Conservation Agriculture for the rice-wheat systems of the Indo-Gangetic Plains of South Asia: A case study from India[1]

Peter R. Hobbs, Raj Gupta, R.K.Malik and S.S. Dhillon[2]

Abstract

One of the major cropping systems of South Asia is rice-wheat grown on 13.5 million hectares in the Indo-Gangetic Plains (IGP). It is a major system for food security in the region and provides livelihoods and income to millions of farmers and workers. The rice-wheat consortium (RWC) is a CG eco-regional program that combines natural resource management with production development in the IGP in geographically defined areas and targets different socio-economic groups. Its members include the national programs of Bangladesh, India, Nepal and Bangladesh, International centers (CIMMYT, IRRI, ICRISAT, IWMI and CIP) and various advanced institutions. The RWC has been promoting conservation agriculture in the IGP for the past 10 years, especially 0-tillage and reduced tillage systems and more recently permanent bed systems. This paper is a case study of the remarkable revolution that has taken place in the region with data from the State of Haryana in India. In this State, farmers have adopted 0-tillage wheat after rice and more recently bed planted wheat with gusto and the acreage has risen from zero in 1997 to 40,000 ha last year. Local artisans at a cost affordable to farmers manufacture all of the equipment. A participatory technology development paradigm was used to successfully achieve this impact. Benefits from this technology include reduced costs, less wear and tear on equipment, less weeds, improved water and fertilizer efficiency, less diesel use and therefore a reduction in greenhouse gas emissions and even an increase in yield. This improves farmer profit, improves his livelihood and eventually reduces poverty. All economic class of farmer also uses the technology since most farmers have to hire service providers for ploughing and this technology needs just one call to get the job done. Bed planting where the benefits of 0-tillage are combined with a bed and furrow system is also described. The use of conservation agriculture is probably one of the best ways to increase production, increase food security, improve farmer livelihoods and create environmental benefits while undertaking efficient natural resource use. The example of the information from the Sate of Haryana in India amply supports this statement.

---

[1] Paper presented at the 1st World Congress on Conservation Agriculture Madrid, 1-5 October, 2001

[2] CIMMYT regional representative for South Asia and co-Facilitator of the rice-wheat consortium for the Indo-Gangetic Plains of South Asia, Facilitator of the RWC, Agronomist/weed scientist at Haryana State University, Hisar, India, and agronomist PAU Ludhiana, India, respectively.

Conservation Agriculture for the rice-wheat systems of the Indo-Gangetic Plains of South Asia: A case study from India

Peter R. Hobbs, Raj Gupta, R.K.Malik and S.S. Dhillon

Background and introduction:

Rice and wheat are grown sequentially in a mainly irrigated, double cropping pattern in the Indo-Gangetic Plains of South Asia on about 13.5 million hectares in Bangladesh, India, Nepal and Pakistan (Ladha, 2000). It is a major cropping system for sustaining food security in the region and there are millions of farmers and agricultural workers dependent on this system for employment and livelihoods.

The rice-wheat consortium (RWC) is an eco-regional program of the consultative group on international agricultural research (CGIAR), convened by CIMMYT that combines natural resource management with production development in the Indo-Gangetic plains of South Asia. It is a forum made up of many partners, including staff from national program research and extension, International agricultural research centers (CIMMYT, IRRI, IWMI, CIP and ICRISAT) and various advanced research institutions (Cornell, Rothamsted, CABI-UK, University of Melbourne, IAC, Wageningen). It promotes regional and global linkages for the development and deployment of improved, sustainable, productive rice-wheat cropping systems for the region.

The RWC has been promoting the use of conservation agriculture practices in this eco-regional zone for the past decade. These resource conserving technologies are based on reducing costs of production, improving the efficiency in the use of natural resources, providing environmental benefits, reducing costs while at the same time increasing production.

Geographical area and characteristics

The case study will use data from the Indian State of Haryana situated in the Northwestern side of the sub-continent in the Districts of Karnal, Kurukshetra and Kaithal (Harrington, 1993). The soils in this area are mainly alluvial in nature and many are recently reclaimed saline/sodic soils. The climate is a semi-arid, sub-tropical one with a distinct wet rainy season from June to September and a dry season from October to May. Rainfall is mostly in the rainy season (85%) and averages about 4-500 mm per year. Irrigation from canals and tubewells is needed to allow cropping. The main cropping system in the three Districts for this case study is rice in the monsoon season followed with wheat in the cooler dry season. Both crops are grown in the one calendar year. The rice crop is usually planted into seedbeds in May/June and the uprooted seedlings transplanted into flooded, puddled soils in June/July. Irrigation is used to supplement the rainfall. Long duration, *Basmati* type rice (40-50%) and shorter duration modern varieties are grown. The short duration varieties are harvested from late September through

October. The *Basmati* rice is harvested later in November and can cause late planting of the next wheat crop.

