

Sustaining Indian agriculture – conservation agriculture the way forward

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Indian agriculture has been successful in increasing foodgrains production in the past, guided by the goals of 'self-sufficiency' in the country. The mission of increasing foodgrains production somehow stands achieved, however, accompanied by series of problems related to the environment and natural resources. We have reached a situation where we must look for new directions, learning from our past. Conservation agriculture can be seen as a new way forward for conserving resources and enhancing productivity to achieve the goals of sustainable agriculture, which demands a strong knowledge base and a combination of institutional and technological innovations.

Keywords: Conservation agriculture, foodgrains production, Indian agriculture, institutional changes, resource conservation.

INDIAN agriculture is now at crossroads. We have come a long way. Over the past four decades our strategies, policies and actions were guided by goals of 'self-sufficiency' in foodgrains production. Indian agriculture has been successful in achieving increased foodgrains production albeit at a low level of satisfaction. While the mission of increasing foodgrains production stands somehow achieved, these gains were accompanied by widespread problems of resource degradation, which now pose a serious challenge to the continued ability to meet the demand of an increasing population and lifting our people above the poverty line¹. Indian agriculture has reached a point where it must seek new directions – those by way of strategies, policies and actions which must be adopted to move forward. New directions are needed because past strategies are no longer taking agriculture forward. Moving forward in the present context also does not imply the same as was imagined in the 1960s. The nature and dimensions of the problems being faced today are much different and complex than those faced in the 1960s and 1970s.

There appear no two opinions with respect to the need for further increasing foodgrains production for the growing population, and the need for healthy and nutritious food continues. The past strategies to increase foodgrains production, however, have resulted in massive exploitation of natural resources, contributing to unsustainable growth; there is need to change this in the future. This will call for strategies, which are different than the ones we adopted in the 'green revolution' era. Our only focus of increasing production (and for right reasons) in the shortest possible time led us to focus all efforts to more favourable areas – those where irrigation facilities were either available or

could be created easily. This led to the neglect of vast areas of rainfed agriculture, where productivity continues to remain low². These are the areas where vast majority of the poor live in the country. Any efforts to reduce poverty must aim at improving the agriculture in these regions, and the past strategies have proved largely ineffective – mainly due to extensive problems of resource degradation – soil erosion and run-off and our inability to come up with strategies, which matched the socio-economic conditions along with strong technological and policy support. Also, in the well-endowed irrigated regions where high levels of productivity have been achieved, maintaining farm-level profitability is an increasing concern today. The government is being forced to continue and further distort policies to protect farmers profitability, notwithstanding widespread and intensive resource degradation problems, for example, declining water tables in the high productivity northwest irrigated region will seriously constrain productivity and ecology of the region³. High levels of fertilizer use and decreasing resource use-efficiency are increasingly contributing to groundwater pollution and increased emissions of green-house gases (GHGs)⁴. High levels of pesticides used in many areas have become a major health hazard. Thus, with continuously deteriorating resources, widespread problem of soil and water contamination and eroding ecological foundation, sustainability of agriculture is becoming highly questionable⁵. There is need to seriously debate on the strategies required to ensure that agriculture continues to play a critical role in the overall development.

Agriculture must play a critical role

For a vast majority of our people agriculture is a way of life. Enhancing agricultural productivity while maintaining and improving the environment and living conditions of

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our villages is the key to sustainable development. Accelerated agricultural growth based on increasing land and labour productivity is fundamental to poverty reduction. Past experience has shown that speed of poverty reduction has closely followed increases in agriculture productivity. The direct effects of increased productivity include availability of cheaper food, increased farmer income and additional employment opportunities. Increasing productivity plays a catalytic role in stimulating growth outside the agriculture sector, where the economic growth is faster. The process, however, invariably has to begin with increasing productivity on small-scale labour-intensive farms. Although the relative contribution of agriculture to overall growth vis-à-vis other sectors will decline over a period of time, the beginning has to be made with agriculture. No other sector of economy can match growth in agriculture for its impact on broad-based poverty reduction. Creating employment opportunities is vital to reducing poverty and creating growth outside agriculture.

Another green revolution prospect unlikely

Future sources of growth for increasing agricultural productivity are going to be different and diverse from those in the past. The declining productivity growth rates reflect reduced responsiveness of the agricultural inputs and exploitation of natural resources like soil and water⁶. Further increase in the use of agricultural inputs has not led to similar increase in the productivity of the crops, indicating that these sources of growth have reached a saturation point and there is a need to look for other sources of growth to increase agricultural productivity. It is not uncommon to hear that India needs another green revolution or an evergreen revolution through various routes like organic farming, GM crops, biotechnology, etc. Targets for achieving a particular growth rate are also fixed only to remain unachieved, year after year. According to the National Agricultural Policy⁷, India must achieve a growth rate in of 3–4% per annum in the agricultural sector, and foodgrains production of 400 million tonnes by 2020. The question that is rarely asked is: how will these growth rates and targets be achieved? The past strategies which ushered the green revolution of the 70s and 80s are no longer working. Thus, there is a need to identify and focus on new strategies to achieve these goals. In areas that witnessed green revolution, the productivity levels are high, but over the past decade yields have been stagnating and in some cases even declining. Past sources of growth productivity (expansion in irrigation, increased use of fertilizers and chemicals for pest control) are no longer relevant. Policy regimes which helped achieve increased productivity are now not only irrelevant but are also contributing negatively to resource quality. Any efforts to enhance and even maintain productivity of these regions is totally linked to concerns of resource conservation. Evidence from several

