

Conservation agriculture

Future for rice-wheat cropping systems in Indo Gangetic plants

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Indo-Gangetic plain is one of the most fertile regions of India. These had been the focal point of the Green revolution and thus were able to satisfy the rising food demand of increasing population. However, post Green revolution has witnessed a negative impact of the intense Rice-wheat cropping system and simultaneous use of high doses of fertilizer and pesticides. Now the time is to rejuvenate the soils of these plains to have sustainability in production for generations to come. Conservation agriculture with its three pillars i.e. conservation tillage, soil cover and crop diversification has the potential to reverse the ill caused to these fertile soils.

Keywords: Conservation agriculture, Green revolution, Indo-Gangetic plains, Rice-wheat cropping system

A PART from the economic aspect of agriculture, sustainability of agriculture production system and its ability to sustain the food security of the nation have vital roles to play. According to FICCI-2015, there is a requirement of 333 mT of food grains by 2050, however, there is a continuous shrinking of per capita agricultural land. Therefore, productivity enhancement requires intensification of agriculture both in time and space dimensions with due attention to environmental sustainability of the agricultural systems. Post Green revolution era has seen increase in production through expansion in area and yield enhancement and thus, the increase in food grain production has kept pace with the rising population. However, agricultural land is shrinking due to rising urbanization and yields are showing stagnation and decline to some extent. The continuing conventional measures has seen fatigue in terms of degradation of land quality, shrinking fertility, rising salinity, reducing groundwater levels, emergence of resistance in existing pest and rising complexity of the new one.

Therefore, it is imperative and indispensable to modify the age old “resource abundance” approach towards the “resource constrained” approach. In this scenario, the importance of conservation agriculture cannot be set aside.

Concept of Conservation agriculture

According to FAO (2016), conservation agriculture is a farming system that maintains a permanent soil cover to assure its protection, avoids soil tillage and cultivates a diverse range of plant species to improve soil conditions, reduce land degradations and increase water and nutrient use efficiency. It seeks to

bring harmony between available soil, water and biological resources with external inputs to have efficient use of natural resources, and improve and conserve thereupon. The three basic principles of conservation agriculture are: minimum disturbance of soil, maintaining the soil cover and crop rotation (Fig. 1). In comparison to conventional agriculture, it is beneficial in terms of reduced erosion, better soil structure, and enhanced organic matter content in the soil, better infiltration capacity and carbon sequestration (Table 1).

Indo-Gangetic Plains

Indo-Gangetic plains is one of the

Table 1. A brief comparison of conservation and conventional agriculture has presented as below

Conventional Agriculture	Conservation Agriculture
Excessive tillage and soil erosion	No till/ drastically reduced tillage
Residue burning or incorporation	Surface retention of residues
Use of ex-situ FYM/ compost	Use of in situ organic/ compost
Green manuring (incorporated)	Green manuring (surface drying)
Freewheeling of farm machinery	Controlled traffic
Crop based management	Cropping system-based management
Single or sole crops	Inter cropping/ relay cropping
Uneven field levels	Precision laser land leveling

