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Research Paper

Should we go for conservation agriculture in Nepal?

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Abstract: The conservation agriculture (CA) is a set of practices consisting of three core principles; maintenance of permanent or semi-permanent soil cover; minimum soil disturbance, and regular crop rotations. The factors namely precision land leveling, no-till systems, furrow iirrigated raised bed planting systems, easy accessibility of machines/equipments, crop residue management practice and crop diversification in Terai and plain areas enhance the suitability of CA in those areas but in the hills the presence of sloppy terraces makes cultivation difficult, scope of crop residue incorporation is limited since it is used for livestock fodder, no or limited roads to transport the heavy machines/equipments, poor affordability of the farmers for machines and rainfed agriculture that may limit the promotion of CA based technologies. In Nepal the extension and adoption of CA technologies are in the primary stage and for their expansion, they require concerted efforts of all the stakeholders in the partnership and participatory approaches. Today scenario of labor scarcity, increasing production costs and declining or static productivity are the major challenges of agriculture in Nepal. CA promotes reverse degradation processes, improves resource quality, reduces production costs and helps achieve sustained high productivity. Therefore promoting and adopting CA management systems in Terai and plain areas can provide sustainable and increased crop production in Nepal.

Keywords: Conservation agriculture, tillage, production and Nepal

Abbreviations: CA: conservation agriculture; GDP: gross domestic products; CSISA: Cereal System Initiatives for South Asia; IFAD: International Fund for Agriculture Development; CIMMYT: International Maize and Wheat Improvement Centre; Mt: metric ton

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INTRODUCTION

Agriculture is the main stay of livelihood in Nepal, but production is barely sufficient to meet domestic consumption needs. Thirty-two per cent of the population still lives in poverty. Food insecurity persists in many parts of the country.

Repeated tillage, removal or burning of the crop residues and absence of crop rotations are the fundamental causes of unsustainable conventional agriculture system in Nepal. Stagnation of agricultural productivity, degrading soil (soil losses ranges from 0.2 to 105 Mt ha^{-1} by erosion on barilands of Nepal) and water resources are the major problems of the agricultural production system in Nepal. Since, rice needs approx. 3000 liters of water to produce one kg of grain). Agriculture impacts climate change causing green house gas emissions, and is at the same time impacted by effects of climate change as well. Increasing uncertain in availability of water due to increasing frequency of drought and or excess water events rexulting in uneven water availability in time and space. Lack of technologies that impart greater resilience to production systems are the great threat to all; researchers, farmers and policy makers alike.

Although agriculture is the mainstay of the rural economy, people employ different livelihood strategies like labor migration. More than a million Nepalese youth are working each year abroad. Unfortunately, present day agriculture has not been the profession of attraction for educated youth in the country.

What is CA ?

CA is an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. The zero tillage, along with other soil conservation practices, is the cornerstone of CA. Its approach is based on three principles; first farmers should cover the soil as far as possible, second, tillage of fields should be kept to a minimum. If possible, the soil should not be tilled (plowed) at all. And the third, farmers should adopt the crop rotations spatially and temporally.

If these broad concepts are followed, significant improvements can be made in water conservation, enhancing soil quality and improving soil fertility. We receive rains very ferociously within the short period of the rainy season. The high velocity raindrops break up the surface of the soil and carry the fragments away. When you keep the soil covered, the residues absorb that impact, more water is absorbed by the soil and runoff is reduced. Similarly, tillage is a harmful practice. It accelerates erosion and emission of green house gases and is also energy-intensive. Tillage-based operations are costly and impart unsustainability. Essentially, resource conservation issues have become a prerequisite for agriculture. And conservation agriculture enables farmers to improve their resource base using their own resources. Through such steps, we can reverse the degradation of soils and move towards more sustainable agriculture.

Importance of CA

CA has been the best alternative production system in many of the developed and developing countries in the world. Although there were many early attempts to cultivate crops without tillage, modern no- tillage research started in the 1940s and adoption by farmers in the early 1960s as one of the principal components of CA.

