals, there may also be synergy with R7955. Outside RNRRS, complimentarity between R7331 and work on zero-tillage in the rice/wheat system funded by ACIAR and the World Bank, and to research on production constraints in wheat (India) and rice (south-east Asia) carried out by Prof. Serge Savary (currently at INRA Bordeaux) and colleagues over a number of years.

Validation

B. Validation of the research output(s)

*10. **How** were the output(s) validated and **who** validated them?*
Please provide brief description of method(s) used and consider application, replication, adaptation and/or adoption in the context of any partner organisation and user groups involved. In addressing the "who" component detail which group(s) did the validation e.g. end users, intermediary organisation, government department, aid organisation, private company etc... This section should also be used to detail, if applicable, to which social group, gender, income category the validation was applied and any increases in productivity observed during validation.

(A) Knowledge transfer. No formal validation study was conducted at the end of the project. However, indicators of the effectiveness of knowledge transfer activities were collected by the project members during training workshops organised by the project and afterwards. Each workshop was evaluated by the workshop participants. Also, the way skills, transferred during training workshops at CCSHAU, training at SAC, and research activities, were used by local scientists was recorded, providing indicators of the value of the knowledge transfer activities.

(B) Scientific outputs. The project's scientific outputs were primarily validated by the scientific community through the peer-review of papers published in science journals. Furthermore, science outputs were validated by local scientists and extension workers at CCSHAU, who were not already part of the project, and through feedback received at conferences, workshops and other science meetings where the outputs were presented. The information gathered by the project resulted in practical recommendations on *Phalaris minor* control, and provided a scientific basis for the development-oriented work funded by the Australian government (ACIAR), World Bank and CIMMYT. Their work focussed on promoting integrated weed control approach including the application of reduced tillage techniques among rice-wheat farmers in the Indo-Gangetic plains. This *Phalaris minor* control strategy was evaluated by the Centre for International Economics, Canberra, Australia (commissioned by ACIAR) together with rice/wheat farmers in the Indo-Gangetic plains.

*11. **Where and when** have the output(s) been validated?*

(A) Knowledge transfer outputs were validated at CCSHAU in India during training workshops and towards the end of the project's lifespan.

(B) Scientific outputs were validated through peer-review of publications and at science meetings worldwide during the project and afterwards, and at CCSHAU in India towards the end of the project. Recommendations for integrated *Phalaris minor* control strategies were validated in 2001-2002 with rice-wheat farmers in the Indo-Gangetic plains in northern India, primarily from Haryana State and Punjab (irrigated, high potential). No particular social group of farmers was targeted in this evaluation, although the group of farmers who had adopted improved weed control techniques tended to be socio-economically better positioned than farmers who did not adopt, as highlighted by the socio-ecological audit conducted in the current project.

Current Situation

C. Current situation

12. ***How and by whom*** *are the outputs currently being used? Please give a brief description.*

(A) Knowledge transfer. During training workshops organised by the project electronic copies of the training manuals were transferred to CCSHAU, and are currently used at CCSHAU for research and teaching purposes. Modelling software used in the second workshop was introduced to CCSHAU with a free site license for research and teaching purposes. The content of the second workshop was used by Dr RS Banga to develop an undergraduate course in modelling in weed science, which is now part of the syllabus at CCSHAU. Furthermore, Dr RP Saharan received training at SAC in techniques used in molecular ecology, which resulted in new molecular biology facilities at CCSHAU used to support the research programme on *Phalaris minor.* Skills transferred during the workshop and the project's research activities are currently being used by Indian scientists and students.

(B) Scientific output. Papers and abstracts based on the scientific activities of the project are being used by the scientific community, in particular by scientists working in the field of crop protection and farming systems research. New knowledge on the lifecycle of *Phalaris minor*, especially its seed biology, predictions made by the lifecycle model, and results from the socio-economic survey resulted in a strong recommendation to pursue the promotion of reduced tillage techniques in the Indo-Gangetic plains as a mean to reduce weed pressure and enhance the overall resilience of the farming system. Reduced tillage techniques in wheat are currently being used by many farmers in the Indo-Gangetic plains. Besides curbing *Phalaris minor* emergence, the technique has the additional advantage of reducing input costs (fuel, farm machinery, labour), reducing erosion and improving soil fertility. Therefore, reduced tillage techniques are also being adopted in areas of the Indo-Gangetic plains where *Phalaris minor* does not pose a threat to wheat production.

