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Soil & Tillage Research xxx (2007) xxx–xxx
Soil & Tillage Research
www.elsevier.com/locate/still

Editorial

Constraints to adopting no-till farming in developing countries

No-till (NT) farming, practiced in combination with crop residues mulch and growing a cover crop in the rotation cycle, is widely recognized by soil scientists and agronomists as a viable alternative to plow tillage for making agriculture a part of the solution to improving the environments and sustaining use of natural resources. The literature is replete with manuscripts documenting numerous economic, ecologic, environmental, and social benefits of NT farming. Important among these are erosion control, water conservation, nutrient cycling, saving in time, reduction in use of fossil fuel, less wear and tear of machinery, stable and sustainable crop yields, and soil carbon sequestration along with an additional income stream for farmers through trading of carbon (C) credits. Such beneficial impacts of conversion from plow tillage to NT have been documented since 1960s in the U.S. Corn Belt, and 1970s in West Africa, South America, and Australia. Yet, in 2006 NT was practiced on less than 100 million hectares (Mha) worldwide, or on merely 6% of the global cropland area. Furthermore, most of the NT farming is presently done in USA, Brazil, Canada, Chile, Paraguay, Australia, and other developed countries. These regions are characterized by large scale mechanized monocropping of corn, soybeans, wheat, and other row crops.

The adoption of NT farming is practically negligible by resource-poor small land holders of sub-Saharan Africa (SSA), South and Southeast Asia, Central America, the Caribbean, and the Pacific Islands. These are also the regions where the potential benefits of NT farming are probably the highest. Therefore, the lack of adoption of NT farming, especially by farmers cultivating erosion-prone soils in harsh tropical climates, necessitates a thorough and an objective analyses of biophysical, economic, social, and cultural constraints which have been barriers to using this promising innovation of the 20th century.

There are definitely some biophysical constraints which indicate that NT is not a panacea, and does not always produce equivalent crop yields in climates with cold springs, sub-optimal soil temperatures, and poorly drained and heavy-textured soils. In such ecosystems, plowing under of crop residues leads to quick soil warming, rapid drainage and soil drying, early seedling establishment and increase in crop yields. Ecological conditions in the lowland tropics are in sharp contrast to those in temperate and Boreal regions, where springs are dry and warm, temperatures are supra-optimal, and soils are prone to drought stress even 5 to 10 days after a heavy rain. In such edaphological conditions, use of NT farming with crop residue mulch would alleviate predominant biophysical constraints due to specific ecologic, climatic, and pedologic factors. Thus, there must be other constraints which limit the adoption of NT farming in developing countries of the tropics and sub-tropics.

Resource-poor and small-size land holders of SSA and South Asia do not have access to herbicides needed for an effective weed control. Paraquat, roundup, atrazine and other chemicals are either prohibitively expensive or are not available. There is also a conspicuous non-availability of appropriate seeding equipment. The conventional seed drill used on a plowed land cannot be used in an NT field with heavy mulch of rice straw, sorghum stocks or corn stover. Even a 2-row NT seeder cannot be pulled by a small 30-HP tractor normally available to farming communities in SSA and South Asia.

Lack of or even complete absence of crop residues mulch and other biomass on the soil surface is perhaps the most important constraint limiting the adoption of NT farming in developing countries. Benefits of NT farming (e.g., erosion control, water conservation, soil fertility enhancement, C sequestration) are directly attributed to the amount of crop residue mulch and application of dung/manure as soil amendments. How-

0167-1987/$ – see front matter
doi:10.1016/j.still.2007.02.002

ever, biomass (e.g., crop residues, animal dung) is also the most important fuel source for cooking and heating in the rural communities in developing countries. For example, in 2005, India used 250 million metric ton (Mt) of fuel wood, 62 Mt of dried cattle dung and 36 Mt of crop residues as cooking fuel (Venkaraman et al., 2005). In comparison, the amount of fuel wood, cattle dung and crop residue used as residential fuel was 800–930 Mt, 130–200 Mt and 430–545 Mt, respectively in Asia; and 1324–1615 Mt, 150–410 Mt and 442–707 Mt in the world (Venkaraman et al., 2005). About 2.5 billion people, mostly in South Asia and SSA, rely on biomass for cooking and heating, which account for more than 80% of their residential energy needs (World Energy Outlook, 2002). The aerosols emitted by combustion of biomass in rural kitchens, often under unventilated conditions, have a strong impact on regional climate and human health. Ramanathan et al. (2001) reported that aerosols released by biomass combustion enhance scattering and absorption of solar radiation, and produce brighter clouds that are less efficient at causing precipitation. Such aerosol effects weaken the hydrologic cycle and have adversely impacted monsoons in the Indian sub-continent. Bailis et al. (2005) reported that household indoor pollution caused by combustion of dung and crop residues will cause an estimated 9.8 million pre-mature deaths by 2030 in SSA.