Source: Gupta and Sayre, 2007

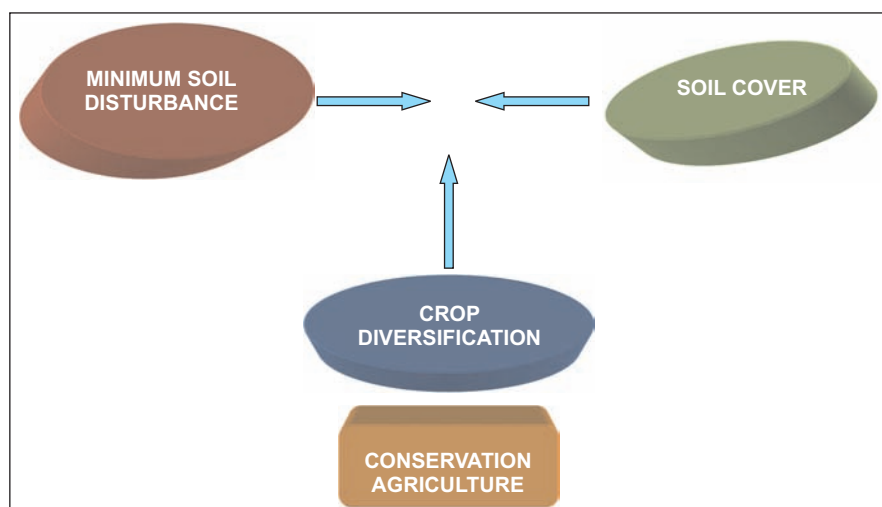


Fig 1. Three basic principles of conservation agriculture

most extensive and fertile plains of the World. Fertility of the soil had been responsible for the growth of ancient civilization and flourishing kingdoms in this region. It occupies nearly 43.7 mha and represents eight agro-ecological regions and 14 agroecological sub-regions. The area of Indo Gangetic plains is nearly 13% of the total geographical area and 50% of the total food grain production to feed 40% of the total population of the country. The plains in general and the western plains in particular, had been the centre of the Green revolution. The extension of high yielding varieties to the region had been followed by the incessant use of fertilizers, irrigation water and pesticides. This led to the deterioration of the soil quality in terms of its structure, water conductivity, organic matter content decreasing soil micro flora and fauna, increase vulnerability to erosion and salinity. The problem has now been aggravated by the large-scale deforestation due to rampant urbanization, industrialization and agriculture. Around 30% of the total geographical area is being impacted by desertification. Hence, there is an urgent need for shifting agricultural practices from conventional to conservation agriculture mode.

Rice-wheat cropping sequence (RWCS) is the most important cropping system of Indo-Gangetic plains. Rice-wheat cropping system occupies 13.5 mha of cultivable land in South Asia of which 10 million ha

are in India, 2.2 million ha in Pakistan, 0.8 million ha in Bangladesh and 0.5 million ha in Nepal, constituting 1/4 to 1/3 of total rice-wheat production of these countries. This system has been the backbone of the green revolution which, however, overtime has raised eyebrow over the sustainability of this cropping system. It is a soil exhaustive cropping system and both crops require extensive soil disturbance. The puddling for transplanted rice leads to the structural breakdown and after harvesting of the crop there is a need for carrying out extensive tillage operations to bring the soil to suitable tilth for wheat. The study analyses various conservation practices which can be followed in this dominant cropping pattern of Indo Gangetic plains.

Conservation tillage

Conservation tillage refers to the tillage practices that aim at maintaining 30% of the soil surface covered with crop residues. Under minimum tillage, the land is disturbed to the least to have satisfactory germination and root growth whereas, zero-tillage is the extreme form of minimum tillage in which the primary tillage is completely avoided and secondary tillage is restricted to the crop rows for sowing of seeds. Zero-tillage is practiced with the help of zero-till fertilizer-cum-seed drill where the seeds are sown in between the rice

stubbles. Conservation tillage reduces the tillage intensity. The tractor-drawn zero-tillage drills allow tillage intensity to be drastically reduced for the wheat crop from eight tractor passes to a single tractor pass. Sowing of the wheat after rice is advanced by 7-10 days under zero-tillage. Thus, it is highly beneficial in the basmati rice belts, where sowing of wheat is delayed. It also allows the inclusion of short duration summer mung bean in the rice-wheat cropping system. In addition, if the sowing of wheat is delayed e.g. in sugarcane belts, the wheat crop suffers due to terminal heat stress. With zero-tillage practices, duration of heat stress can be reduced. Conservation tillage helps save the fuel cost, tractor and precious groundwater required for the land preparation.

Bed Planting

Under the bed planting practice, there is laying of the field in beds size of 0.6-1.0 meters and furrow is left in between the beds (Fig. 2). These beds can adjust 2-3 rows of the crops.

The aim of the raised bed planting is to have minimum soil disturbance. The major advantage of bed planting is saving irrigation water *i.e.* around 30-35% has been reported. It offers good scope for intercropping. The crop raised on bed planting is lesser prone to water logging and thus, reduces the susceptibility of crop to lodging. It will be highly suitable for Eastern parts of Gangetic plains where the lowland topography exists and crop is susceptible to waterlogging. Wheat cultivation on FIRBS results in saving 25-40% of seeds, 25-40%



