Indian Journal of Agriculture and Allied Sciences

ISSN 2395-1109
e-ISSN 2455-9709
Volume: 4, No.: 3, Year: 2018

www.ijaas.org.in
Received: 03.08.2018, Accepted: 25.09.2018
Publication Date: 30th September 2018

RESOURCE CONSERVATION TECHNOLOGY FOR SUSTAINABLE AGRICULTURE

Abhinandan Singh[1] and Pankaj Kumar Ojha[2]
*[1]Department of Agronomy, RPCAU, Pusa, Samastipur, Bihar, E-mail: agabhi92@gmail.com, [2]Assistant Professor, Department of Agricultural Extension, BUAT, Banda, U.P. and *Correspondence Author: Abhinandan Singh*

Abstract: *Resource conserving technologies will refer to those practices that enhance resource- or input-use efficiency. This covers a lot of ground. New varieties that use nitrogen more efficiently may be considered RCTs. Zero or reduced tillage practices that save fuel and improve plot-level water productivity may also be considered RCTs, as may land leveling practices that help save water. For sustainable intensification of crop production, RCTs is the base concept. The degrading land resources, declining quality irrigation water and increasing demand for food and feed has forced farmers for the adoption of RCTs. Conservation technologies meet the increasing demand for food and fibre, promote sustainable utilization of natural resources, protect or restore the environment enhance, economic viability of farms and rural livelihoods lastly improve quality of life for farmers and society as a whole. Until recently, the choice of technologies available to farmers was largely determined by the need to increase production, profits and productivity. The main constraints were the availability of capital, knowledge of how to use the technology and market risks—risks that in many countries policies were shielded by government policies. In the past, "good policy practices" was therefore rather straightforward, relating primarily to increasing output and the aim of agricultural policies was to increase productivity in agriculture. Agricultural research and extension services could concentrate, for example, on improving the productivity of small farms.*

It needs to be internationally competitive, produce agricultural products of high quality while meeting sustainability goals. In order to remain competitive, agricultural producers need rapid access to emerging technologies. Farmers are faced with many more constraints and also more opportunities. In addition to being profitable, they need to meet environmental standards and regulations, as well as deal with direct and indirect consumer and lobby group pressures. They may also be flooded with information from various government and industry sources that make choosing appropriate technologies more difficult. Farmers also need to change their production and management practices in response to agricultural policies that include environmental conditions and I am confident that farmers have the capacity to do so.
Keywords: *Resource, Conservation, Technology, Food Product, Sustainable Agriculture, Quality, Farmers and Policy.*

Introduction: Resource conserving technologies will refer to those practices that enhance resource- or input-use efficiency. This covers a lot of ground. New varieties that use nitrogen more efficiently may be considered RCTs. Zero or reduced tillage practices that save fuel and improve plot-level water productivity may also be considered RCTs, as may land leveling practices that help save water. There are many, many more. In contrast, conservation agriculture practices will only refer to the RCTs with the following characteristics:

- Soil cover, particularly through the retention of crop residues on the soil surface;
- Sensible, profitable rotations; and
- A minimum level of soil movement, e.g., reduced or zero tillage.

The distinction is important because some RCTs, while attractive in the near-term, may be unsustainable in the longer-term. An example of this is the use of zero tillage without residue retention and without suitable rotations which, under some circumstances, can be more harmful to agro-ecosystem productivity and resource quality than a continuation of conventional practices [1].

Need of Resource Conservation Technology: For sustainable intensification of crop production, RCTs is the base concept. The degrading land resources, declining quality irrigation water and increasing demand for food and feed has forced farmers for the adoption of RCTs. The need for RCTs can be discussed as under:

1. Land Degradation: Land degradation is a serious environmental problem that threatens the ecosystem, health and food security. More and more fertile land has comes under marginal and degraded lands [2]. The main land degradation processes like soil erosion, nutrient mining, carbon loss etc. are aggravated by human interference and intensified agricultural operaions.

