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Getting Agriculture to Work for People and the Environment

Conservation Agriculture Based Technologies for Maize Systems, The Way Forward...

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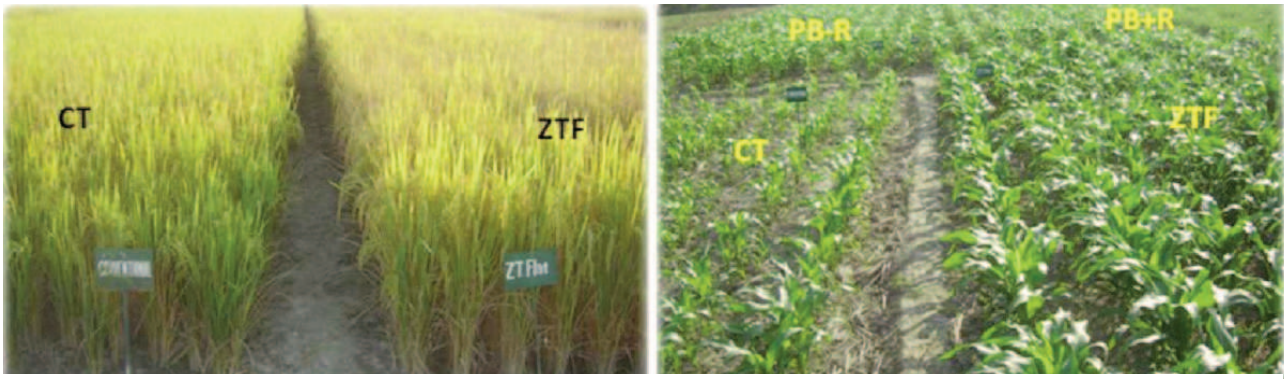

Figure 1: Early maturity of rice in zero till (L), facilitated early planting of zero till maize (R).

This article presents results of on-station trials conducted on rice-maize and maize-wheat cropping systems in eastern Indo-Gangetic plains (IGP). Results clearly indicate significant saving in inputs and improved yields and system productivity. As can be seen, conservation agriculture based technologies reinforce its relevance for maize systems in the South Asian region.

Achieving sustainable food security is a major challenge considering the growing population with changing diets and a degrading resource scenario. Maize or corn (Zea mays) is an important food and feed crop and is one of the most versatile, high yielding food crops of the world. In South Asia with limited availability of water, and aberration in temperature on account of climate change, it is becoming increasingly important that issues concerning it be addressed. Wheat and rice, the common cereal crops having C-3 metabolic pathway are more vulnerable to climate change compared to maize. With maize being four times better than rice in terms of water use efficiency; it seems to be the future cereal crop to feed increasing human population and livestock in South Asia.

Maize lends itself to various applications and has a high yield potential and wide adaptability across regions, seasons and altitudes, making it suited in different cropping and farming systems. Its demand is increasing on account of the shift towards animal based diets and expansion of the bio-fuel industry.

Traditionally maize is planted after repeated tillage and through broadcast sowing. However, sometimes it is also dibbled (largely hybrids) in lines mainly due to expensive seed or is even inter-cropped with other crops. Broadcast/ dibbled sowing in absence of fertilizer placement and proper weed management results in poor resource use and lower yields. A number of weeds compete with the crop for nutrient, water and other natural resources. In the rainy season in particular, conventional weed management becomes difficult with reduced labor availability for weeding operation, given their deployment for purposes of rice transplanting. During winter season, due to slow growth of maize the weed competition period is usually very long and needs repeated weeding, proving expensive.

Global climate change is a serious threat to the environment, the natural resources, and production systems; and resource poor farmers and communities dependent on agriculture are highly vulnerable as a consequence. The climate change effects such as increased temperature and reduced rainfall, degradation in soil health and terminal heat stress and extremes in climatic effects thus need immediate attention. As a result of these impacts, and reduced water availability for crops like rice, and terminal heat stress that the wheat suffers; maize presents itself as a viable alternate given its high productivity, less vulnerability to terminal heat, and high water use efficiency. The maize area is expanding dramatically by replacing rice in Bangladesh and in southern and eastern

IN THIS ISSUE

parts of India. Thus a rice-maize system is gaining ground, where maize is replacing winter/boro rice mainly due to less water and labor availability. Maize is also believed to be helpful in reducing arsenic toxicity because of reduced water requirement compared to winter/boro rice. The expansion of maize thus needs sustainable, ecologically sound cropping system based technologies that can support livelihood and food security in the region.

Treatment	Rice (t/ha)			Maize (t/ha)			Rice+Maize (t/ha)		
	07-'08	08-'09	Mean	07-'08	08-'09	Mean	07-'08	08-'09	Mean
ZTF	4.3	4.4	4.35	5.1	9.2	7.15	9.4	13.6	11.5
PB-R	4	4.1	4.05	5.21	8.04	6.63	9.21	12.14	10.68
PB+R	4.1	4.2	4.15	5.52	9.33	7.43	9.62	13.53	11.58
CT	4.2	4.4	4.3	3.04	7.15	5.1	7.24	11.55	9.4
CD at p=0.05	ns	ns		0.46	0.89				

KEY: ZTF= Zero-till Flat; PB-R = Permanent Bed without Residue; PB+R= Permanent Bed with Residue; CT = Conventional Tillage; CD = Critical Difference at P=0.05; ns = Not Significant

Table 1: Effect of tillage and crop establishment systems on productivity of rice maize systems in eastern IGP

The carbon sink capacity of the world's agricultural and degraded soils is 50 to 66% of historic carbon loss of 42 to 78 giga tons of carbon. An increase of 1 ton of soil carbon pool of degraded cropland soils may increase crop yield by 20 to 40 (kg/ha) for wheat, 10 to 20 kg/ha for maize, and 0.5 to 1 kg/ha for cowpea. Other than helping in enhancing food security, carbon sequestration has the potential to offset fossil fuel emissions by 0.4 to 1.2 giga tons of carbon per year, or 5 to 15% of the global fossil-fuel emissions. *(R.Lal 2004)*

Conservation agriculture based Resource Conservation Technologies (RCTs) including zero/reduced tillage, retaining crop residues on soil surface, diversification, water conservation and harvesting and balanced crop nutrition can immensely help in sequestering carbon in degraded lands for improved crop productivity, livelihood and profitability accruing to farmers.