Worlwide around 105 million hectares of land is under no-till agriculture until 2005. Since 1987 the technology has experienced a 74 fold increase in Latin America from 670.000 ha to 49.6 million ha in the year 2008 against a 6.5 fold increase in the USA. Approximately 47, 39, 9 and 3.5 percent of

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the land is under CA in South America, US and Canada, Australia and rest of the countries respectively (Derpsch, 2005). It can save the producton cost significantly and it was found that production cost per acre of soybeans under no- tillage are reduced by US$ 27.00 in Argentina, by US$ 14.18 in the USA and by US$ 11.50 in Brazil. After 19 days, total losses of carbon from ploughed wheat fields were up to five times higher than for un-ploughed fields (Reicosky, 1997). Experiences of Chitwan farmers also revealed that it saves the land preparation cost by approx. 30 and intercultural operation cost (weeding) by 25% respectively under direct seeded rice and zero-tillage wheat. No-till wheat significantly reduced the costs of production; farmers estimate this at about 2,500 rupees/ha (US$ 60/ha), mostly due to using less diesel fuel, less labor, and less pumping of water. In an experiment conducted at Rampur, Nepal since 2010, Dahal et al. (2014) reported in 2013 that the grain yields and economics under no till and residue retained over conventional till and residue removed field was significant and is shown in Table 1 and 2.

Table 1. Effect of tillage, residue, fertilizer and weed management on grain yield, stover yield, harvest index and grain stover ratio of spring maize in Chitwan, Nepal, 2013

Factors	Grain yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Harvest index (%)	Grain: Stover ratio
Tillage methods				
CT	5.39[b]	7.46[b]	39.65	0.68
NT	6.64[a]	9.30[a]	41.71	0.72
F-test	*	*	NS	NS
$LSD_{0.05}$	1.01	1.78	-	-
SEm±	0.17	0.29	1.54	0.04
Residue management				
RK	7.02[a]	10.00[a]	40.53	0.70
RR	5.02[b]	6.76[b]	40.83	0.70
F-test	*	*	NS	NS
$LSD_{0.05}$	1.13	2.72	-	-
SEm±	0.19	0.45	0.49	0.01

*NS=Non significant, *= significantly different at p≤0.05 by DMRT, LSD value differs according to the level of significance. CT=Conventional tillage, NT=No tillage, RR=Residue removed and RK=Residue kept.*

Table 2. Effect of tillage, residue, fertilizer and weed management on gross return, net return and B: C ratio of spring maize in Chitwan, Nepal, 2013

Treatments	Gross return (Rs. '000 ha^{-1})	Net return (Rs. '000 ha^{-1})	B:C ratio
Tillage methods			
CT	134.81[b]	82.16[b]	2.43[b]
NT	166.10[a]	116.65[a]	3.30[a]
F-test	*	*	*
$LSD_{0.05}$	25.14	25.14	0.51
SEm±	4.13	4.13	0.08
Residue management			
RK	175.45[a]	119.90[a]	3.18[a]
RR	125.46[b]	78.91[b]	2.54[b]
F-test	*	*	*

$LSD_{0.05}$	28.23	28.23	0.59
SEm±	4.64	4.64	0.10

**=* significantly different at $p \leq 0.05$ by DMRT, LSD value differs according to the level of significance. CT=Conventional tillage, NT=No tillage, RR=Residue removed and RK=Residue kept.*

Since planting can be accomplished in one pass of the seed drill, time for planting was also reduced, thus freeing farmers to do other productive work.

Water-use efficiency is also increased and save water by 15-50% through the adoption of CA technologies. It reduces water runoff, better water infiltration and more water in the soil profile throughout the crop growing period. It has potential to increase water application efficiency by over 50 %. Similarly, it increase in nutrient use efficiency of the crop by 15- 25 %.

While fossil fuels are the main producer of carbon dioxide, estimates are that the widespread adoption of conservation tillage could offset as much as 16% of world-wide fossil fuel emissions. CA also reduces crop vulnerability to extreme climatic events. More importantly, smallholder farmers relegated by the conventional agriculture can also be benefitting from it.

Yield gains of 200-500 kg/ha are found under rice-wheat system with no-till wheat against conventional-till system (Hobbs and Gupta, 2004). It is reported that, it increases in yield of crops by 15 to 25 %. Sufficient evidence has accumulated to conclude that CA contributes to sequester significant quantities of atmospheric CO_2 in the form of soil organic matter. Similarly, CA can reduce the significant amount of green house gas emission through improved input use efficiency.

Limitations of CA in Nepal

Despite the tremendous opportunities of CA, no work has been undertaken in Nepal. The primary restriction to CA adoption is the assumption that soil tillage is essential for agricultural production. Other restrictions include those of intellectual, social, technical, environmental and political characteristics. Key restrictions with mainstreaming CA systems relate to problems with up-scaling which is largely due to the lack of knowledge, expertise, inputs (especially equipment and machinery), adequate financial resources and infrastructure, and poor policy support (Friedrich *et al.*, 2009). CA has actually two intellectual barriers to overcome: the first is that CA concept and principals are counterintuitive and contradict the common tillage-based farming experience, which has worked for generations, and which often has created cultural values and rural traditions; the second is the lack of experiential knowledge about CA and the mechanism to acquire it.