13. ***Where*** *are the outputs currently being used? As with Question 11 please indicate place(s) and countries where the outputs are being used.*

Outputs of the knowledge transfer activities are primarily being used at CCSHAU, as well as the agricultural universities of Pantnagar and Ludhiana in northern India. The scientific output is being used by the scientific community worldwide. Improved *Phalaris minor* control techniques were primarily applied by farmers in Haryana State and Punjab, India, but are now used throughout the Indo-Gangetic plains in India, Pakistan, Nepal and Bangladesh.

14. What is the scale of current use? Indicating how quickly use was established and whether usage is still spreading.

Given that a considerable part of the knowledge and skills transferred to scientists and student at CCSHAU has been incorporated in the syllabus at CCSHAU, it is clear that current use of skills and knowledge, transferred during the project, is considerable.

The practical recommendations on *Phalaris minor* control based on the scientific work from the current project and others has been widely adopted by farmers. ACIAR has commissioned an adoption study and an economic study on the impact of improved *Phalaris minor* control strategies including reduced tillage in Haryana State and Punjab. It was estimated that in 2006, close to a million ha of land is under reduced tillage in Haryana State and Punjab alone, and its usage is still spreading. In Haryana and Punjab, problems with *Phalaris minor* control accelerated the adoption of reduced tillage. However, the technique has also been adopted in other parts of the Indo-Gangetic plains where *Phalaris minor* does not pose a major threat to wheat production, because of the additional financial and environmental benefits provided by this technique, as further discussed under Question 21. Also in other parts of the Indo-Gangetic plains, the use of reduced tillage techniques is currently rapidly expanding

15. In your experience what programmes, platforms, The policy, institutional structures exist that have assisted with the promotion and/or adoption of the output(s) proposed here and in terms of capacity strengthening what do you see as the key facts of success?

(A) Knowledge transfer. An important component contributing to the successful transfer of knowledge / skills was the identification of knowledge and skills gaps by the national partner CCSHAU *prior* to the start of the project. Therefore, the demand for the knowledge and skills offered by the project was high. Workshops provided by the project were well attended by scientists and post-graduate students and a great deal of the training manuals, software and techniques for molecular ecological research are used for further studies and education at CCSHAU.

(B) Scientific output. The presence of a strong Weed Science research group at the national partner (CCSHAU) was essential for the promotion and adoption of the practical recommendations arising from the scientific work. Towards the end of the project, the group at CCSHAU organised an international workshop on the control of *Phalaris minor* and the use reduced tillage techniques, which greatly contributed to creating awareness and knowledge of the scientific outputs of the project among regional scientists and extension workers.

Furthermore, the collaboration with other projects in the region funded by ACIAR, World Bank, CIMMYT and the Rice Wheat Consortium was essential for the adoption of outputs by farmers. This collaboration prevented the duplication of research efforts. In addition, it ensured a rapid translation of research findings into practical recommendations for farmers, and the dissemination of successful technologies to a great number of farmers in the Indo-Gangetic plains.

Policies from the Indian national government also affected the uptake rate of *Phalaris minor* control strategies. The government generally pursued a favourable policy towards agricultural change. However, unintentionally, the government's decision to rapidly reduce subsidies on diesel over 1999-2002 greatly enhanced the uptake of reduced tillage techniques, which, besides reducing *Phalaris minor* pressure, saved petrol relative to conventional tillage techniques.

Current Promotion

D. Current promotion/uptake pathways

16. ***Where*** *is promotion currently taking place? Please indicate for each country specified detail what promotion is taking place, by whom and indicate the scale of current promotion.*

Promotion of improved *Phalaris minor* control techniques is taking place primarily through the national system of agricultural universities of India and other countries of the Indo-Gangetic plains (Pakistan, Bangladesh, Nepal). Furthermore, the rice-wheat consortium, an alliance between national research organisations in countries of the Indo-Gangetic plains CGIAR centres and other advanced research institutes, is promoting reduced tillage technologies in the region.