Wheat is planted after the rice crop is harvested starting in late October through November and sometimes into December. Multiple plowings (6-12) are usually done with a disc harrow or 9-tine cultivator before planting the wheat. Often the wheat seed is broadcast by hand before incorporating with the cultivator because of residue problems. Many farmers also burn the residues, especially after combine harvest and create severe air pollution. This multiple plowing not only increases the cost of production but also delays wheat planting especially where *basmati* rice is grown. This reduces yield by 1-1.5% per days delay after November 20 (Ortiz-Monasterio 1994). Maximizing yields requires timely planting and good plant stands. Wheat is harvested in April to early May. *Phalaris minor* is a major grass weed in the wheat crop and recently this weed developed resistance to *Isoproturon,* the most commonly used herbicide in the State.

Rice is the major crop in the monsoon season but brassica oilseeds, potatoes, legume fodders (*berseem* clover) and other crops can be grown instead of wheat. Sugarcane is grown on some coarser textured soils in 3-4 year rotations with rice and wheat.

New Resource conserving technologies

This paper will describe two RCT's being promoted in the IGP's:

1. Zero-tillage establishment of wheat after rice – this system uses a modification of the opener for the traditional *rabi* (winter) crop seed drill to allow planting of wheat into fields following rice harvest without plowing the field. The modification is base on an inverted-T opener used on a seed drill imported from New Zealand to Pantnagar University in 1988. This system works well after hand harvested rice where there are anchored rice residues but few loose residues. It's utility is less in fields that are combine harvested where large amounts of loose straw creates a raking problem. Farmers traditionally burn the loose straw residue and do the same when planting with the 0-till Pantnagar drill.
2. Bed planting of wheat, rice and other crops on top of a ridge and furrow system. This technology was introduced after Indian scientists visited the CIMMYT program in Mexico and learnt about this technique eagerly adopted by farmers in the Yaqui valley of Sonora State. This system is being promoted mainly for the benefits that accrue from water savings, but also in areas where grassy weeds are a problem since this system allows mechanical weeding and a reduction in costly herbicide applications. This system also allows for fertilizer placement, both basal and topdress, and increased efficiency of these inputs.

Farmer perceptions on the RC technologies

1. Zero-tillage

The approach used by the RWC partners in introducing the 0-till technologies to farmers in Haryana was one of enhanced participation of farmers, extension, scientists and local manufacturers. The technology was introduced to the farmers in the first year and then left the farmers to experiment with the technology in the second year as they gained confidence in its benefits. In this way, there was very good feedback of needed improvements to the drill and what worked and didn't work. These changes were incorporated into the machinery and management package for the next year's work. This led to rapid expansion in area for this technology for the benefit of all partners.

The farmers are very enthusiastic about this technology and adoption has risen from a few acres in 1998 to more then 100,000 acres in Haryana in 2001. Stories abound about skeptical farmers ridiculing innovative farmers when the technology was first tried. Some farmers conducted the trials at night to avoid being seen experimenting with this technology. However, once the crop emerged farmers became convinced it would work and rushed to borrow or custom-hire the equipment to sow their fields. The main constraint in further accelerating this technology is availability of sufficient drills to satisfy the demand of the farmers. This will be corrected in coming years as more local manufacturers provide drills for farmers. It is now been accepted as a recommended practice by the State extension service.

Data shows that small landholders without tractors benefit from this technology since they only have to contact the service providers once to get their fields planted whereas for normal land preparation this had to be done many times. That frees up time for other employment. It also saves 4 million liters of diesel and 40 billion liters of irrigation water in the State.The carryover of the stemborer larvae has been the one major reason why some scientists and extension agents have not approved this technology. Data from monitoring shows that this is not the case. In fact, 0-tillage promotes beneficial insects by leaving a favorable habitat in the form of un-burnt residues that help control stemborer populations.

2. Bed planting

Bed planted wheat acreage has also grown the past two year as more drills were made and the number of farmers experimenting with this technology increased. This included planting wheat onto beds used for a previous rice crop and after minimal bed shaping. Farmers are interested in bed planting as a way to reduce irrigation. They would be even more enthusiastic if the beds could be permanent and just require some simple reshaping between crops. The bed planting would then combine the benefits of beds with those of zero-tillage. Bed panting was only introduced to farmers a few years ago and already almost 100 acres are planted in Haryana

The most astounding finding was the performance of rice on beds. This was unexpected and was only undertaken to see if we could use permanent beds in rice-wheat areas (this would significantly help in reducing the cost of forming beds and make the technology more appealing to farmers). One farmer got 8.3 t/ha of rice from an acre planted to this system, and even more encouraging he did it with 65% less water!! Data shows that costs of bed planted rice (2900-3300 Rs/ac) were less than for normal transplanted rice (4500). Of 11 fields planted, yields for bed planting was 4500 kg/ha while normal transplanted rice was 3680. Average water savings was 50% or 50cm water per acre. Interestingly, we went straight to the farmers with this technology, the same farmers who benefited first from the 0-till introduced to them.