1) Evaluation of tillage crop establishment options for rice-maize system

A long-term crop establishment experiment was started during 2007 on rice-maize system at Rajendra Agriculture University, Pusa in Bihar on a silty loam soil having pH 8.6; organic carbon 0.49%; alkaline $KMnO_4$-N 230 kg N ha^{-1}; Olsen's P 18.6 kg P_2O_5 ha^{-1}; and 1 N NH_4OAc-K 105 kg K_2O ha^{-1} (*Jackson 1973*). The trial with four treatments including rice and maize on zero till (ZT) flat with anchored residues (ZTF) with an average row distance of 22.3 cm for rice, ZT permanent beds with full residue (PB+R), ZT permanent beds without residues (PB-R) (one row of rice on either side of beds 67cm wide, an average row distance 33.5 cm for rice), and puddled transplanted rice by conventional till maize (CT) (rice transplanted on hill at 20 x 15 cm) was done during the crop years 2007-2009. The experimental rice crops were sown using a ZT controlled traffic planter at recommended seed rate (25 kg/ha rice,) in zero till plots. However, the maize was hand dibbled, planted with plant to plant and row to row distance of 20 and 67 cm respectively in all the treatments. Rice cultivars PHB 71, Rajendra Mahasuri; and maize hybrids Shaktiman 3 and Pioneer 30V92 were used in year 2007 and 2008, respectively. Recommended doses of fertiliser were applied. Needed crop management practices were followed as and when required with the experimental crops harvested manually, and grain and straw yields of rice and maize recorded.

The results indicated that growth of rice was better under zero till flat (ZTF) sowing as compared to ZT beds with or without residue (PB+R/-R) or puddle transplanting (CT). Residue retention did not affect the growth of rice, at least in initial years. More tillers/m^2 and crop dry matter, taller plants were observed in rice in ZTF, mainly due to higher plant population and closer spacing, some tiller mortality in ZTF was also observed (See Table 1).

Rice on ZTF (4.35t/ha) produced comparable yield with rice on beds (4.05-4.15) or CT (4.3). Presence of crop residue on permanent beds did not influence the yield attributes and yield of rice. Slightly higher rice yield in ZTF might be due to optimum plant population due to closer spacing (22.3 cm) than on beds (33.5 cm).

Zero till planted maize on permanent beds (PB+R) produced tallest plants followed by zero till flat, zero till bed without residue, and conventionally (tilled) planted maize. Higher grain yield (7.43 t/ha) and yield contributing characters were observed in PB+R and ZTF (7.15 t/ha), followed by PB-R (6.63 t/ha) sown maize which were higher than CT maize (5.10 t/ha). The average yield of maize after ZTR (7.43-6.63 t/ha) is mainly due to elimination of puddling from the system resulting in improved soil physical condition for maize, i.e. improved water holding capacity of soil, and soil temperature buffering due to application of residual mulch.

Moreover elimination of puddling and transplanting hastened maturity of rice, to add to which elimination of tillage allowed the early seeding of maize by 12 to 15 days in these treatments compared to conventional till maize

Figure 2: Retaining crop residue (R) offsetting terminal heat stress effects than without residue (L).

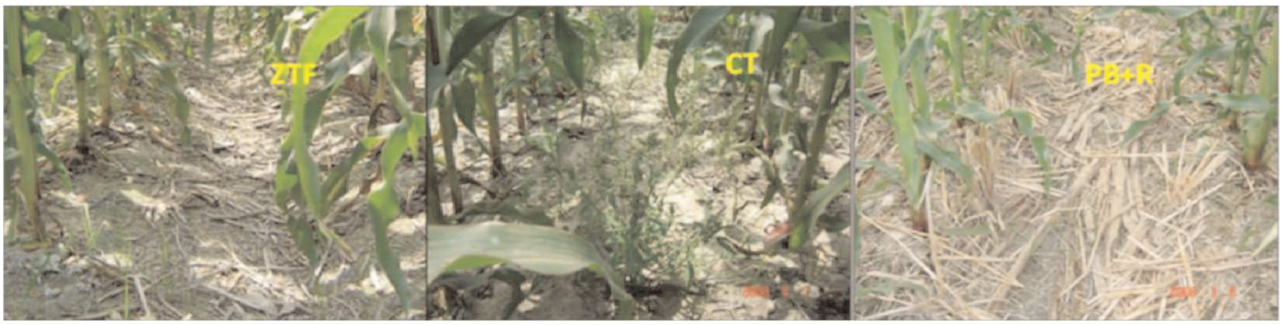

Figure 3: Weeds in different tillage establishment systems in maize in rice maize system

after puddle transplanted rice. Early planting of maize helped in offsetting maize from cold stress at early stages and resulted in faster growth, while delayed planting in conventional system led to phosphorus deficiency due to low temperature and poor growth of maize (Fig-1). On the other hand, delayed planting led to extended life cycle of maize causing anthesis coinciding with high temperature, with the maize crop suffering due to terminal temperature stress at grain filling stage (fig 2).

Nevertheless, higher maize yield in presence of anchored or full residue is also associated with less weed infestation. More annual weeds e.g. Chenopodium, Melilotus, Rumex were observed in conventionally tilled plot, few perennial weeds eg. Cyperus rotundus were present in ZTF plot however, treatment PB+R being almost weed-free due to reduced availability of light by residue mulch at initial crop stage and strong competition by vigorous crop at a later stage (fig.3).

2) Evaluation of summer maize varietes for zero-till and permanent beds in maize wheat system

The following trials were conducted at village Keshwe, Begusarai during 2009 summer season to evaluate the performance of different maize cultivars under different tillage systems - 14 maize cultivars (12 hybrids and two local checks -Tulbulia and Jaunpuria) under 3 tillage crop establishment systems (zero tillage (ZT), conventional tillage (CT), and permanent beds (PB) with three replications. Under ZT and permanent bed plots, glyphosate was applied to control perennial weeds and whereas in CT plots three passes of ploughing followed by planking was done. The seeding of all cultivars was done by manual dibbling. The experimental crop was planted on a sandy loam soil with recommended package of practices.

Comparing the tillage systems in maize cultivars, it was observed that taller plants were in PB followed by ZT than in CT. Yield attributes i.e. rows and columns per cob, cob girth and cob length were observed similar in all tillage systems. Test weights, weight per cob, grain weight per cob, and grain yield/ha were observed significantly higher under PB as compared to ZT and CT. Higher crop growth and yield of maize in PB or ZT might have been noticed due to escape of temporary water logging, improved biological activity and soil temperature buffering in presence of residues that helped the maize to grow better. Moreover, conventional till plot was badly infested with weeds especially Cyperus rotundus despite a hand weeding operation. However, ZT and PB plots were almost weed-free (fig-3). Preplant glyphosate application together with low doses of 2,4 D, was very effective on Cyperus rotundus and other weeds. Among the cultivars NK 30 produced highest yield followed by HTMH 5401, 30B07, CP 808, NK 6240, CP 818.