2. Soil Erosion: The soils today are being degraded at a much faster rate than they can be formed by natural processes. Excessive tillage as practiced in conventional tillage is one of the most important drivers of soil erosion. Due to erosion during last 40 years, about 30 % of the world's arable land has become unproductive and most of it has been abandoned for agriculture [3].

3. Soil Nutrient Mining: Soil nutrient mining occurs when extraction of useful nutrients from the soil by agriculture exceeds the rate of replenishment in the system. Nutrient depletion in soil adversely affects the soil quality and reduces crop yield. Because of this reason the per kg grain output due to unit kg NPK supply in India has reduced from 13.4 in 1970 to 3.7 in 2010. If we want to keep soil enriched with nutrients for the future generations to come, we need to adopt CA as a solution.

4. Declining Fertility and Productivity: Due to continuous traffic on the soil, the physical and chemical properties of the soil get degraded. More dependence on inorganic fertilizers has resulted in poor organic carbon status of the soil. If crop residues are incorporated before sowing it supplies sufficient quantities of micro nutrients also.

5. Soil Carbon Loss: Soil carbon/organic matter is known as black gold because of its vital role in physical, chemical and biological processes with in the soil system [4]. Soil erosion results in the removal of organic matter and essential plant nutrients from the soil and the reduction of the soil depth. Conversion of virgin land for cultivation and grazing, repeated cultivation promoting soil respiration without additional carbon inputs and soil erosion are the main causes of loss of organic matter.

Types of Resource Conservation Technology: Over the past few decades, rapid strides have been made to evolve and spread various approaches to enhance resource conservation. Various CA-based RCTs for crop management include zero and reduced tillage with residues recycling, laser assisted precision land levelling, direct drilling into the residues, direct-seeded rice, brown manuring with *Sesbania*, unpuddled mechanical transplantation of rice, raised bed planting system, crop diversification and associated component technologies like site-specific nutrient management (SSNM), leaf colour chart (LCC), green seeker, soil test crop response, fertigation, customized fertilizer and agro-forestry, which help in conservation of soil, water and nutrients. The RCTs approaches are different across environments. The approaches for Indo-Gangetic Plains (IGPs) are different from that of hill region or desert region. It also differs according to various types of cropping systems. In hill farming systems, rain water harvesting on watershed basis for availing water for irrigation and other purposes, mulching to reduce run off and increasing water infiltration into the soil surface, contour farming and strip cropping *etc*., are used under RCT approaches while for IGPs region furrow irrigated raised bed system (FIRBS), zero tillage, laser land leveling, use of different seeding machines *etc*., are followed.

The major natural resources in agricultural production system are soil, water, vegetation and climate. Some of the modern tools and techniques/practices which have the potential for resource conservation and improving the use efficiency of these resources are discussed here.

1. Zero /Reduced Tillage: Intensive soil tillage is the main cause of reduced soil organic matter and hence of soil degradation. Tillage accelerates the mineralization of organic matter and destroys the habitat of the soil life. On the contrary, when soil tillage is reduced or eliminated, soil life returns and the mineralization of soil organic matter slows down, resulting in better soil structure. Under zero tillage the mineralization of soil organic matter can be reduced to levels inferior to the input, converting the soil into a carbon sink [5]. Zero tillage also results in water saving and improved water-use efficiency: since the soil is not exposed through tillage, the unproductive evaporation of water is reduced while water infiltration is facilitated. The potential water saving through zero tillage varies according to the cropping system and the climatic conditions. On average, water savings of 15 to 20 percent can be expected [6]. Used in isolation, however, zero tillage can lead to problems with weed control, compaction or surface crusting, depending on the soil type.

One of main reasons for low yields of wheat in rice-wheat cropping system is delayed planting of wheat due to late maturing of preceding rice crop sown in region besides high cost of land preparations and other inputs. After rice harvest, sufficient residual moisture is generally available to establish new crop. Conventional tillage accelerates soil moisture evaporation and requires extra irrigation water to bring field back to semblance of a seedbed. This causes major delays in wheat sowing, which ultimately affects final crop yields. Decrease in wheat yield @ one percent per day after mid November is well documented due to delay in sowing. Zero tillage is an innovation that not only offers conservation of water and energy resources but also results in better crop yields. This technology had been in use since long in many parts of world and then it was introduced in India. Zero tillage technology has been rapidly accepted by farmers due to its contribution in reducing cost of production, conservation of resources, and improving yields. View that a profit-driven advantage of zero tillage technology has allowed small and medium farmers to gain confidence in this technology [7].