Results

Five sets of farmer fields are being monitored with one acre field using 0-till and one conventional. Farmers have agreed to continue with the same practice for 3 years although they really want to shift the entire farm to 0-till. Average wheat yields for the 5 monitored sites was 5.56 for 0-till and 5.20 t/ha for conventional. In only one site out of 4 was 0-till less than conventional. The highest 0-till yield was 6.82 t/ha while that for normal was 6.0. The extra yield in 0-till was the result of timelier planting and fewer weeds. In fact, the monitoring data shows that 0-till helps reduce weed population over time. Data is also showing that 0-till fields have a higher soil organic carbon content although this needs to be confirmed over time.

Since the yields of wheat are higher and the costs of production are lower, the farmers improve the profitability of their wheat and this in turn improves their livelihoods. Since resource poorer farmers can also avail this technology they also benefit from being adopters. There are also many benefits to the country in that diesel imports can be reduced. If this technology were used on just 5 million hectares of the 13.5 million hectares of rice-wheat, 300 million less liters of diesel would be needed.

There are also benefits to natural resources and the environment. Zero-till saves about one third of the water needed. This is even higher with bed planting (up to 50% on wheat and more in rice). This is equivalent to about one million liters of water per hectare savings or if practiced on 5 million hectares, 5 billion cubic meters of water each wheat season. That would fill a lake 5 km wide, 10 km long and 100 meters deep. Since water is becoming a major natural resource constraint in the region, this benefit has major implications if the field level savings translate into basin level savings. Bed planting has even more water savings and there is a possibility it can be combined with drip irrigation systems to create even more benefits.

Environmentally, these technologies have profound effects on greenhouse gas emissions. The savings in fuel (0.3 billion liters from 5 million hectares of wheat) translates into almost a million tons of carbon dioxide. Further savings are obtained through using less energy to pump water and the energy saved because of more efficient use of fertilizers. Zero-tillage and permanent bed planting also allow residues to be left on the soil surface and provide an alternative to burning. This is the research thrust and challenge for the future – to provide farmers with a suitable system for handling loose residues. If the residues could be left on the surface without burning on 5 million hectares of land, more than 40 million tons of carbon dioxide would not immediately enter the atmosphere. It would also have an immediate effect on improving air quality at the time of harvest.

Data from various on-station experiments also show that the benefits of 0-till can be even higher if wheat is planted after non-puddled rice. Future research will look at ways to grow rice without puddling both on the flat and on beds. Weeds will be a major problem that will need attention.

Conclusions

0-till wheat is now an established crop management activity for farmers in Haryana rice-wheat areas. It will continue to grow as more machines are made available and will save millions of rupees in costs, fuel and tractor wear and tear. Environmental benefits will increase as the issue of handling loose residue instead of burning becomes feasible. Bed planting will also grow in popularity as more machinery and more farmers experiment with it. Permanent bed planting will cut costs, improve yields and drastically reduce natural resource use, especially water but also fertilizer and other inputs. There is still a lot to do. The technology needs to be adapted to smaller two-wheel and animal drawn systems that would be more feasible for the resource poor farmers of the eastern IGP where plot size is also much smaller. Issues of weed carryover from the rice crop to the wheat crop will also be more important in these warmer eastern areas. Fields need to be monitored over time to establish whether any unforeseen problems arise that will need attention, but also to document the benefits of this technology on soils, biotic and socio-economic variables. Data is needed on the effects of these two practices in saline/sodic soils. Leveling of lands can also bring about further benefits in water savings and yield and this needs to be promoted in the region. The use of conservation agriculture is probably one of the best ways to increase production, increase food security, improve farmer livelihoods and create environmental benefits while undertaking efficient natural resource use. The example of the information from the Sate of Haryana in India amply supports this statement.

References

Harrington, L.W., S. Fujisaka, M.L. Morris, P.R. Hobbs, H.C. Sharma, R.P. Singh, M.K. Chaudhary, and S.D. Dhiman. 1993b. Wheat and Rice in Karnal and Kurukshetra Districts, Haryana, India: Farmers' Practices, Problems and an Agenda for Action. Mexico, D.F.: Haryana Agricultural University (HAU), Indian Council for Agricultural Research (ICAR), CIMMYT, and IRRI.

Hobbs, P.R., Y.Singh, G.S.Giri, J.G. Lauren and J.M. Duxbury. 2000. Direct Seeding and Reduced Tillage Options in the Rice-Wheat Systems of the Indo-Gangetic Plains of South Asia. Proceedings of an IRRI workshop entitled “Direct Seeding in Asian Rice Systems” held in Bangkok Thailand from 25-28 January 2000.

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

Malik,R.K.; Gill,G.; Hobbs,P.R. 1998. Herbicide resistance - a major issue for sustaining wheat productivity in rice-wheat cropping system in the Indo-Gangetic plains. Rice Wheat Consortium Research Paper series number 3. 36 pp. New Delhi, India: Rice Wheat Consortium for the Indo-Gangetic Plains.

Ortiz-Monasterio, J.I., Dhillon, S.S. and Fischer, R.A. 1994. Date of sowing effects on grain yield and yield components of irrigated spring wheat cultivars and relationships with radiation and temperature in Ludhiana, India. Field Crops Research. 37: 169-184.