long-term experimental station studies reveals that the quality of soil is on the decline⁸. This is owing to declining soil organic matter content due to intensive cultivation, which in turn adversely affects and limits the capacity of the soil to perform vital functions, including maintenance of good physical properties, ability to retain and regulate supply of water and nutrients, etc. Current nutrient management practices result in inefficient use of nutrients applied through chemical fertilizers, resulting in increasing environmental problems, decline in the quality of groundwater, increasing emission of GHGs, etc. Current cropping patterns (rice–wheat) are also causing exploitation of groundwater resources, reinforcing that current agricultural practices and policies are contributing to fast degradation of resource base and unsustainability of production systems⁹. The key question, therefore, is how to reverse processes of resource degradation and make agriculture more sustainable. Achieving goals of sustainable agriculture in these regions will not come about by adopting the same policies, strategies and agricultural practices which have led to unsustainable resource use. The challenge is to define a new mission and ways of going about it.

Rainfed agriculture: untapped potential

An important avenue for achieving increased production goals is to enhance the productivity of vast areas under rainfed agriculture, which constitute nearly 60% of the net cultivated area of the country¹⁰. These are areas where the green revolution technologies made limited or no impact. These are also areas where vast majority of the poor live and whose livelihoods are intimately linked to our ability to impact agriculture in these areas. Rainfed agriculture is practised under a wide range of soil and climatic conditions. Rainfall regimes and soil characteristics are the key determinants of rainfed cropping potential. The unirrigated areas differ widely with respect to both. The amount and distribution of seasonal rainfall differ widely among regions as well as from year to year. Three major soil groups are found extensively in the rainfed regions: red, black and submontane soil. Rainfall in red-soil areas ranges from 750 to 2000 mm per annum. Soil depth varies but most soils are shallow and have low water-retention capacity. In the absence of cost-effective moisture retention and conservation technologies, the soil suffers from rapid water run-off and erosion reducing the productive capacity. Red soils have considerable agronomic potential but to achieve this potential there is need to popularize effective soil moisture conservation practices.

Precipitation¹¹ in black soil areas ranges from 500 to 1500 mm. Compared to the red soils, the black soils are deeper and heavier and hold more water. However, they are highly erodible and run-off can be as high as 40% or more depending on rainfall volume and intensity and on the slope. Surface drainage is essential in medium and high

rainfall regions. Given appropriate technologies to cope up with constraints associated with these soils' considerable management difficulties there is ample scope to enhance productivity. When wet, black soil swells and becomes sticky, but shrinks rapidly when dry, leaving large clods and deep fissures and posing considerable difficulties in field preparation and timely planting operations¹². There is a large gap between actual and potential crop yields in these regions and there are significant opportunities for increasing production. Submontane soils prevalent in the hill and foothill regions have good potential for agriculture. With rainfall varying from 750 to 2000 mm, effective water management is essential to control run-off and erosion to protect against dry season moisture stress limiting productivity.

There is considerable potential to enhance productivity of rainfed areas. Realizing this potential essentially hinges on our ability to reverse the process of degradation – processes that will contribute to institutionalize water conservation, reduced run-off and erosion. Thus, resource conservation issues represent an essential prerequisite to achieve enhanced productivity. Given the wide variations in soil, climate and socio-economic situations, it is obvious that these technologies have to evolve and spread considering local situations and in a participatory manner. In the past there has been little R&D effort, which recognizes that resource conservation is a precondition to sustained productivity increase. Over the past two decades, the Government of India has devoted considerable attention and resources in programmes of watershed development in rainfed areas¹³. These included several externally aided projects. The main focus in these programmes was to generate water resource by run-off collection and reuse of water by concentrating on various engineering structures^{14,15}. While these efforts have benefitted in some ways, a more fundamental way to sustained productivity is to reduce run-off and soil erosion by technologies which improve *in situ* conservation of rainwater by improving the capacity of the soil to absorb and retain water and reduce erosion, i.e. to bring about a reversal in the processes that are leading to degradation¹⁶.