Cultivars

The interactive effect of tillage and cultivars on yield was found to be significant (Table 2). Cultivars 30B11, 30V92, Tulbulia and Jaunpuria performed better under ZT as compared to CT and PB both in terms of grain yield. Cultivars like HTMH 5401, NK 30, CP 818 yielded better under permanent beds than other systems. None of the cultivars produced higher yield in CT when compared to ZT and PB.

It appeared that with the development of high yielding maize hybrids and resource use efficient production techniques (that compete with common crops with respect to farm profitability) and are resource efficient under diverse soil and climatic conditions have led to development of several maize based cropping systems.

Cultivars Yield - t/ha															
	30 B 07	30 B 11	30 V 92	CP 808	CP 818	900 M G	DKC 9072	PINACLE	NK 6240	NK 30	SAMPANN	HTMH 5401	Jaunpuria(C)	Tulbulia (C)	Mean
ZT	3.71	2.96	3.01	3.28	3.2	2.78	2.18	2.19	3.61	4.06	2.2	3.85	2.07	2.52	2.96
CT	2.59	2.18	2.20	3.15	2.42	1.98	1.81	1.97	2.77	3.04	2.13	2.98	1.54	1.80	2.32
PB	4.12	2.65	2.88	3.98	3.73	3.63	2.95	2.83	3.8	4.16	2.75	4.12	1.78	2.34	3.26
Mean	3.47	2.60	2.70	3.47	3.12	2.80	2.31	2.33	3.39	3.75	2.3	3.65	1.80	2.21	

CD for comparing cultivars at same level of establishment methods @P=0.05, 0.52
CD for comparing establishment methods at same level of cultivars @P= 0.05, 0.50

Table 2: Interactive effect of tillage, crop establishment method and cultivars on grain yield (t/ha) of maize in maize wheat system

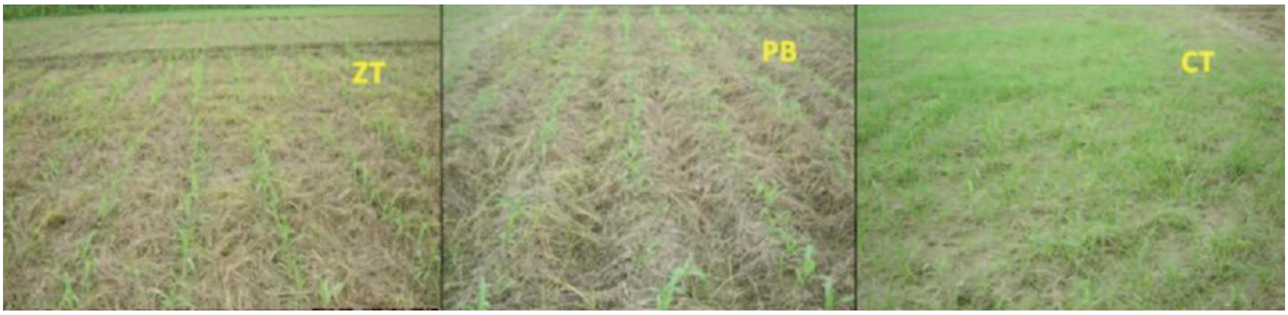

Figure 4: Effective control of Cyperus rotundus due to glyphosate (pre-plant application) in zero till and permanent beds and resurgence of C. rotundus in conventional till plots (15 days after sowing).

Further, under the emerging limitations of natural resource base with the existing input-intensive crop rotations, maize systems with RCTs are emerging as potential drivers for sustainable diversification of input intensive and less profitable production systems (*Sain Dass et al 2009*).

The result of several farmer participatory trials on CA based RCTs in maize systems shows a consensus among farmers for adoption of conservation agriculture based RCTs. Farmers are optimistic that these RCTs can help them in offsetting climate change impact and that they can produce more at a lesser cost.

They agree on the positive implications on soil health due to adoption of these farm friendly technologies. They have also understood that CA based RCTs are the way to achieve high levels of productivity and profitability in a sustainable manner. Including short duration catch crops like determinate cowpeas or mung bean can make these systems more profitable for small farmers. Also that simple small scale and scale neutral machineries can play a major roll in large scale adoption of CA based RCTs.

There is also an agreement among farmers on key elements of CA based RCTs, viz. reduced tillage, residue retention, crop diversification etc. The main driving force at farm level was cost saving, flexibility in time of planting, less water requirement, and favorable support from government. The farmers clearly understood the cost saving on account of timely planting, better resource use, reduced labor requirement, apart from improvement in soil health. Technical teething problems with large scale adoption of these farm-worthy technologies are associated with weeds and crop establishment constraints. In absence of proper weed management some of the weeds may become difficult to manage. Similarly, lack of knowledge in machinery operation can lead to poor seed distribution and improper stand establishment. Presence of residue in initial years may also invite cutworms that can affect stand establishment. However, with proper knowledge of package of practices these issues can be tackled. The main constraint in large scale adoption appears more from a socio-economic perspective rather than technical.

Dissemination of these technologies is more complex because managing CA based cropping systems need demonstration of full package approach than a simple technology e.g. seeds of a new variety or a pesticide. The main reasons for slow adoption are:

i) Poverty conditions among medium and small farmers make them risk averse
ii) Lack of availability of machinery at the village level
iii) Lack of skilled workforce to work with machineries
iv) Lack of availability of certain herbicides and knowledge about its appropriate use
v) Many of the public and private extension systems believe in business as usual and are not ready for radical change, as needed
vi) Lack of regional system based information on long term and sustainable basis
vii) Farmer's reluctance to adopt needed changes
viii) Unclean field appearance without tillage with presence of residues maybe disliked by farmers

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Sain Dass, Jat, M.L., Ravi Gopal and Gupta R.K. 2009. Resource Conserving Technologies for Maize systems in India. Indian farming. WCCA special issue February 2009

Figure 5: Winter maize (a) and following cowpea (b) planted by rolling punch planter (c).