2. Bed Planting: Bed planting facilitates the sowing of crops on raised beds (narrow or broad beds) separated by furrows using a raised-bed planter. Raised beds are usually made at 60-100 cm apart where 2-3 rows of crops are sown and irrigation is given in the furrows. First time raised beds are prepared after conventional tillage using a raised-bed planter and are left for 30 days to settle. These beds can be used for direct drilling for the subsequent years, but with little reshaping of the beds once in a year, preferably before *kharif* crops are planted. In RWCS of western IGPs, raised beds are mare at 37 cm wide at the top and 15 cm in height and separated by furrows having a 30-cm-wide top. The distance between the centers of two subsequent furrows is kept at 67 cm. Rice is drilled on the raised beds keeping two rows on both sides at the top of the beds with a spacing between two rows at 25 cm. After rice, wheat is directly sown using the same bed planter that reshapes the beds along with simultaneous placement of seeds and fertilizer [8]. Bed planting facilitates more efficient use of water under rainfed as well as irrigated situations owing to efficient storage of water and drainage of excess water. It helps in conserving inputs like seed, water, nutrient, etc. Bed planting has the potential to save water by up to 30-50% in wheat [9]. The furrow irrigated raised-bed system (FIRBS) of wheat cultivation results in savings of inputs like seed by 25-40%, water by 25-40% and nutrients by 25%, without compromising with the crop productivity. It also provides the option for crop diversification [10]. The other benefits include: (i) less lodging, (ii) less soil compaction and improved soil aeration, (iii) safe disposal of excess water specially in heavy textured soils, (iv) more potential tillers and better canopy formation, (v) more interception of solar energy by crop canopy, (vi) reduced weed growth on the beds, (vii) higher efficiency of chemical weed control and easier mechanical weeding on the furrows, (vii) moderation of soil temperature, and (viii) better crop growth and productivity.

Some precautions must be taken for adopting bed planting technique. These include: (i) furrows should be filled with irrigation water up to 3/4th height of the raised beds and water should not flow over top of the beds, (ii) the field should be clod-free and uniformly levelled, preferably be laser levelled, (iii) beds should be made weed-free before sowing of each crop using herbicides like glyphosate or paraquat under non-cropped situation, (iv) proper soil moisture should be maintained in the beds for better germination, (v) water can be applied at the appearance of hairline cracks on the soil surface at the bottom of the furrows.

3. Laser Land Leveling: In India, surface irrigation (mainly flood irrigation) is a common practice wherein a significant amount of irrigation water is lost during application because of poor management and uneven fields that lead to lower crop yields, higher irrigation costs and poor input-use efficiency [11]. Laser assisted precision land leveling (commonly known as laser land leveling) is a pre-requisite technology for adopting RCTs like zero tillage or bed planting that require properly leveled fields for uniform distribution of inputs like seeds, water and fertilizer. It uniformly levels the land surface (± 2 cm) and alters the fields to create a constant slope of 0 to 0.2% using laser equipped drag scraper. This practice makes use of large horsepower tractors and soil movers that are equipped with global positioning systems (GPS) and/or laser-guided instrumentation so that the soil can be moved either by cutting or filling to create the desired slope/level [10].

Precision land leveling provides a very accurate, smooth and leveled field which facilitates application of less water more uniformly under surface irrigated systems and reduces leaching losses, thus improving the use-efficiency of applied water and reducing irrigation cost. This can also reduce water losses by suppressing evaporative and percolation losses owing to faster irrigation times (as irrigation water reaches to the tail ends of the fields in less time) and elimination of depressions.

This technology helps in saving of irrigation water by up to 25-30% and improves the use-efficiency of applied N. There is about 3-4% increase in the area irrigated due to removal and/or fewer bunds and channels. Other benefits include improved crop stand and productivity (up to 20%) and reduced labour requirement (up to 35%). This technique can be very useful for rice since irrigation water requirement is reduced drastically [12].