Fig 2. Furrow Irrigated Raised Bed System in wheat

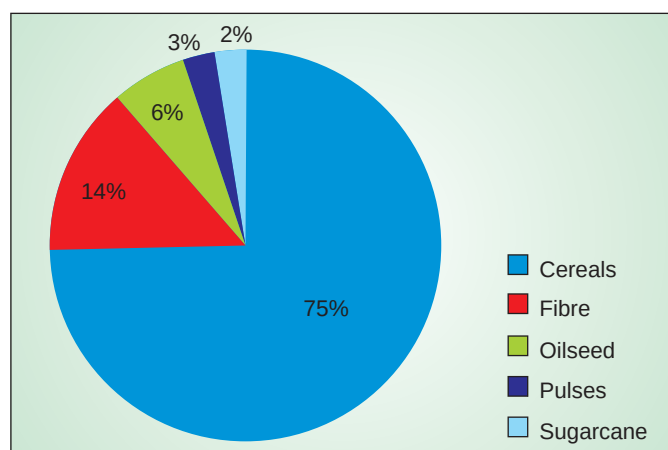


Fig 3. Crop wise residue generation data
Source: DoA&C, MoA, GoI, 2014

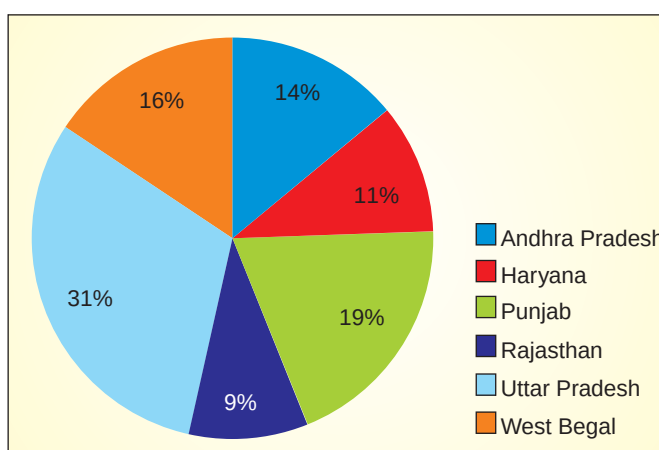


Fig 4. Cereal straw generation state wise for states having > 20 mT generation.
Source: Jain *et al.*, 2014

water and 25% nutrient, without affecting the grain yields.

Alternate rice systems

Rice is traditionally grown under puddled conditions, where the nursery is raised separately and the main field is puddled and subsequently the seedling is transplanted with an average age of 20-25 days. This method is resource intensive where 200 mm water is required for the puddling operations and 40-50 mm of water for seedling raising. For the rest of the period, rice crop is under submerged condition requiring 800-1000 mm of water. Thus, this system is water intensive practice. In addition, it brings about a structural break down of soils.

There are alternate methods of rice establishment mainly direct seeded rice, aerobic rice and system of rice intensification. Under direct seeded rice, the sowing is done 10-15 days before the historical trend of onset of monsoon. The sowing is done either through broadcasting or drum seeder. The aerobic rice is similar to direct seeded rice. One of the proven technologies is system of rice intensification, in which there is no need to keep the crops submergence throughout the growing period. The crop is kept submerged only at critical stages and; the soil is dried up to hair line cracks during the rest of the period. This alternative method will lead to reduced water use, reduced degradation of soil and will provide the opportunity to adjust any

short duration legume e.g. summer mungbean in the rotation.

The practice of brown manuring can also be followed in the rice crop. Both rice and *Sesbania* are sown together and allowed to grow for 25-30 days. Afterwards, the *Sesbania* plants are knocked down with 2,4-D spray and incorporated in the soil. It acts as mulch in between the crop and supplies nitrogen to the standing rice crop.

Crop residue management

Crop residue management is a major issue in Indo-Gangetic plains. According to the Ministry of New and Renewable Energy, around 500 mT of Crop residues is generated annually in India.

On perusal of crop wise-data, it can be inferred that cereal constitutes 3/4th of the total residue (Fig 3) and share of rice in total cereal straw is 34%. The 70% share in cereal straw generation is of the four Northern states i.e. Uttar Pradesh, Punjab, Haryana and Rajasthan (Fig 4).

The combine harvester leaves the straw in the field and the farmer has two options either incorporation in soil or in-situ burning in the field. The studies by Punjab government concluded that 81% of rice straw and 48% of wheat straw is burnt in the field and only around 1% is incorporated in the field. The economic cost in terms of loss of nutrient from the paddy straw (if not incorporated in soil) can be inferred from the below mentioned Table 2.

The residue burning instead of soil

incorporation, raises the soil temperature which can cause the loss of organic matter and consequently of Nitrogen, phosphorus, sulphur and other micronutrients. This aggravates the low organic matter status of the soils due to the subtropical climatic conditions of these plains. Environmental impact is in the form of a rise in particulate matter, oxides of nitrogen and sulphur, aerosols. These along with the high-pressure conditions of the atmosphere in the plain region after the rice harvesting season, leads to haze and smog.