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2	A Brief History of Conservation Agriculture in Latin America, South Asia, and Sub-Saharan Africa	Dr. L.W. Harrington
2	The Story of Tigra Village, Haryana	PACA Editorial Team
2	PACA Inaugural Meet, June 17 2008 - Is CA the Way Forward?	PACA Editorial Team
3	Conservation Agriculture in South Asia-Some Lessons Learnt	Dr. Raj Gupta & Dr. Ken Sayre
3	Highlights of GFAR Meeting at Rome	PACA Editorial Team
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3	Recommendations of June 17 PACA Meet “Is Conservation Agriculture the Way Forward for India”	PACA Editorial Team
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5	A Report on National Consultation on Conservation Agriculture	PACA Editorial Team
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5	Laser Shaping Using Laser Guided Precision Leveler	Dr. Raj Gupta & Dr. M.L. Jat
5	Tsukuba Declaration on Adapting Agriculture to Climate Change	PACA Editoral Team
6	IVth World Congress on Conservation Agriculture: Innovations for Improving Efficiency, Equity and Environment	PACA Editoral Team
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6	10 Principles of Sustainable Soil Management- Dr. Rattan Lal	Dr. Rattan Lal
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8	Conservation Agriculture and Environment	PACA Editorial Team
8	Conservation Agriculture- Potential for Vertisols	Dr. S.S. Tomar
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Towards Unpuddled No-Till Direct Seeded Rice in Haryana: Progress and Prospects

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Introduction

Sustainability of rice-wheat production system in northwest India became a major concern in the mid-nineties owing to its ecological consequences, stagnating system productivity and diminishing economic returns. A major intervention towards addressing the concern was the development of the zero-till seeding machine for wheat. Its wide adoption since 1997 enabled the crop's timely seeding and helped reduce cost of cultivation on account of savings on fuel and labor. This created condition for the crop's enhanced productivity and improved economic returns.

Direct seeded rice proved more cost effective (77%), more water efficient (20-30%), less labor- intensive (8%), and more eco friendly (with lessening of methane emission by 77%). Other benefits included higher tolerance to water deficits, less cracking in soil, earlier crop maturity by 7 to 15 days, less incidence of insect-pest and diseases due to better aeration in crop canopy, and overall higher profits

However, the ecological concern surrounding deteriorating soil quality and sub-optimal water management could be addressed only by promoting the practice of leaving crop residue on the soil surface and maintaining a permanent soil surface cover. This thus required development and promotion of a zero-till machine that could seed crops in standing crop residue. The development of 'Happy' and 'Turbo' zero-till seed drills that enable seeding wheat in standing rice residue became a significant step towards filling this gap. While this takes care of the sustainability issue in the wheat crop, the critical question that still remains and continues to adversely impact the sustainability of the rice-wheat production system is the need for puddling the soils before manually transplanting rice-seedlings in the rainy season.

Puddling, other than drawing upon precious water resources, is energy intensive, involves high labor costs, destroys soil structure, and is conducive to high methane emissions. This implies that any benefit that accrues by way of improving resource base quality by adopting practices such as residue retention on soil surface and zero-till seeding in wheat will be largely negated due to puddling. The adverse impact of puddling is getting increasingly manifested in other ways. Declining water tables in the region are attributed to some extent to reduced soil infiltration rates. Soil compaction impacts root growth and penetration, particularly of wheat crop, and results in inefficient use of water and nutrients. These considerations have assumed increasing criticality in enhancing sustainability of production system. The primary rationale for pursuing puddling practice lies in being able to control weeds and keep water ponded on the soil by reducing percolation losses. Fortunately evidence has been accumulating to show that puddling per se is not a requirement for achieving high yields and that direct seeding or mechanical transplanting in un-puddled dry or no till situations could prove to be a suitable alternative to manually transplanted rice in puddled fields.

Fig. 1 Seeding in Dry Soil

Efforts to Test and Adopt Direct Seed Rice

Initial studies (2001 to 2005) conducted in Haryana province of northwest India showed that direct seeded rice (DSR) could prove more successful in scented rice cultivars due to little or no yield penalty as compared to coarse grain group of cultivars (*Malik and Yadav, 2008, Yadav et al., 2009a*). Trials, particularly with direct seeded basmati rice, showed that yields similar to transplanted rice could be obtained provided effective weed management is ensured, niche area identified, appropriate seeding machinery is available, and proper irrigation scheduling evolved. Direct seeded rice proved more cost effective (77%), more water efficient (20-30%), less labor-intensive (8%), and more eco friendly (with lessening of methane emission by 77%). Other benefits included higher tolerance to water deficits, less cracking in soil, earlier crop maturity by 7 to 15 days, less incidence of insect-pest and diseases due to better aeration in crop canopy, and overall higher profits. However, in DSR, in addition to the increased weed pressure of usual grassy and broad leaved weeds and sedges, there is invasion of aerobic grassy weeds like *Leptochloa chinensis, Eragrostis tenella and Dactyloctenium aegyptium.* This requires a battery of suitable herbicidal combinations integrated with other weed management methods. Moreover, in DSR, there are understandable perceived concerns that rice culture under aerated condition would be susceptible to decreased uptake of micro-nutrients (particularly zinc and iron) from soils and hence increase in yield costs, and that maintaining standing water conditions would be very difficult due to improvement in infiltration rates. While these concerns are well placed, they need to be viewed considering the potential environmental benefits by way of increased recharge of aquifers, reduced green house gas emissions, enhanced carbon sequestration, improved soil quality and opportunities for diversified copping systems.

Progress in Adopting Zero Till Seeding

Prior to 2007, most experimentation was aimed at direct seeding/transplanting in wet conditions. It is only since 2008 that efforts were initiated to explore the possibility of direct seeding under optimum soil moisture conditions using a seed drill. In year 2010, seed-cum-fertilizer drills with inclined plate seeding mechanism were used for sowing under optimal soil moisture conditions with first irrigation after two weeks, and also in dry conditions immediately followed by irrigation. In case of latter, sowing was done at a shallow depth of 2-3 cm followed by irrigation immediately after sowing and 1-2 subsequent irrigations within 5-7 days to ensure good germination. And in case of the former, sowing depth was slightly more (3-5 cm), followed by planking to restrict moisture loss, and first irrigation was required after two weeks of sowing. Pressing wheels behind tynes could be more useful than planking for proper seed to soil contact, which is a must to achieve uniform germination. The trials on more than 100 acres at farmers' fields in Haryana during *kharif* season of 2010 indicate that dry DSR could be successfully implemented with seed-cum-fertilizer drill fitted with inclined plates and inverted T-type tynes under optimal moisture conditions as well as under dry conditions.

Generally, it is reported that there is 20-30 % water saving under DSR. This is made possible since irrigation is not required for the initial 10-15 days after sowing with follow up irrigations provided at 7-10 days interval. Moreover, crop under DSR matures 12-15 days earlier under direct seeding compared to puddle-transplant

The learning over years of experiment with DSR are summarized below:

Cracking

Based on two years (2001 and 2002) trials, it was realized that there was almost no cracking in soil even if irrigation was delayed in rice grown under zero till. Cracking was also noticed to be less under unpuddled situations compared to puddled (Table 1).