A large fraction of crop residues (especially that of wheat, sorghum and millet) is also used as fodder for livestock. Furthermore, whatever stubbles remain in the field after clean harvest are heavily grazed. In the process, soil is denuded of any protective vegetation cover against erosivity of wind and water and dessication effect of tropical Sun, deprived of plant nutrients contained in plant residues and animal dung, and subjected to the compactive effects of animal trampling leading to crustation and massive structure. It is estimated that dung used as fuel in India would be worth $800 million per year if it were used as fertilizer (World Energy Outlook, 2002).

Under these conditions, loosening of soil by any tillage (manual by a hoe, animal drawn traditional ard or tractor driven moldboard plow or sub-soiler) improves porosity and structural characteristics of a compacted soil, albeit temporarily. In addition, plowing also enhances mineralization of whatever little soil organic matter still remains in the soil. The enhanced mineralization releases essential nutrients (N, P, K), which also improves plant growth especially in traditional agriculture where chemical fertilizers are rarely or minimally used.

The scientific community is convinced of the long-term benefits of using crop residues and animal dung as amendments for improving soil quality, increasing use efficiency of fertilizers and other off-farm input, enhancing and sustaining crop yields and restoring degraded/desertified ecosystems. It is also known that even traditional farmers, who neither have access to the published literature nor to extension services, are fully aware of the benefits of using crop residues and animal wastes as soil amendments. Yet, the economic realities, helplessness, and desperate needs for using biomass either as cooking fuels or as fodder for feeding the cattle, prevent them from availing the benefits of using them as soil amendments. It is this desperate situation which leads farmers to perpetually use the extractive farming practices for short-term gains rather than investing in long-term stewardship of soil and water resources.

These resource-poor farmers are also aware of the severe problems of soil and environmental degradation caused by their actions of using extractive farming practices. In biophysical terms, they know that fragile soils in harsh climates are highly vulnerable to degradative processes. In socioeconomic terms, they also know that they pass on their sufferings to the land when they are themselves hungry and poverty stricken. As Barry Commoner (1972) stated ‘‘all things are inter connected’’, and then ‘‘there is no such thing as free lunch’’. Farmers pay a heavy price for use of crop residues and animal dung as fuel in terms of soil and environmental degradation. As a Quaker saying goes ‘‘if you beat the nature, nature will beat you’’; yet, these desperate farmers often do not have a choice, because it is a matter of their survival.

Therefore, a strategy needs to be developed to provide clean cooking fuel to rural households in developing countries. Such a strategy would involve establishment of biofuel plantations and identification of other clean sources of residential fuel, incorporation of forages (clover, grasses) in the rotation cycle, using controlled grazing, and application of chemical fertilizers in conjunction with strategies of integrated nutrient management. This is where the path of Soil & Tillage Research crosses with those addressing issues related to economic, social and the human dimensions for promoting sustainable agricultural practices and advancing food security in developing countries.

Adoption of NT farming is also indicative of the economic and industrial development of a society. It is a natural step forward when other components of economic and social development are in place. As Theodore Roosevelt (1908) once said ‘‘The men with the muck-rakes are often indispensable to the well-being

Please cite this article in press as: Lal R., Constraints to adopting no-till farming in developing countries, Soil Tillage Res. (2007), doi:10.1016/j.still.2007.02.002

of society, but only if they know when to stop raking the muck''. Roosevelt's views were also supported by Francis Bacon in the 17th century who stated that ''money is like muck, not good except it be spread'' (Holmes, 2006). Thus, crop residue and animal dung must be spread on the soil to reap the monetary rewards through adoption of NT farming in the developing countries. In the meanwhile, resource-poor farmers will have to continue practicing plow tillage while fully realizing that it is not a sustainable practice.

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Please cite this article in press as: Lal R., Constraints to adopting no-till farming in developing countries, Soil Tillage Res. (2007), doi:10.1016/j.still.2007.02.002