17. What are the current barriers preventing or slowing the adoption of the output(s)? Cover here institutional issues, those relating to policy, marketing, infrastructure, social exclusion etc.

(A) Knowledge transfer. We found the bureaucratic and ineffective governance of the higher management of the partner university in India (CCSHAU), to be a major barrier for a further uptake and spread of knowledge and skills as promoted by the project. This bureaucracy, for example, greatly delayed the spending of project funding through the university channels and frustrated project members in their work.

(B) Scientific output. The project identified a strong, positive relation between farmer's socio-economic position and the adoption rate of improved *Phalaris minor* control strategies, in particular reduced tillage techniques, in Haryana. Farmers with a poor socio-economic status were less likely to adopt new weed control technologies. These were often farmers owning little land. This variation in adoption rate of new farming technologies was related to differences in the ability to invest resources (financial, land, labour) associated with adopting new technologies. Also a bias of extension workers preferring to collaborate with farmers that have a high socio-economic status, and a poor access of farmers with a low socio-economic position to other sources of information on farming, contributed to this difference, slowing down the overall adoption rate.

18. What changes are needed to remove/reduce these barriers to adoption? This section could be used to identify perceived capacity related issues.

Changes in the governance of the Indian universities would be required to make the institutes more effective and less bureaucratic. With regard to the adoption of new technologies by farmers, a focus on socio-economically disadvantaged groups by agricultural extension workers could partly reduce this 'adoption bias'. Furthermore, a focus on innovative technologies that require little initial investment (financial, labour or land) would result in a more equal adoption rate throughout the farming community than technologies with a high initial investment requirement.

19. What lessons have you learnt about the best ways to get the outputs used by the largest number of poor people?

A pro-poor focus throughout the entire lifespan of the project may be essential to get project outputs used by large numbers of poor people. In an early phase of technology development, technologies should be tested under real-life conditions together with the target group. In addition, technologies should be robust and flexible enough to suit the wide range of biophysical and socio-economic environments in which farmers work. Furthermore, poor access to information (from media, extension workers, farmer study groups, etc.) is often limiting the adoption of new technologies by poor people. A more farmer-participatory, pro-poor focus of extension workers will contribute to a higher adoption rate of new technologies by poor people. On the long term, education of poor farmers and their families will give them better access to information sources and the means to innovate and adopt new technologies

We also noticed that a focus on very poor people is not always the most effective way of rapidly disseminating new technologies to many farmers. The preference of Indian extension workers to deal primarily with farmers that are socio-economically well positioned was also related to the innovative attitude of these resource-rich farmers. Poor farmers had fewer resources to experiment with new technologies and were more risk-averse than rich farmers. Thus, targeting richer farmers was an efficient way to get new weed control technologies rapidly adopted in parts of the farming community. Subsequently, technologies may spread throughout the entire farming community. A disadvantage of this approach is that it contributes to growing differences in wealth between socio-economic groups. New *Phalaris minor* weed control strategies were, after initial investments, more profitable than traditional techniques. The difference in adoption rate was thus likely to enlarge differences in wealth status between socio-economic groups, which can eventually further marginalise the poorest farmers. For example, we found that only 23% of Haryana rice-wheat farmers owned 12ha or more. In a survey of reduced tillage use in six different districts in Haryana in 2001/02 Punia *et al*. (2002) report that the average area of self-owned land under reduced tillage by 152 drill owners was 12.6ha, suggesting that reduced-tillage drill owners are generally the largest farmers.

Impacts On Poverty

E. Impacts on poverty to date

20. Where have impact studies on poverty in relation to this output or cluster of outputs taken place?

The following studies will be useful to assess the impact of the project on poverty in the Indo-Gangetic plains, which is further discussed under Question 21. As far as we are aware, no formal impact studies on poverty in relation to the cluster of outputs have been conducted.