Table 1. Problem of cracks in puddled and unpuddled soil

Cracks	Puddled soil	Unpuddled soil
No./M^2	4-5	1-2
Width (cm)	1.0 -1.2	0.2 -0.5
Length (cm)	7-10	2-4

Labour cost

Over the years, cost of labour for transplanting has gone up from Rs 1500 ha^{-1} during 2007 to Rs 2100 ha^{-1} in 2008, Rs 2500 ha^{-1} in 2009 and Rs 3000-4000 ha^{-1} in 2010. For want of labour, there was delay in transplanting during years 2008-10 compelling farmers to carry out repeated puddling. Late transplanting of rice delayed wheat sowing and consequently the yield of both crops suffered. Moreover, because of the ban on early transplanting of rice by the Government, transplanting in the whole area now has to be completed within a period of about a month. On account of these circumstances the interest of farmers in DSR has increased tremendously.

Weed Management

Weed dynamics change with establishment methods (Yadav *et al.*, 2009b). Aerobic soil conditions and dry tillage practices coupled with alternative wetting and drying conditions in DSR encourage germination and growth of all types of weeds leading to critical weed competition from 15 to 45 days after sowing (DAS). It is now well established that weed competition is more severe under DSR compared to puddle transplant. Yield losses due to heavy weed infestation under DSR may be as high as 100 per cent. Due to heavy weed pressure and intermittent emergence of weeds in DSR, it is quite risky to rely only on a single herbicide or mechanical or manual weeding. Integrated weed management including mulch/cover crops like *Sesbania*, tank mixture or sequential application of herbicides supplemented with need-based hand weeding become essential for success of DSR. Stale bed technique could be useful for DSR under unpuddled situations.

Choice of effective herbicides for DSR is limited. Based on intensive research efforts, following options of herbicides alone or in combination were found suitable against different type of weed flora:

a) Grassy Weeds

Though *Echinochloa crus-galli* is the dominant weed in puddle as well as in DSR conditions, yet aerobic weeds start dominating under DSR very quickly. Bispyribac at 25 g ha^{-1} applied at 15 and 25 days after superior is superior to other herbicidal treatments.

b) Broadleaf Weeds

Bispyribac has been found to be quite effective in controlling *Echinochloa crus-galli* along with other weeds; however, it is not much effective against some broadleaf weeds like *Ammannia baccifera.* Application of chlorimuron + metsulfuron 4 g ha^{-1}, ethoxysulfuron 18.75 g ha^{-1}, 2, 4-D Ester or Amine 500 g ha^{-1} in combination with bispyribac 25 g ha^{-1} resulted in improvement in control of Broad Leaf Weeds (BLW) and sedges in wet DSR. Sequential application was found better than tank-mixture, particularly in case of 2, 4-D and ethoxysulfuron, which had antagonistic effects on the efficacy of bispyribac against *Echinochloa* when applied as tank-mix. Tank-mix application of azimsulfuron or pyrazosulfuron with bispyribac also improved the control of BLW.

Transplanting in Unpuddled Soil

c) Sedges

Azimsulfuron even at very low doses (15-20 g/ha) provided almost complete control of sedges including *C. rotundus* along with improvement in control of BLW when applied as tank-mix with bispyribac or even alone. Azimsulfuron was specifically quite effective against *C. rotundus*. Bispyribac as tank-mix or sequential application with pyrazosulfuron was also found to be quite effective against sedges. Maximum grain yields were obtained under bispyribac + pyrazosulfuron 25+25 g/ha followed by bispyribac + azimsulfuron 25+20 g/ha. Tank-mix application of bispyribac 25 g ha^{-1} with pyrazosulfuron 25-37.5 g ha^{-1} was found to be effective against sedges, particularly *Cyperus rotundus,* in farmers' participatory trials during 2009 and 2010. However, their efficacy as standalone or sequential application has not been found to be effective particularly in fields dominated by *C. rotundus.*

The use of pre-emergence herbicides (like pendimethalin) in combination with some post-emergence herbicides (like bispyribac-sodium) was considered a pre-requisite to attain satisfactory weed control in dry DSR (Yadav *et al*., 2009a). Earlier workers have also reported suitability of this combination in dry DSR (Walia *et al*., 2008). The experiments during *kharif* season of 2010 revealed that the pre-emergence application of pendimethalin in dry DSR could help a lot in controlling the aerobic grassy weeds along with some control of *Echinochloa* and BLW. However, pendimethalin alone could not provide satisfactory control of *Echinochloa* and many other weeds, and it needed support of sequential application of byspyribac (15-25 DAS) alone or coupled with tank mix application of azimsulfuron or pyrozasulfuron in case sedges are dominant, and sequential application of Almix, ethoxysulfuron or 2,4-D if fields are infested with BLW. Manual or mechanical weeding can solve the problem if still there are some escapes. Experiences in the past have revealed that residues of previous crop retained on the soil surface reduce the pressure of weeds.

Dry-seeded crop stand

Water Savings

Nearly 30% of the total water used (1,400–1,800 mm/season) in rice culture is consumed mainly in puddling and transplanting operations. Generally, it is reported that there is 20-30 % water saving under DSR. This is made possible since irrigation is not required for the initial 10-15 days after sowing with follow up irrigations provided at 7-10 days interval. Moreover, crop under DSR matures 12-15 days earlier under direct seeding compared to puddle-transplant. This not only facilitates timely sowing of wheat but also results in water saving that could compensate to some extent the extra water required for early sowing. Residue retention on soil surface under No-Till DSR will further enhance water saving.

Deficiency of Micronutrients and Plant Protection

Deficiency of micronutrients particularly Fe and Zn was frequently noticed under DSR. Spray of 0.5% $FeSO_4$ solution repeated as per requirement has been found to be effective in remedying the deficiency symptoms of Fe. Termites have been observed to cause more damage in DSR due to a more aerobic system. Bakanae disease that was found in puddle transplant rice fields (due to dry uprooting of rice seedlings) did not infest DSR (Yadav *et al*., 2009a). Occasionally, higher incidence of brown spot was noticed in DSR plots; possibly on account of water stress situations under unpuddled conditions of DSR.

Conclusions

Direct seeding in rice, particularly *basmati,* can produce yields similar to transplanted rice provided effective weed management is achieved and appropriate seeding machinery is available. DSR under No-Till situations with residue retention on soil surface will help harness additional benefits of technology provided appropriate machinery is made available to growers. Results on chemical weed control in DSR are encouraging and a package of recommendations on integrated weed management for cultivation of DSR is expected to be available very soon. However, a common weed management strategy will not work under DSR and we will have to select it on a case-by-case basis for different locations. Laser leveling needs to be encouraged more emphatically to make DSR and mechanized transplanting more successful. Concentrated extension efforts are required to accelerate the adoption of DSR.