4. Direct-Seeded Rice: Direct-seeded rice (DSR) is an emerging production system as consequences of water scarcity, labour scarcity, energy crisis and continuous climate change. In DSR system, rice can be sown directly on dry seed bed (dry-DSR) or pre-germinated seeds can be sown on puddled soil (wet-DSR) or sowing can be done into shallow standing water (water seeding). This can save inputs like water, labour, fuel and time. Dry-DSR is grown under aerobic soil conditions without prolonged periods of flooding as periodic irrigations maintain the soil at field capacity. It avoids huge water and labour requirement during land preparation (puddling) and/or transplanting, thereby reducing overall water and labour demand. Direct-seeded rice significantly lowers total water requirement (up to 35-57%) and labour requirement (up to 67%) than transplanted rice depending on season, location, and type of DSR [13]. Moreover, rice cultivation through puddling and transplanting deteriorates the soil structure, forms a hard pan which may suppress the growth and yield of succeeding crop. DSR maintains good soil physical conditions which facilitates desired tilth and timely sowing of the succeeding crop.

DSR can fetch yield similar to transplanted rice if weeds are managed properly. Weed infestation is considered as the main biological constraint to the success of DSR. High weed pressure and shift toward more difficult-to-control weed flora limit the productivity. It even causes complete crop failure under extreme cases [14]. Judicious use of herbicides (either in a sequence or mixture) along with other cultural practices provides an effective weed control and good yield.

Direct seeding has a number of other benefits over transplanting of rice such as faster and easier planting, reduced drudgery, improved physical conditions of soil, efficient use of irrigation water, higher tolerance to water deficit, lesser emissions of methane, and often higher profit in areas with assured water supply [15]. In addition to this, DSR matures 7-10 days earlier than the transplanted rice which allows timely planting of the succeeding crop *rabi* season crop especially wheat in IGPs.

5. System of Rice Intensification: The system of rice intensification was developed in Madagascar by Fr Henri de Lau Lanie in association with NGO- Association Tefy Saina (ATS) and many small farmers in the 1980s is becoming popular in many countries including India. SRI is a system methodology [16] rather than a technology. It is based on the insight that rice has the potential to produce more tillers and early transplanting along with optimal growth condition like wide spacing, optimum humidity, a vibrant healthy soil and aerobic soil conditions during vegetative growth can fulfill this potential. Water saving in SRI maybe as high as 40 percent as compared to conventional practice. In a field trial at Directorate of Rice Research (Hyderabad, India), SRI gave 166 percent higher grain yield than normal transplanting method. The varietal response to SRI and normal cultivation was wide SRI method gave nearly 46 to 48 percent higher yield in hybrids, 52 to 17 percent in HYVs while negative results were also observed in case of Pusa Basmati due to its shy tillering habit under wider spacing. All the varieties are not promising for SRI cultivation method and response of cultivars to SRI varies as per their ability to exploit the natural resources. Hence, there is a need to develop varieties that can give better response to SRI cultivation and must have compact plant type, profuse tillering, better root system, bolder grains, low water requirement, responsive to organic inputs (inorganic inputs constitute 25 to 50 percent only), and resistance to pest and diseases. Besides, rice matures 10 – 15 days earlier as compared to conventional practice and thereby vacates the land for timely sowing of succeeding crop. Therefore, genotypes used for SRI should be able to produce more with less duration. High yield varieties and hybrids are the most suitable cultivar for system of rice intensification. In addition, high tillering rice cultivars are also recommended for SRI. Research work conducted at BCKV [17] during 2012-14 revealed that in Weed management in comparison to weedy check the hand weeding, chemical herbicides and botanical aqueous extracts from *Parthenium hysterophorus*, *Tectona grandis* and *Calotropis procera* followed by two mechanical weeding (paddy weeder) at 20 & 40 DAT yielded 27.97, 29.39 and 23.67 % more, respectively. Average yield increase in 2014 than 2012 was 13.5 %. The major outcome is farmers are accepting gradually the low cost weed management and self-dependent – not depending fully on labours for weed control. In Nutrient management the treatment INM - 50 % ORM & 50% INORF (replacing of 50 % inorganic fertilizers through organic manures like compost etc.) resulted more yield in 2013, but in the final year 2014 the treatment INM 75 % ORM & 25% INORF (replacing of 75 % inorganic fertilizer by organic manures) resulted better yield, lesser pest attack and better soil health status. Average yield increase in 2014 than 2012 was 11.9 %. In Water management average yield increase in 2014 than 2012 was 11.49 %.