Bolliger, A., Magid, J., Amado J.C.T., Neto, F.S., Ribiero, M.F.S., Calegari, A., Ralisch, R., de Neergaard, A. (2006) Taking stock of the Brazilian ‘Zero-till revolution’: a review of landmark research and farmers’ practice. *Advances in Agronomy* 91: 47-110.
Ekboir, J., Boa, K., Dankyi, A.A. (2002) No-till technologies in Ghana. CIMMYT, Mexico D.F., Mexico, pp. 42.
Franke, A.C. McRoberts, N., Marshall, G., Malik, R.K., Singh, S., Nehra, A.S., Gill, G.S. (2001) The contribution of zero tillage for the management of *Phalaris minor* in the Indian rice-wheat system. Brighton Crop Protection Conference 2001 – Weeds: 901-906.
Franke, A.C. (2003) Ecological and sociological aspects of the *Phalaris minor* epidemic in the rice-wheat system of Haryana, India. PhD thesis. Scottish Agricultural College, Glasgow University, Glasgow, U.K., pp.188.
Franke, A.C., McRoberts, N., Marshall, G., Malik, R.K., Singh, S., Nehra, A.S. (2003) A survey of *Phalaris minor* in the Indian rice-wheat system. *Experimental Agriculture* 39: 253-265. See also Annex 2.
Hobbs, P.R. (2002) Resource conserving technologies – a second revolution in south Asia. International Workshop on Herbicide Resistance Management and Zero Tillage in rice-wheat cropping system, March 4-6, 2002. CCS Haryana Agricultural University, Hisar, India.
Hobbs, P.R., Gupta, R., Ladha, L.K., Harrington, L. (2000) Sustaining the green revolution by resource conserving technologies: the rice-wheat example. *ILEIA Newsletter* 16(4): 8-10.
Singh, S., Kirkwood, R.K., Marshall, G. (1999) Biology and control of *Phalaris minor* Retz. (littleseed canarygrass) in wheat, review article. Crop Protection 18: 1-16.
Singh, S. Yadav, A., Malik, R.K., Singh, H. (2002) Long-term effect of zero-tillage sowing technique on weed flora and productivity of wheat in rice-wheat cropping zones of Indo-Gangetic plains. International Workshop on Herbicide Resistance Management and Zero Tillage in rice-wheat cropping system, March 4-6, 2002. CCS Haryana Agricultural University, Hisar, India.
Vincent, D., Quirke, D. (2002) Controlling *Phalaris minor* in the Indian rice-wheat belt. Centre for International Economics, Canberra, Australia. ACIAR Impact Assessment Series, No. 18. (See also Annex 1)
Yadav, A., Malik, R.K., Singh, S., Chauhan, B.S., Yadav, D.B., Murti, R., Malik, R.S. (2002) Long-term effects of zero-tillage on wheat in rice-wheat cropping system. International Workshop on Herbicide Resistance Management and Zero Tillage in rice-wheat cropping system, March 4-6, 2002. CCS Haryana Agricultural University, Hisar, India.

*21. Based on the evidence in the studies listed above, for each country detail how the poor have benefited from the application and/or adoption of the output(s)**:***

- *What positive impacts on livelihoods have been recorded and over what time period have these impacts been observed? These impacts should be recorded against the capital assets (human, social, natural, physical and, financial) of the livelihoods framework;*
- *For whom i.e. which type of person (gender, poverty group (see glossary for definitions) has there been a positive impact;*
- *Indicate the number of people who have realised a positive impact on their livelihood;*
- *Using whatever appropriate indicator was used detail what was the average percentage increase recorded*

To establish a causal relationship between knowledge transfer and capacity building at the agricultural university CCSHAU in India, as conducted through this project, and poverty impact is difficult. However, it is likely that, on the long term, an improved capacity to conduct agricultural research will result in more resilient farming systems and rural development in the Indo-Gangetic plains, leading to poverty reduction in rural areas.