It cannot be denied that high C:N ratio of the rice and wheat residue prevents its rapid decomposition. However, it is inferred from various studies that incorporation of residues 2-3 weeks before sowing and incorporation of farm yard manure or nitrogen can increase their degradation rate in soil. The residues if applied to crop fields, will also act as mulch that moderates the soil temperature and soil and water conservation. However, the residues

Table 2. Loss of nutrient from the paddy straw

Parameter	Nutrient content in rice stubble (kg/ha)	Economic cost of nutrient (₹/ha)
Nitrogen	39	424
Phosphorus	6	96
Potassium	140	NA
Sulphur	11	231
Total		751

Source: Kumar *et al.*, 2014

pose a serious problem in the sowing operations.

The turbo/ happy seeder has made the sowing operation easier under such conditions. Moreover, the incorporation of residues will reduce carbon emission and help in the carbon sequestration. The practice can also be followed in rice cultivation. However, the rice crop should be either direct sown or aerobic rice.

Crop diversification

Crop diversification aims at bringing in a variety of crops under cultivation at farm level both in temporal and spatial dimension. Crop diversification holds the potential for conservation agriculture as if a legume crop is introduced; for maintaining soil structure, enhancement of soil organic carbon, increase in nitrogen content, positive influence on soil biota and recycling of nutrient from the lower strata of soil to the upper one. Rice-wheat is the major cropping system in Indo-Gangetic plains. There is sufficient time lag between the harvesting of wheat and sowing of rice in these plains and thus, summer mungbean can be introduced which will not only benefit the soil but also enhance the income of the farmer.

Moreover, there is a need to bring in crops e.g. rice-potato-mung bean or rice-chickpea which can act as a break for various crop associated weeds e.g. *Phalaris minor* in wheat and pest population. In areas, where there is considerable loss of groundwater, rice crop in rotation can be replaced with upland maize. While considering the crop diversification, inclusion of forage crops e.g. berseem can be done. This will be beneficial especially for the marginal land holders to enhance their income.

Challenges and prospects for adoption of conservation agriculture under rice-wheat cropping system in Indo-Gangetic plains conditions

The study discussed various aspects on conservation agriculture. If these are not implemented in the farmers' field, this indispensable practice will merely reduce to



Fig. 5. Inter cropping Sugarcane + Mungbean, Sugarcane + Cucurbits

academic discussion. The extension of this technology to the farmers' field has several constraints which also needs to discuss. Conservation agriculture is site specific practice. There cannot be any blanket approach e.g. maintaining the rice residues in preceding wheat crop is highly beneficial in terms of soil and water conservation, however, it will also lead to the buildup of the population of yellow stem borer in the field, depending on endemic nature of pest in certain area. Similarly, crop rotations depend on the soil and climate of the area. The equipment availability is another serious constraint as the turbo happy seeder, though, suitable for the sowing of crop in between the stubbles, is restricted to the farmers who have resources to purchase it. The custom hiring centres at village levels can address this issue. This technology has proved efficient in the research findings, however, its viability at field level need to be tested on extensive scale. More focus should be laid on the research managed trials involving the teams comprising the agronomists, extension workers, State agriculture and development officers. In other words, the approach needs to be institutionalized at the district or state level. The Minimum Support Prices policy of India needs to be designed so that farmer can be lured for the diversification of the crops. As the practitioner of conservation agriculture contribute towards a reduction in carbon emissions, the monetary recognition of his/ her efforts needs to be done. This will inspire other farmers to adopt the technology.

Conservation agriculture holds a lot of prospects. It is a technology which can reduce the production cost through saving in fuel, labour and other input costs. It will help in reducing the incidence of weeds, saving of irrigation water as the crop residues act as mulch. In the long run, the soil organic carbon content will enhance which will definitely improve the fertility and productivity of soil. Crop diversification will also help in addressing the nutritional security in the country.

Conclusion

Green revolution in the past has proved that innovation and technology can address the food security of the country. With the availability of responsive varieties, there has been high use of inputs. Conservation agriculture is not only sustainable but can also prove profitable in the long run for farmers. However, this approach should be seen in integration with other approaches such as integrated nutrient management and integrated pest management. At the field level, there is a need to adopt the farming system approach i.e. down to top approach where the model of conservation agriculture being developed should have the resource availability of the majority farmers belonging to marginal category in view. An integrated approach can go a long way in addressing the resource constraints of nation.

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