6. Brown Manuring: Brown manuring (BM) is a practice of concurrent sowing of Dhaincha (*Sesbania*) in alternate rows of rice manually and subsequent application of 2, 4-D @ 0.25-0.5 kg/ha to knockdown the *Sesbania* at 25-30 days after sowing. Rice is drilled in lines and *Sesbania* is broadcasted in the inter-row spaces on moist soil. Bispyribac-Na, a broad-spectrum herbicide can be applied (20-25 g/ha) instead of 2, 4-D. Brown manuring has the potential to offset the drawbacks of green manuring which requires additional water for irrigation, fuel costs for its incorporation. And also little water availability during peak summer season hinders to take the full benefits of green manuring [10].

Sesbania while growing with rice provides a quick vegetative cover and smothers various weed species and conservers soil moisture by checking evaporation from the soil surface. After knocking down, it forms a brown mulch on the soil surface and thus suppresses weed, reduces herbicide use and supplies about 15-20 kg N/ha with a fresh biomass of 10-12 t/ha [18]. It conserves soil moisture, lowers irrigation requirement, improves soil health and enhances grain yield and profitability without adding much on cost of production (only seed cost).

This technique can also be adopted for other cereal crops like maize, pearl millet, sorghum, etc. where *Sesbania* can be cut manually and spread in between the crop rows as mulch for conservation of resources [8].

7. Crop Residue Management: Crop residues are the parts of a plant or crop which are left in the field after harvest or discarded during processing. Management of crop residues or efficient recycling of crop residues is crucial, especially in rice-wheat belt of IGPs, where it is burnt in situ. India produces huge amount of crop residues (more than 600 million tonnes) annually of which major quantity is contributed by rice and wheat. A vast potential is available to effectively recycle the huge volume of crop residues.

A large quantities of residues are burnt in situ every year by the farmers to facilitate land preparation for crop succeeding crop. Crop residue on burning increases rates of mineralization that rapidly depletes nutrients and organic matter from the soil and also causes air pollution. It is estimated that burning of one tonne of straw releases 3 kg particulate matter, 60 kg CO, 1460 kg CO_2, 199 kg ash and 2 kg SO_2 [19]. Various new drills/planters such as Happy/turbo seeder or rotary-disc drill have been developed which are able to cut through the crop residue for zero-tillage crop planting and can operate in residue load up to as much as 10 t/ha. Thus, burning of residue can be avoided and release of some 13-14 tons of carbon dioxide potentially can be reduced [20].

In CA, a critical level of crop residue as permanent or semi-permanent organic soil cover must not kept on the soil surface. Retention of residue on the surface provides numerous benefits which are listed below.

- It protects organic matter enriched top soil from weather aggressions and water erosion by reducing crust formation and enhanced infiltration
- Organic matter formed after residue decomposition acts as a reservoir of plant nutrients, prevents nutrient leaching and improves cation exchange capacity (CEC)

- Residue left on the soil surface helps in suppression of germination and growth of weeds, thereby reducing herbicide use
- Crop residue maintains or improves soil physical, chemical and biological properties and prevents land degradation. It helps in water conservation through enhanced water infiltration and reduced evaporation
- Retention of crop residue moderates soil temperature by raising minimum soil temperature in the winter and decreasing soil temperature during summer
- It provides climate change mitigation benefits through carbon sequestration
- It provides shelter and food for the soil biota and enhances microbial and enzymatic activity
- It plays an important role ameliorating soil acidity and alkalinity
- Crop residue is also an important source of fodder for animals

However, rate of decomposition and release of nutrients from residue depend on soil, climatic conditions and the C: N ratio residue. Nevertheless, there are some negative aspects of crop residue retention, like increase in incidence disease and pest infestation with retained residue which may hinder its adoption. But the benefits appear to be greater than the disease-pest factor.