The scientific activities of the project have improved the understanding of the broader socio-ecological context that has allowed *Phalaris minor* to develop into a serious wheat production constraint, and of *Phalaris minor* population dynamics (Franke *et al*., 2001 & 2003; Franke, 2003). Weed management recommendations that arose from the scientific work carried out through this project and other projects in the region had a major impact on weed control and farm productivity in the Indo-Gangetic plains (i.e. in India, Pakistan, Nepal and Bangladesh) (Hobbs *et al*., 2000; Hobbs, 2002; Yadav *et al*., 2002). Vincent & Quirke (2002) estimated that in 2006, close to a million ha of land is under reduced tillage in Haryana and Punjab alone, giving a total annual producer gain of 67 million Aus $, which will further rise to approximately 150 million Aus $ by 2010, relative to the situation in 1999. For a family with a farm of 5 ha, this would result in an additional annual income of Aus $ 870 in 2010. The study does not specify which type of farmer benefited most of the gains made by the adoption of improved *Phalaris minor* control techniques. More than half of the poor in the Indo-Gangetic plains live in rural areas. Where improved weed control technologies were adopted, poor people were likely to have benefited from the technologies directly or indirectly. Poor people that own land, *i.e.* moderate poor people, were likely to have gained more than landless poor. Indeed landless poor often harvest *Phalaris minor* from wheat fields as a source of free fodder, so improved weed control may act against their interests. Given the Indian system of minimum guaranteed prices farmers receive for agricultural products such as wheat, gains resulting from improved farming technologies will primarily benefit farmers and other rural people, and not urban consumers.

Reduced tillage techniques have been adopted in many parts of the world (Bolliger *et al*., 2006; Ekboir *et al*., 2002), because the technique has the advantage of reducing input costs and erosion rates, and increasing soil organic carbon levels, soil biological activity, and soil moisture conservation. For the Indo-Gangetic plains, little data is available on the effects of reduced tillage on long-term soil fertility. However, it is likely that also here reduced tillage techniques increase the overall resilience of the farming system, contributing to farmer's natural capital assets. This is in line with the stable increase in wheat yields by 5-10% recorded in fields under reduced tillage, relative to conventional tillage practices (Yadav *et al*., 2002; Singh *et al*, 2002). The application of reduced tillage techniques in the Indo-Gangetic plains decreases labour requirements by approximately 50% in a period when labour opportunity costs are relatively high (Franke, 2003). Labour savings may indirectly contribute to all capital assets, except for natural capital, depending on how the extra spare time is used.

Environmental Impact

H. Environmental impact

24. What are the direct and indirect environmental benefits related to the output(s) and their outcome(s)?

There are several direct environmental benefits related to the uptake of improved *Phalaris minor* control technologies. Reduced tillage decreases *Phalaris minor* emergence and thus farmers' reliance on herbicides later in the season for its control. It also decreases diesel consumption for land reparation by 60-75%, reducing CO_2 emissions, while increasing carbon in crop residues returned to the by 40%. Soil water demand for irrigation is reduced by around 12% and water use efficiency increased by 16%. Burning of rice straw in the field is widely practiced in the Indo-Gangetic plains to clean the field before conventional tillage and sowing operations for wheat, which causes considerable air pollution. Reduced tillage and direct seeding of wheat into the stubble of the previous rice crop allows farmers to use rice straw as a protecting soil cover, making rice straw burning an unnecessary and economically unattractive option.

25. Are there any adverse environmental impacts related to the output(s) and their outcome(s)?

Outside the Indo-Gangetic plains, the adoption of reduced tillage techniques has often coincided with an increased use of pre-emergence herbicides, such as glyphosate, which may have negative environmental impacts. In the rice-wheat system, very few weeds survive the dramatic change in environment from paddy rice in summer to wheat in winter, making the use of pre-emergence herbicides in wheat under reduced tillage unnecessary in the vast majority of fields.

26. Do the outputs increase the capacity of poor people to cope with the effects of climate change, reduce the risks of natural disasters and increase their resilience?

The application of reduced tillage techniques can contribute to an increased soil water holding capacity, and a better physical structure of the soil, which allows crops to survive drought spells induced by climate change.
