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A Review on Resource Conservation Technologies to Achieve Sustainability

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ABSTRACT: Nowadays conventional farming practices are not sustainable and produce harmful effects on the environment. In many developing countries, environmental degradation is mainly takes the form of nutrient depletion and reduces the potential of food production. Challenges demand that the issues of efficient use of resources and adoption of resource conservation technologies (RCTs). Cropping system which enhance the maintenance of a permanent soil cover, minimum disturbance of soil, diversification of crop species, improvement of biodiversity and enhance natural biological processes above and below the soil is known as conservation agriculture. Conservation agriculture has four principles: 1) minimizing mechanical soil disturbance and seeding directly into untilled soil improve soil organic matter content and soil health; 2) enhancing soil organic matter using cover crops and crop residues. This protects the soil surface, conserves water and nutrients, promotes soil biological activity; 3) diversification of crops in associations, sequences and rotations to enhance system resilience that complement reduces tillage and reduce retention by breaking cycles of pests and diseases; 4) controlled traffic that loosen soil compaction. These RCTs are in the form of reduced tillage, residue management, laser land levelling and site specific nutrient management etc. These technological components also plays an important role to decrease the greenhouse gases by decreasing the use of fossil fuels. There is a need to adopt these new technologies under diversified cropping system and appear to be appealing options to achieve sustainable and intensive crop production under different agro-ecological environments. Now, a move from conventional to conservation farming system is highly warranted to maintain the ecological balance for future generation.

I. INTRODUCTION

Continuous use of conventional farming operations and burning of agricultural wastes has degraded the resources of soil with decreasing the crop production capacity. In ancient agriculture, broadcasting of seeds and harvesting meager yields was a common feature whereas substantial yield can be obtain by use of improved varieties, fertilizers, pesticides, weedicides were the main threat of modern agriculture (Ramesh et al 2016). For improving the sustainability and productivity of crops, resource conserving technologies (RCTs) are used. These RCTs are in the form of reduced tillage, zero tillage, minimum tillage, residue management (Hobbs and Gupta 2003). Conservation agriculture has four principles: 1) minimizing mechanical soil disturbance and seeding directly into untilled soil improve soil organic matter content and soil health; 2) enhancing soil organic matter using cover crops and crop residues. This protects the soil surface, conserves water and nutrients, promotes soil biological activity; 3) diversification of crops in associations, sequences and rotations to enhance system resilience that complement reduces tillage and reduce retention by breaking cycles of pests and diseases; 4) controlled traffic that loosen soil compaction.

(Singh et al 2011) The indo-gangetic plain is one of the world's major food grain producing regions. The states comes under this region are Punjab, Haryana, Uttar Pradesh, Himachal Pradesh, Bihar and West Bengal. It is generally believed that rice-wheat cropping system in this region strained the natural resources. Therefore, it is necessary to enhance the alternative technologies (Resource conservation technologies) that would help to conserve the natural resources and maintain the soil health. Use of unsustainable groundwater and improper water management practices produce several threats in the country for future food production. On farm resource conservation technologies in state like Punjab have a potential over other technologies. Like levelling of land by laser land leveller is such proven technology which is highly useful for conservation of irrigation water and also enhancing the productivity of crop (Kaur et al 2012). Results of laser land leveller are quite encouraging.

Agronomical challenges are lack of basic information, inadequate sampling and scouting procedures, absence of site-specific fertilizer recommendations, misuse of information, and lack of qualified agronomic services. There are multiple technological barriers that relate to machinery, sensor, GPS, software, and remote sensing. However, these barriers will be progressively lifted and precision agriculture will be a significant component of the agricultural system of the future. It offers a variety of potential benefits in profitability, productivity, sustainability, crop quality, food safety, environmental protection, on-farm quality of life, and rural economic development (Robert 2019).