8. Crop Diversification: Crop diversification refers to a shift from existing sole cropping or monoculture towards more balanced and diversified cropping system. Different planting and harvesting times can reduce risks from weather abnormalities and disease-pest infestations and new crops can be adjusted in the existing cropping systems. Therefore, crop diversification has been recognized as an effective strategy for (i) reducing risks associated with yield, market and prices (ii) reducing the degradation of natural resources and the environment (iii) attaining national goals like providing food security and nutritional security, employment generation, income growth, poverty alleviation and earning foreign exchange (iv) judicious use of land and water resources, improving biodiversity, soil health, agro-ecosystem and environment [21].

Short duration crops like pulses, oilseeds and other high value crops can be used as sequential or intercrops for crop intensifications and higher yield stability. Thus, an increase in cropping intensity can contribute substantially to additional demands of food and cash crops. Development of new crop varieties with enhanced photosynthetic efficiency and shorter duration would be of massive help in increasing cropping intensity. Pigeon pea, one of the most important pulses in south Asia has shown tremendous potential for diversification of rice crop in the IGPs. Introduction of extra short duration pigeon pea (ICPL-88039) and FIRBS planting technique in this region would enable small and marginal farmers to utilize limited land and water resources in more efficient manner [22]. There are two approaches of crop diversification. These are:

Horizontal Diversification: It takes place through substitution or intensification (addition) of the cropping system for improving the system productivity.

Vertical Diversification: In this approach, the economic produce of various crops is refined and graded to add additional values to the final product

9. Site-specific Nutrient Management: Nutrient management and recommendation process synchronized with crop demand or plant need-based application is crucial for minimizing losses from the soil-plant system and achieving high yield and nutrient-use efficiency. Site-specific nutrient management (SSNM) is an approach for providing need based feeding of crops with nutrients while recognizing the inherent spatial variability. The SSNM emphasizes on principles of ‘5Rs’, i.e. the right source, the right rate, the right time, the right place and the right method. It takes into account all pathways of plant nutrient flows, and judiciously makes use of all combinations of fertilizers, bio-fertilizers, organic manures, crop residues and nutrient efficient genotypes for sustaining agricultural production. It avoids indiscriminate use of fertilizers and aims at nutrient supply at optimum rates and times to attain improved productivity, profitability and nutrient-use efficiency by the crop [22]. The SSNM approach comprises three steps, viz. (i) establishing attainable yield targets (ii) effectively use existing nutrient sources and (iii) application of fertilizers to fill the deficit between demand and supply of nutrients.

10. Chlorophyll Meter: The chlorophyll meter, also known as SPAD (Soil plant analysis development) meter, is a simple, non-destructive and portable diagnostic tool for instant estimation of leaf nitrogen (N) status. Nitrogen content is related to chlorophyll content, which is displayed in arbitrary values (0-99.9) in SPAD meter. It has been used successfully for synchronizing N application with N needs of crops (plant need-based N management) and improving N-use efficiency. Wheat crop showed response to N application at maximum tillering stage at SPAD value of below 44. Application of 30 kg N/ha at critical SPAD value of 42 at maximum tillering stage increased the wheat grain yield by up to 20%. It has been found that plant need-based N management through chlorophyll meter reduces N requirement of rice without any decrease in yield [23].

11. Leaf Colour Chart: The cost of the chlorophyll meter restricts its widespread use by farmers. Leaf colour chart (LCC) is a simple hand-held and inexpensive tool for quick estimation of plant N status without causing damage. Use of LCC promotes timely, efficient and plant need-based N management, especially in rice and wheat [10]. Leaf colour chart is a high quality plastic strip with different shades of green colour ranging from light yellowish green to dark green. Japanese scientists first developed this N management tool [24]. A LCC uses the green color intensity of rice leaves to assess the N status, since leaf color intensity is directly related to leaf chlorophyll content and leaf N status [25]. It is a promising eco-friendly tool and now is being standardized with chlorophyll meter.