There is no doubt that DSR needs further refinement but it has already attracted the attention of researchers, extension agencies, and more recently growers in Haryana. It is assumed that direct seeding of *basmati* rice and mechanical transplanting of coarse rice will certainly be instrumental in avoiding puddling and manual transplanting in future.

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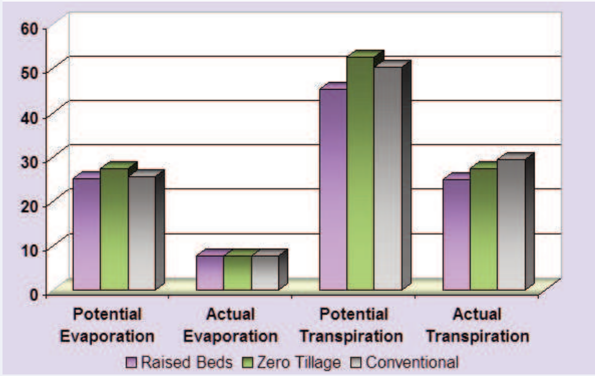
We will be happy to hear from you of your experiences of practices similar to Conservation Agriculture in your region. Should you like to share cropping experiences related to minimal soil disturbance, crop residue cover, mulching, and crop rotation; we will be glad to hear from you at info@conserveagri.org.

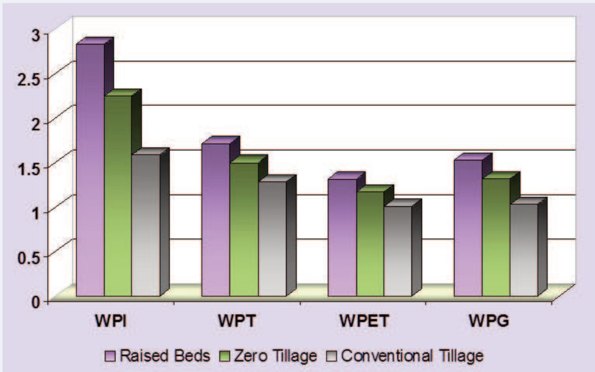
When did you last visit the Content page on our website? You can download past issues of our newsletter and other information booklets such as the FAQ, Factbook, and even the Education Series on Soil available in 5 parts. Click here if you wish to access it now www.conserveagri.org/content.htm.

INFOPIX

This section will present research data in pictorial form from past studies for benefit of readers

Water Balance Components and Water Productivity Under Various Tillage Systems





Note: WPI: Water Productivity (kg/cum of Irrigation Water); WPT: Water Productivity (kg/cum of Transpiration); WPET: Water Productivity (kg/cum of Evapo-Transpiration); WPG: Water Productivity (kg/cum of Rain and Irrigation Water)

Soil Water Atmosphere and Plant (SWAP) model has been used in this study in the head reach of Pabnawa Minor of Bhakra Canal System to compute the water balance components and water productivity in a farmer's field under different tillage systems viz., raised beds, zero tillage and conventional tillage. The water balance components as obtained with SWAP model (given in the upper figure) is generally used to select viable water management options.

Results presented indicate that actual transpiration is much less than potential transpiration indicating that farmers are under-irrigating their wheat crop. As a consequence, actual wheat yields are less than the potential yields. It is observed that water productivity in raised bed planting was higher than zero till system by 25 per cent and by 79 per cent compared to conventional tillage. On the other hand, values of water productivity under zero tillage are higher by 42 per cent from that observed under conventional tillage (given in the lower figure). The study concludes that with appropriate agronomic practices for weed management, yield losses in raised bed planted rice can be altogether avoided besides significant savings in irrigation water.

Source: Ravish Chandra, Alok Sikka, Samar Singh, Raj Gupta, A K Upadhyaya, R Sakthivadivel. Impact of Resource Conserving Technologies on Water Use and Water Productivity in Pabnawa Minor of Bhakra Canal System. CIMMYT and RWC Technical Bulletin 10. 2007. New Delhi

Happenings

Indian Agriculture Sector Working on Tie-ups with US

The visit of US President Barack Obama to India provided a momentum to the Indo-US collaboration in the agriculture sector – taking it beyond the tie-ups firmed up between PM Manmohan Singh and then US President George Bush in 2005. In a departure from the Agricultural Knowledge Initiative (AKI) of 2005, that focused more on academic exchanges and driven by companies in the agriculture sector, the new deal is going to be more broad-based with tangible activities on the ground. The new deal to be based on the MoU signed between the two countries early this year, will have three major focus areas - crop weather forecast, agricultural marketing & extension, and food security issues. Ahead of Obama's visit, both sides are learnt to have chalked an action plan for next four years. Sources said that crop-weather forecast is one area that witnessed a lot of progress since the signing of the MoU. Planning Commission member K Kasturirangan has already visited the US to explore the areas of collaboration between the two countries. Both countries are expected to deepen their technical partnership in the area of medium-term weather forecast to enable Indian farmers plan their agricultural operations better. Sources said this collaboration is most likely to be driven primarily by the private sector on either sides. The agricultural marketing and extension initiatives would focus more on food processing sector with thrust on post-harvest and value-addition to enable farmers earn more per penny invested in agricultural operations.

Hectic planning is underway in the field of food security as well with both countries reportedly having identified two broad streams of collaboration – one bilateral; the other identifying Indian experiences that can be shared with least developing countries from Africa to achieve national food security. Under the bilateral stream, India will have two major thrust areas for collaboration – rainfed agriculture and Green Revolution in eastern India. USAID, in fact, is learnt to have committed about Rs 500 crore for undertaking initiatives such as pilot experiments, conservation agriculture, capacity building, and other such areas over the next four-year period. India, on its part, is also expected to commit a similar amount to undertake activities under these thrust areas.

Source: http://www.indianexpress.com/news/agriculture-sector-works-on-tieups-with-us/703534/

Plan B 4.0: Mobilizing to Save Civilization by Lester R. Brown, Earth Policy Institute, 2009

The Earth Policy Institute (EPI) set up to provide a plan of a sustainable future along with a roadmap of how to get there has in its recent update on Plan B 4.0: Mobilizing to Save Civilization by Lester R. Brown referred to the latest in the soil conservation toolkit – conservation tillage that includes both no-till and minimum tillage. Some extracts are:

"Instead of the traditional cultural practices of plowing land and discing or harrowing it to prepare the seedbed, and then using a mechanical cultivator to control weeds in row crops, farmers simply drill seeds directly through crop residues into undisturbed soil, controlling weeds with herbicides. The only soil disturbance is the narrow slit in the soil surface where the seeds are inserted, leaving the remainder of the soil undisturbed, covered by crop residues and thus resistant to both water and wind erosion. In addition to reducing erosion, this practice retains water, raises soil carbon content, and greatly reduces energy use for tillage.