The area under zero-tillage of wheat and direct seeding of rice has been increasing across the Terai region. Mainly the socio-economic constraints are competing uses of crop residues, lack of appropriate machinery, changes to pest dynamics especially weeds, knowledge-intensive adjustments to standard agronomic management practices, uncertain land use rights, poorly developed infrastructures like market, credit and research and development services. Larger areas in the hills and mountains where crop ecologies are entirely different than the Terai are not being explored for the CA. Nepal Agricultural Research Council and Department of Agriculture are the main drivers to develop, verify and disseminate the CA based technologies in Nepal. A major requirement of this system is the development and availability of machines and equipments that promotes good germination of crops planted into soil that is not tilled and where residue mulch occurs on the soil surface. It should also be able to place bands of fertilizer for increased efficiency. In Terai, several such machines are tested and improved, however still not perfectly executed. Whereas, in the hills cultivations are done mostly in sloppy terraces, scope of crop residue incorporation is limited since it is used for livestock fodder, no or limited roads to transport the heavy machines/equipments, poor affordability of the farmers for machines and rainfed agriculture that may limit the promotion of CA based technologies. No implements and equipments are being tested in the hills for reduced and zero-till condition. Similarly, none of the tools are for no-till weeding and mowing in the hills.

Feasibility of CA based technologies in Nepal

Precision land leveling, no-till systems, furrow irrigated raised bed planting systems, crop residue management and crop diversification are potential areas of CA in Terai and plain areas of Nepal. Similarly, no-till, residue incorporation, strip cropping, intercropping and crop rotation with legume species, introduction of high yielding varieties of crops are few of the potential technologies to be tested, verified and promoted in the hills. In order to minimize the cost of intercultural operation especially for weeding and minimize the intensity of nutrient mining, integrated weed management strategy consisting of mechanical, manual, herbicide, cover crops, trap crops can be adopted in both hills and Terai. Multicrop, zero-till ferti-seed drills fitted with inverted-T openers, disk planters, punch planters, trash movers or roto-disk openers are being used into loose residues in Terai. Laser land leveling machines are also being used in these areas. Mini-power tiller along with fitted seed drill, punch and jab planter having drill for both seed and fertilizer, weed mower and chopper are some of the tools and implements that require less labor and fuels appropriate for the hills. The critical scientific manpower in CA is also available in the country. NARC as an apex body of country's agricultural research is presently working through 56 different research stations/programs/divisions and DoA as an apex body of agricultural extension is working with 75 District Agricultural Development Offices across the country can be fully utilized. Global warming has become the major threat across the globe; hence resources can be available in CA, since it minimizes the emission of green house gases. Presently, CSISA has been promoting CA based technologies under rice based system in eastern and mid Terai and IFAD through CIMMYT, Nepal has been involved in testing and promoting CA based technologies under maize based system in the western Terai and adjoining hills of Nepal.

Where to go ?

For adoption of CA it is not only enough to find any progressive farmer who will prove the concept to work, but the farmer must have a socially important role, and be respected and integrated in the community. Wider adoption of CA technologies require concerted effort of all the stakeholders in the expanded partnership and participatory approaches in which farmers experiment and provide rapid feed-back. This would need to be supported by institutional changes that promote knowledge-sharing, flexibility and decentralized decision-making for rapid adoption of technologies to maintain production and productivity, increased food security and livelihood of the farmers. However, in order to sustainably adopt the CA, the farmers besides NT, must markedly alter their cropping systems, to diversified crop rotations, including the use of green manuring crop. This necessitates the learning and mastering of an array of new crop management skills. Farmer's co-operatives need to be upgraded with the support of public and private sector. The experiences of Cereal System Initiatives for South Asia working for Terai and inner Terai and International Fund for Agriculture Development through International Wheat and Maize Improvement Centre based in Western Terai involved in promoting CA based technologies can be capitalized. Similarly, the success stories of CA among the North and South American countries CA can also be taken into consideration.

In order to formulate CA based agricultural policies, a task force consisting of researchers, extensionists, farmers and private sectors along with machine manufacturers need to be formed urgently. As per the recommendations of the task force short, medium and long-term strategies for research and development need to be formulated and implemented soon in Nepal.

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