The LCC has been standardized and refined over the years. The new LCC has 4 colour strips by removing panels 1 and 6 (pale yellow and dark green) of the 'IRRI-PhilRice' version of LCC (as these colours were rarely seen under field conditions). It has reduced cost but the effectiveness remains the same. It is light-weight, smaller (can easily fit in pocket) and has a provision for a neck sling.

Leaf colour chart can help farmers avoid over application of N to rice. Nitrogen applied as per LCC values can save 20-30 kg of fertilizer N/ha without compromising with rice yield. For achieving best results of LCC-based N management, N should be applied (20-30 kg/ha) at LCC<3 in basmati and direct-seeded rice and at LCC<4 in coarse and hybrid rice [10]. Moreover, in LCC-based N management, basal application of N can be skipped without any reduction in terms of grain yield and fertilizer N-use efficiency.

Some precautions must be taken into account for LCC-based N management. These are: (i) the topmost, fully expanded and healthy leaf should be taken to compare with the LCC, (ii) middle part of the leaf must be placed on LCC colour strips for comparison, (iii) comparison must be done during the morning hours and (iv) LCC must not be exposed to direct sunlight during the comparison.

Conclusion: The demand of increasing population, there is need to produce more food grains but not at the cost of our future generations. For achieving the production targets without damaging the environment, focus should be on minimizing input cost and increasing input use efficiency. Emphasis should be given on using the natural resources judiciously. For this, the resource conservation technologies can be of great help. Since the adoption of resource conservation technologies is not up to the desired extent, therefore, there is need to popularize them through different educational interventions among the farming community of the state. A sustainable farming system refers to the capacity of agriculture over time to contribute to overall welfare by providing sufficient food and other goods and services in ways that are economically efficient and profitable, socially responsible, while also improving environmental quality. It is a concept that can have different implications in terms of appropriate technologies whether it is viewed at the farm level, at the agri-food sector level, or in the context of the overall domestic or global economy.

References

1. Sayre, K. (2000). Effects of tillage, crop residue retention and nitrogen management on the performance of bed-planted and furrow irrigated spring wheat in northwest Mexico. Paper presented at the Conference of the International Soil Tillage Research Organization, 15; Fort Worth, Texas, USA; 2-7 Jul, 2000.
2. Vlek, P. L. G. (2008). The incipient threat of land degradation. *J of Ind. Soc of soil Science*. 56 (1): 83-87.
3. Kendall, H. W. and Pimental, D. (1994). Constraints on the expansion of the global food supply. *Ambio*, 23: 198-205.
4. Reicosky, D. C. and Saxton, K. E. (2007). Reduced environmrntal emissions and carbon sequestration. pp. 52-58.
5. Reicosky, D.C. (2001). Conservation agriculture: global environmental benefits of soil carbon management. *In* L. Garcia Torres, J. Benites & A. Martinez-Vilela, eds. *Conservation agriculture, a worldwide challenge*, Vol. I, p. 3–12. Rome, FAO and Brussles, ECAF.
6. PDCSR. (2005). Project Directorate for Cropping Systems Research, Annual Report 2004-05, Modipuram-Meerut, India, p.143.
7. Malik, Y.S., Y. Chander, S.C. Gupta and S.M. Goyal, (2005). A retrospective study on antimicrobial resistance in mannheimia

(pasteurella) haemolytica, escherichia coli, salmonella species, and bordetella avium from chickens in minnesot. *J. Appl. Poult. Res.*, 14: 506-511.