Fossil fuels will be more costly, adding to production costs through higher diesel prices but also higher fertilizer and other input costs. Greenhouse gas emissions such as carbon dioxide, methane, and nitrous oxide that have inherent warming effects on the atmosphere will increase with subsequent effects on climate, especially an increase in severe climatic events such as drought, floods, etc. This will make the challenge more difficult and complex. One obvious way to accomplish this sustainable food production objective is to make more efficient use of the natural resources that are needed to produce food; this includes water, soils, air, inputs, and people. This paper discusses how promotion and adoption of conservation agriculture (CA) by farmers should be considered as one avenue to pursue in meeting the challenge (Hobbs 2006).

RCTs for Sustainability

Zero tillage:(Gupta and Seth 2007) RCTsis an exponent of CA improves yield, reduce the consumption of water and decrease the harmful effects on the environmental quality. In the farmer field, out of several RCTs developed and promoted by different institutions only zero tillage and bed planting is widely used. Adopters of RCTs led to reduce the use of inputs without affecting the yield of crop negatively and also save the cost of cultivation (Singh et al 2011).(Baeumer and Bakermans 1974) Zero tillage maintains crop residues on soil surface and protects the soil from the water and wind erosion. The less disturbance of soil is reducing the sowing operations in the field. There is a lack of previous knowledge about zero tillage and farmers had to create their own channels to exchange information. On the other hand, information channels had been built over the years around most products with a commercial value and agents knew where to look for information when they had problems (Ekboir 2003).

Zero tillage wheat is particularly appropriate for rice-wheat systems in the Indo-Gangetic Plains by alleviating system constraints by allowing earlier wheat planting, helping control the weed Phalaris minor, reducing production costs and saving water. Zero tillage wheat after rice generates substantial benefits at the farm level through the combination of yield effect and cost savings effect particularly (Erenstein and Laxmi 2008).

Crop residue management: Crop residue are materials left in an agricultural field or orchard after the crop has been harvested. These residues include stalks, stubble (stems), leaves, seed pods etc.Crop residues on the soil surface reduce soil erosion from water and wind. Depending on the amount of crop residues left on the soil surface, soil erosion can be reduced by up to 90% compared to an unprotected, intensively tilled field. It provides mulching/cover to field which helps to decrease evaporation and attain moisture for long time. (Mandal et al 2004) A rice-wheat sequence that yields 7 t ha^{-1} of rice and 4 t ha^{-1} of wheat which removes more than N 300, P 30 and K 300 kg ha^{-1} from the soil, the residues of rice and wheat amount to as much as 7-10 t ha^{-1} $year^{-1}$. Burning of these residues results huge loss of N up to 80%, P 25%, K 21%, and S 4-60%, air pollution @CO_2 13 t ha^{-1} and also deprive the organic matter in the soil.Residue management significantly influenced the level of microbial biomass C; for example, burning residues reduced microbial biomass up to 57%. Microbial C represented 4.3, 2.8, and 2.2% and microbial N 5.3, 4.9, and 3.3% of total soil C and N under grass pasture, annual cropping, and wheat-fallow, respectively. Both microbial counts and microbial biomass were higher in early spring than other seasons. Annual cropping significantly reduced declines in soil organic matter and soil microbial biomass (Collins et al 1992).

Recycling of rice residues constitutes more potential problems than recycling of wheat straw. The incorporation of rice straw in wheat and wheat straw in rice also caused yield reductions. However, yield reductions can be overcome by either allowing sometime between incorporating residues or sowing the next crop or by composting rice straw or adding farmyard manure (FYM). Control of weeds, diseases, and pests is important for the success of residue management practices. Residues can be incorporated into the soil, left on the soil surface, or partially burned. A mould-board plough or disk can incorporate residue into the soil, but appropriate machinery for the remaining two options is still in the development stage (Samra et al 2003).