In the United States, where farmers during the 1990s were required to implement a soil conservation plan on erodible cropland in order to be eligible for commodity price supports, the no-till area went from 7 million hectares in 1990 to 27 million hectare (67 million acre) in 2007. Now widely used in the production of corn and soybeans, no-till has spread rapidly in the western hemisphere, covering 26 million hectare in Brazil, 20 million hectare in Argentina, and 13 million in Canada. Australia, with 12 million hectare rounds out the five leading no-till countries.

Once farmers master the practice of no-till, its use can spread rapidly, particularly if governments provide economic incentives or require farm soil conservation plans for farmers to be eligible for crop subsidies.

Farming practices that reduce soil erosion and raise cropland productivity usually also lead to higher carbon content in the soil. Among these are the shift to minimum-till and no-till farming, the more extensive use of cover crops, the return of livestock and poultry manure to the land, expansion of irrigated area, a return to more mixed crop-livestock farming, and the forestation of marginal land.

Together, restoring the Earth's tree and grass cover and practicing conservation agriculture protect soil from erosion and reduce flooding. They also sequester carbon, making them powerful tools in the effort to fight global warming."

Source: Chapter 8, "Restoring the Earth" in Plan B 4.0: Mobilizing to Save Civilization *by Lester R. Brown.*

Conservation Agriculture, Environmental and Economic Benefits by ECAF and AEAC/SV, Oct. 2010

European Conservation Agriculture Federation (ECAF) & Spanish Association for Conservation Agriculture/ Living Soils (AEAC/ SV) have come up with a report that aims to summarize the main ideas described in the Workshop on Soil Protection and Sustainable Agriculture organized by the EU Commission DG Environment and the DG Environmental Quality of the Spanish Ministry of Environment. The principles on which conservation agriculture is based, its environmental and economic benefits, and its tentative evolution/acceptance in Europe as part of the good agriculture practices/ agri-environmental measures were discussed. Information on the European Conservation Agriculture Federation (ECAF) and its national associations was also given.

Among the reasons for the slow adoption of conservation agriculture in Europe in the decade from 1990-2000 the following were mentioned:

a) Low level of information on the agri- environment, both on part of the administration and farmer;
b) Little institutional support from the administration;
c) Little pressure in economizing on costs on the part of the farmer, that they could otherwise achieve by adopting conservationist techniques. On the contrary, farmers by receiving "per surface" or "compensatory" agricultural subsidies since the beginning of the 1990's have been obtaining acceptable incomes without any notable environmental obligations; and
d) Little transference of conservation technologies.

In spite of the above, it is being predicted that conservation agriculture will be adopted to a great extent in Europe in the next few years.

The adoption of conservation agriculture in Europe will be a truly revolutionary challenge that will be a positive development for environment and the economy. This change will not be easy for farmers as it signifies a new culture being imbibed in important techniques/operations for crop management. Namely, updating of knowledge and of new techniques, such as direct sowing and the use of herbicides in the handling of plant covers and the control of new weed species, as well as a certain amount of investment in the modernization/ bringing up to date of farm machinery. This eBook on Conservation Agriculture is available here: http://www.unapcaem.org/publication/ConservationAgri/CA1.pdf

Winter School on recent advances in chemical and non-chemical approaches of weed management in cropped and non-cropped areas by ICAR, New Delhi from November 15 to December 6, 2010

Institutional infrastructure for integrated weed management research needs to be remodeled and issues related with weed risk analysis, herbicide residues, herbicide resistance in weeds and crops, weeds in conservation agriculture, better input use efficiency, reduced cost, industry linkages and social and economic changes need to be understood by researchers. This course on weed management being conducted by ICAR provides an excellent opportunity for participants to acquire new knowledge, sharpen their skills in planning and implementation of integrated weed management research.

The objectives are (a) to expose the participants to the range and themes of integrated weed management, (b) to give an overview of the possible technological options for productivity improvement, environmental upgradation and socio-economic benefits and (c) to brainstorm and arrive at suitable integrated weed management modules for back home situations of participants. The training design will be a blend of sessions on theoretical concepts, practical exercises as well as study tours to Weed Management Institute or Laboratories.

The major themes include - integrated weed management, resource conservation technologies, herbicide resistant crops, global warming and weed biology, herbicide resistance in weed and its management, biotechnological options in weed management and significance of weeds in plant quarantine. For details click here: http://www.iari.res.in/files/winterschool-workshop-2010.pdf

CropWorld: Global Congress on Sustainable Crop Production

CropWorld, the global congress on sustainable crop production brought together key stakeholders to discuss issues affecting the global crop production value chain during 1-3 November 2010 at ExCeL, London. Attendees came from more than 75 countries and from a diverse range of sectors. Experts in business, trade, science and technology gathered at CropWorld 2010 to examine how the industry as a whole can work together to meet the challenge of feeding a rapidly growing population in a responsible, sustainable and profitable way. The event encompassed all aspects of crop production, from seed nutrients and spraying technology, to government regulation and retailers' sourcing strategies.

About the event Dr. Theodor Friedrich, Senior Officer (Crop Production Systems Intensification), Plant Production and Protection Division (AGP), FAO (Food & Agriculture Organization of the United Nations) held that "Agriculture is facing an unprecedented challenge: the need to supply a growing population with food, fuel, fibres and other products whilst stopping the degradation of natural resources. In order to achieve the 'sustainable intensification of crop production', a total change in the agricultural paradigm is necessary, talking of a completely different type of agriculture, of which "Conservation Agriculture" as defined by FAO is a core strategy. For details, view CropWorld website here: http://www.crop-world.com/

Regional Conservation Agriculture Working Group (CARWG) 2nd Annual Workshop

The Regional Conservation Agriculture Working Group (CARWG) 2nd annual workshop was held in Johannesburg from October 13 to 14, 2010. Most of the Southern African countries depend heavily on agriculture; however production levels are increasingly hampered by economic, political, and climatic changes in the region. Conservation Agriculture being an innovative part of agricultural production is regarded as an opportunity for increasing food productivity in the region. In view of this, CARWG was formed to support policy frameworks and implementation of Conservation Agriculture. The CARWG for Southern Africa is a regional group that was formed in 2007 with the objective of coordinating Conservation Agriculture (CA) work/activities at regional level including, resource mobilisation and advocacy. To read more, click here: http://www.fanrpan.org/documents/d01013/