8. Das, T.K., Sepat, S., Singh, P., Bhattacharyya, R. and Pathak, H. (2014). Conservation agriculture for enhancing crop productivity and resource-use efficiency. *Indian Farming,* 64(1): 18-21.
9. Hobbs, P.R. and Gupta, R. (2002). Resource conserving technologies for wheat in the rice-wheat system. In: *Improving the Productivity and sustainability of rice-wheat systems: Issues and impacts* (Ladha, X. Ed.). ASA Special Publication. ASA, Madison, WI, USA.
10. Pathak, H., Sharma, A.R., Das, T.K. and Jat, M.L. (2012). Adaptation and mitigation of climate change with conservation agriculture. In: *Climate Change Impact, Adaptation and Mitigation in Agriculture: Methodology for Assessment and Application* (Pathak, H., Aggarwal, P.K. and Singh, S.D. Eds.). pp. 222-240. IARI, New Delhi.
11. Jat, M.L., Gathala, M.K., Ladha, J.K., Saharawat, Y.S., Jat, A.S., Kumar, V., Sharma, S.K., Kumar, V. and Gupta, R. (2009). Evaluation of precision land leveling and double zero-till systems in the rice–wheat rotation: Water use, productivity, profitability and soil physical properties. *Soil & Tillage Research,* 105: 112-121.
12. Gill, M.A., Chaudhary, M.A., Ahmed, M. and Mujeeb-ur-Rehman, A. (2002). Water management, cultural practices and mechanization. In: *National Workshop on Rice-wheat Cropping System Management* (Akhtar, M.S. and Nabi, G. Eds.). Pakistan Agricultural Research Council, Islamabad, Pakistan, 11-12 December, 10p.
13. Mahajan, G., Chauhan, B.S. and Gill, M.S. (2013). Dry-seeded rice culture in Punjab State of India: Lessons learned from farmers. *Field Crops Research,* 144: 89-99.
14. Rao, A.N., Johnson, D.E., Sivaprasad, B., Ladha, J.K. and Mortimer, A.M. (2007). Weed management in direct seeded rice. *Advances in Agronomy,* 93: 153-255.
15. Kumar, V. and Ladha, J.K. (2011). Direct Seeding of Rice: Recent Developments and Future Research Needs. *Advances in Agronomy,* 111: 297-413.
16. Uphoff, N. (1999). Agroecological implications of the System of Rice Intensification. *Environment, Development and Sustainability*, 1: 297-313.
17. Ghosh, R. K., Sentharagai, S. and Shamurailatpam, D. (2014). SRI – A methodology for substantially raising rice productivity by using farmers' improve thinking and practice with farmers' available resources. *Journal of Crop and Weed*, 10(2):4-9.
18. Das, T.K., Sharma, A.R., Rana, D.S. and Paul, T. (2016). Conservation agriculture. In: *Modern Concepts of Agronomy* (Rana, D.S., Ghosh, P.K., Shivay, Y.S. and Singh, G. Eds.). pp. 62-86. Indian Society of Agronomy, New Delhi.
19. Gupta, P.K., Shivraj, S., Nahar, S., Dixit, C.K., Singh, D.P., Sharma, C., Tiwari, M.K., Gupta, R.K. and Garg, S.C. (2004). Residue burning in rice-wheat cropping system: causes and implications. *Current Science,* 87(12): 1713-1717.
20. Gupta, R. and Seth, A. (2007). A review of resource conserving technologies for sustainable management of the rice-wheat cropping systems of the Indo-Gangetic plains (IGP). *Crop Protection,* 26: 436-447.
21. Reddy, B.N. and Suresh, G. (2009). Crop diversification with oilseed crops for-maximizing productivity, profitability and resource conservation. *Indian Journal of Agronomy,* 54(2): 206-214.
22. Ramesh, Negi, S.C. and Rana, S.S. (2016). Resource conservation technologies (RCTs) – needs and future prospects: a review. *Agricultural Reviews,* 37(4): 257-267.
23. Singh, B., Singh, Y., Ladha, J.K., Bronson, K.F., Balasubramanian, V., Singh, J. and Khind, C.S. (2002). Chlorophyll meter–and leaf color chart–based nitrogen management for rice and wheat in Northwestern India. *Agronomy Journal,* 94(4): 821-829.
24. Furuya, S. (1987). Growth diagnosis of rice plants by means of leaf color. *Japan Agricultural Research Quarterly,* 20: 147-153.
25. IRRI-CREMNET. (1998). IRRI-Crop and Resource Management Network. Progress report for 1997. IRRI, Manila, Philippines.