Laser land levelling: From past one decade, ground water table has declined from 18 to 27 meters. The use of laser levelling could save irrigation water and energy by 24 percent with also increasing the yield 4.25 percent. As compare to conventional farming practices, the irrigation cost is reduced by 44 percent and water productivity enhanced by 39 percent. Water use efficiency in paddy cultivation is optimizing by using laser land levelling without producing any harmful effects on productivity (Kaur et al 2012).

Laser levelling in rice fields reduced irrigation time by 47–69 h/ha/season and improved yield by approximately 7 % compared with traditionally levelled fields. In wheat, irrigation time was reduced by 10–12 h/ha/season and yield increased by 7–9 % in laser levelled fields. (Aryal et al 2015) If 50 % of the area under the Rice-Wheat system in Haryana and Punjab states were laser levelled, this would provide an additional production of 699 million kg of rice and 987 million kg of wheat, amounting to USD 385 million/year. Thus, laser levelling contributes to food security and economical use of water and energy resources.

Site specific nutrient management:(Adamchuk et al 2004) The basic objectives of site-specific management of agricultural inputs are to increase profitability of crop production, improve product quality, and protect the environment. Information about the variability of different soil attributes within a field is essential for the decision-making process.(Dobermann and white) The major components of a field-specific, knowledge-based strategy are quantification of crop nutrient requirements based on nutrient interactions and economic yield target; measurement of potential N, P, and K supply; and monitoring of plant N status to optimize N nutrition.In the high-yielding wheat production systems in Northwest (NW) Indo-Gangetic Plains of India, intensive tillage operations and blanket fertilizer recommendations have led to high production costs, decreased nutrient use efficiency, lower profits and significant environmental externalities (Sapkota et al 2014). Over application of N and P and insufficient supply of K are considered primary reasons for restriction of yield improvement. Optimized nutrient management practices based on soil testing and yield targets have been developed (Ping et al 2009). The yield attributes, viz. effective tillers/m^2, grains/spike, harvest index and 1000-grain weight, were recorded significantly higher with STCR approach and SSNM. It can be better option over blanket recommended fertilizer prescription in indo-gangetic cropping system under conservation agriculture. In addition to this, real time N management basal on green seeker was also found effective in wheat under conservation agriculture (Mohanty et al 2015).

Leaf colour chart (LCC): A LCC developed in Japan, is used to measure green colour intensity of rice leaves to assess the nitrogen requirements by non-destructive method and is being standardized with chlorophyll meter.The leaf color chart (LCC)–based real-time N management can be used to optimize/synchronize N application with crop demand or to improve existing fixed split N recommendations. In hybrid as well as inbred rice, N management through LCC proved superior to locally recommended N application in three splits. It was found possible to curtail 20-30 kg of fertilizer N/ha without sacrificing rice yield, when N is applied as per LCC values. (Witt et al 2005) Improved N management caused greater yield responses to fertilizer N application compared to farmer practice, and yield responses to fertilizer phosphorus (P) and potassium (K) application often only occurred after yields increased through improved N management with SSNM. Leaf color charts are an effective, low-cost tool that can assist farmers in improving their N management, and efforts are underway to promote the technology at wider scale among rice farmers.

II. CONCLUSION

Resource conserving technologies, an exponent of conservation agriculture, improve yields, reduce water consumption, and reduce negative impacts on the environmental quality. A cropping system that includes zero tillage, crop rotation, and crop residue retention can increase overall biomass and micro-flora activity and diversity compared with common farming practices. In the long term, zero tillage combined with residue retention creates conditions favourable for the development of antagonists and predators, and fosters a new ecological stability. Zero tillage without residue retention is an unsustainable practice that leads to poor soil health in the long run.

Use of productive but more sustainable management practices described in this paper can help solve many problems. Crop management systems that improve soil health parameters and reduce farmer costs are essential. Development of appropriate equipment allow these systems to be successfully adopted by farmers is a prerequisite for success. Overcoming traditional mind set about tillage by promoting farmer experimentation with this technology in a participatory way will help accelerate adoption. Encouraging donors to support this long-term, applied research with sustainable funding is also an urgent need.

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