Conservation Science and Policy: Global Perspectives & Applications

The 66th International Soil and Water Conservation Society (SWCS) Annual Conference will be held in Washington, DC from July 17-20, 2011. The SWCS Annual Conference includes workshops, symposia, oral and poster presentations, plenary sessions, and technical tours designed to raise awareness to recent developments in the science and art of natural resource conservation and environmental management on working land. The 4 day conference would comprise the following themes:

- Adaptive Management of Conservation Efforts
- Biodiversity Conservation and Management
- Conservation and Environmental Policy and Program Design
- Conservation Outreach and Education
- Conservation in Urban Settings
- Conservation Tools and Technologies
- Soil Resources and Management: Soil Resource Assessment
- Soil Resources and Management: Soil Resource Management and Conservation
- Water Resources and Management

The last date for abstract submission is December 17, 2010. To know more about the program click here http://www.swcs.org/en/conferences/2011_annual_conference/

International Conference on Preparing Agriculture for Climate Change

A 3-day international conference on Climate Change and Agriculture is being organized by Punjab Agricultural University at Ludhiana, India, during February 6-8, 2011. The Conference will comprise invited plenary and symposium presentations and conclude with a panel discussion on "Role of long-term forecasting models and directed adaptation to climate change." There will be symposium lectures in the evenings of the first two days. One session will be devoted to contributory posters from scientists and bright young students.

The conference will center on the following themes:

1. Agriculture: abettor and sufferer
2. Mitigation strategies: Policy and Management interventions
3. Adaptation strategies: Genetic interventions
4. Climate change and biodiversity: Extinction and new emergence

The last date for abstract submission is December 15, 2010. To know more about the program click here http://www.pau.edu/int_conf/

SNIPPETS

Conservation Agriculture for the Dryland Areas of the Yellow River Basin: Increasing the Productivity, Sustainability, Equity and Water Use Efficiency of Dryland Agriculture, while Protecting Downstream Water Users

Under the CGIAR's Challenge Programme on Water and Food, a project is being implemented on Conservation Agriculture for Dryland Areas of the Yellow River Basin. Soil erosion is a major problem in the Yellow River Basin as the river is one of the most sediment laden in the world. Although there is a rainfall gradient from 750 mm in southern Shandong, to 200mm per year in northern Ningxia, most of the rainfed cropping area is in regions with more than 400 mm per year – it is here that the project has concentrated its efforts. Conservation agriculture offers a possible solution since it typically results in increased crop water availability and agro-ecosystem productivity, reduced soil erosion, increased soil organic matter and nutrient availability, reduced labor and fuel use and increased biological control of pests. Most of the recent advances in conservation agriculture in China have been in irrigated areas from which technologies and approaches were adapted for this project.

http://www.waterforfood.org/page/PN12

Vacancy: Agronomist/Program Director CIMMYT

CIMMYT is looking for an Agronomist/Program Director, preferably with a PhD in agronomy or a related field with 10 or more years of appropriate experience. A track record in multi-disciplinary systems agronomy research, with emphasis on conservation agriculture, innovation systems approaches, and work that has achieved large-scale impact among farmers is desirable. The applicant should have the ability to prioritize, formulate, and communicate researchable issues and outcomes relevant for smallholder farmers in developing countries. A vision for applying modern IC technologies and precision agriculture to benefit resource-constrained smallholder farmers in developing countries is necessary. Experience in managing impact-oriented multicultural partnerships, research teams, and budget is needed. The position is based at Mexico and the applicant should be willing to undertake frequent and extended travel, especially in Asia and Africa. Apply for the position online no later than November 25, 2010. To know more in detail, click the link http://www.cimmyt.org/en/about-us/job-opportunities/845-201038-agronomist-program-director

BOOKS/REPORTS UPDATES

Conservation Agriculture and Sustainable Crop Intensification in Lesotho by Laura Silici, FAO, October 2010, ISBN 978 9 25106 588 4(Pb)

The FAO publication Integrated Crop Management Vol.10-2010 deals with conservation agriculture in Lesotho, a small mountainous country characterized by extensive land degradation and erratic climatic conditions. The complex interaction of socio-economic factors and environmental constraints has dramatically affected agricultural productivity in Lesotho and maize yields have fallen from an average 1,400 kg/ha in the mid-Seventies to a current 450-500 kg/ha in most of the districts.

In recent years a growing number of development agencies have been promoting conservation agriculture (CA) as a means to enhance rural livelihoods through sustainable production intensification in Lesotho. Amongst several initiatives, the CA-based practice that so far has shown the highest potential is a planting basin system, locally called *likoti* (a Sesotho word for "holes"), mostly employed by subsistence farmers in the production of maize and beans. WFP alone estimates that so far about 5,000 households have adopted *likoti* with its support in different districts, covering about 8,163 ha of land under CA (or 2.5% of the total arable land). You can download the report from here: http://www.fao.org/docrep/012/i1650e/i1650e00.pdf

Conservation Agriculture: A manual for farmers and extension workers in Africa by International Institute of Rural Reconstruction (2008-10-20), paperback: 280 pages

The manual aims to fill the knowledge gap on conservation agriculture that exists among grassroots players (farmers, extension workers, input suppliers, etc.) who often lack information on what to do and where to do it. Over 60 per cent of Africans depend on some form of farming for their sustenance and livelihoods. Agriculture remains vital for the continent's development and economic growth. Recent stagnation or decline in farm productivity in many parts of Africa is a major concern. For many communities and countries, this has translated into chronic food insecurity and growing poverty. Conservation agriculture aims to overcome these problems. It consists of three simple principles - disturb the soil as little as possible, keep the soil covered, and mix and rotate crops. These principles can be put into practice in many different ways. Farmers throughout Africa and the world are beginning to adopt them and they have seen their yields rise, their soil gain fertility, and their labor need decrease. The book states that to make it a success, conservation agriculture must be promoted actively.

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The following technical briefs can be downloaded from FAO's site at the following location http://fao-reosa.emerge-it.co.za/publications/reosa-technical-briefs

- **FAO REOSA TECHNICAL BRIEF 01 JULY 2010**: Farming for the Future in Southern Africa: An Introduction to Conservation Agriculture.
- **FAO REOSA TECHNICAL BRIEF 02 JULY 2010**: Cultivating Sustainable Livelihoods: Socioeconomic Impacts of Conservation Agriculture in Southern Africa.
- **FAO REOSA TECHNICAL BRIEF 03 JULY 2010**: The Status of Conservation Agriculture in Southern Africa: Challenges and Opportunities for Expansion.