While the major R&D efforts in the 'green revolution' era focussed on enhancing productivity of selected foodgrains and some other crops, the new challenges demand that efficient resource use and conservation receive high priority to ensure that earlier gains can be sustained and further enhanced to meet emerging needs. Issues of resource conservation have assumed importance in view of widespread resource degradation problems, need to reduce production costs, increase profitability and make agriculture more competitive and sustainable. Globally, growing concerns for sustainable agriculture have been seen as a positive response to limits of both low-input traditional agriculture and intensive modern agriculture relying on high levels of inputs for crop production. Sustainable agriculture relies on practices that encourage natural regenerative

processes (e.g. nutrient cycling, soil regeneration, and protection of natural enemies of pest and diseases) and maintain ecological equilibrium, preserve biodiversity and safeguard the environment.

Conservation Agriculture (CA) has emerged as a new way forward to achieve the goals of sustainable agriculture in response to these resource conservation challenges. The new strategies would call for new and innovative ways of generating and promoting technologies that focus on resource conservation as a way to enhance productivity in a sustainable manner.

Conservation agriculture – The way forward

Conservation agriculture has emerged as a new paradigm to achieve goals of sustainable agricultural production¹⁷. It is a major step towards transition to sustainable agriculture. The term CA refers to the system of raising crops without tilling the soil while retaining crop residues on the soil surface. The key elements which characterize CA include:

- minimum soil disturbance by adopting no-tillage and minimum traffic for agricultural operations,
- leave and manage the crop residues on the soil surface, and
- adopt spatial and temporal crop sequencing/crop rotations to derive maximum benefits from inputs and minimize adverse environmental impacts.

Combining the above elements with improved land-shaping (e.g. through laser aided levelling, planting crops on beds, etc.) further enhances the opportunities for improved resource management. In conventional systems, while soil tillage is a necessary requirement to produce a crop, tillage does not form a part of this strategy in CA. Intensive tillage in conventional systems causes gradual decline in soil organic matter content through accelerated oxidation, resulting in reduced capacity of the soil to regulate water and nutrient supplies to plants. Burning of crop residues, a common practice in many areas (e.g. rice–wheat cropping system) further causes pollution, GHG emission and loss of valuable plant nutrients. When crop residues are retained on the soil surface in combination with no tillage, it initiates processes that lead to improved soil quality and overall resource enhancement.

Benefits of CA are several fold. Direct benefits to farmers include reduced cost of cultivation through savings in labour, time and farm power, and improved use efficiency resulting in reduced use of inputs. More importantly, CA practices reduce resource degradation. Gradual decomposition of surface residues improves soil organic matter status, biological activity and diversity and contributes to overall improvement in soil quality. CA is a way to reverse the processes of degradation inherent in conventional agricultural practices involving intensive cultivation, burning and/or

removal of crop residues, etc. CA leads to sustainable improvements in efficient use of water and nutrients by improving nutrient balance and availability, infiltration and retention by the soil, reducing water loss due to evaporation and improving the quality and availability of ground and surface water.

Conservation agriculture success world over

Conservation agriculture has emerged as an effective strategy to achieve goals of sustainable agriculture worldwide. It has the potential to address increasing concerns of serious and widespread problems of natural resource degradation and environmental pollution, while enhancing system productivity. According to current estimates, CA systems are being adopted in some 80 million ha, largely in rain-fed areas and the area is expanding rapidly¹⁸. USA has pioneered research and development efforts and currently CA is being practised in more than 18 million ha of land. Other countries where CA practices are being widely adopted include Australia, Argentina, Brazil and Canada. In many countries of Latin America, CA systems are finding rapid acceptance by farmers. Many countries have now policy decision to promote CA. In Europe, France and Spain, CA was being adopted in about 1 m ha area under annual crops. In Europe, the European Conservation Agriculture Federation, a regional lobby group uniting national associations in UK, France, Germany, Italy, Portugal and Spain, has been founded. CA is also being adopted to varying extents in countries of Southeast Asia, viz. Japan, Malaysia, Indonesia, the Philippines, Thailand, etc. A unique feature which has triggered widespread adoption of CA systems in many countries is the community-led initiative strongly supported by R&D organizations rather than as a result of the usual research-extension system efforts¹⁹.

Conservation agriculture in India

In India, efforts to adopt and promote resource conservation technologies have been underway for nearly a decade, but it is only in the past 4–5 years that technologies are finding acceptance by the farmers. This effort has been spearheaded by Rice–Wheat Consortium for Indo-Gangetic Plains, a CGIAR ecoregional initiative involving several CG centres and the National Agricultural Research Systems of India, Pakistan, Bangladesh and Nepal. Concerns about stagnating productivity, increasing production costs, declining resource quality, declining water tables and increasing environmental problems are the major forcing factors to look for alternative technologies, particularly in the north-west region encompassing Punjab, Haryana and western Uttar Pradesh (UP)²⁰. In the eastern region covering eastern UP, Bihar and West Bengal, developing and promoting strategies to overcome constraints for continued low cropping system productivity have been the chief concern.

The primary focus of developing and promoting CA practices has been the development and adoption of zero tillage cum fertilizer drill for sowing wheat crop in rice–wheat system. Other interventions being tested and promoted include raised-bed planting system, laser-aided land-levelling equipment, residue management alternatives, alternatives to rice–wheat cropping system in relation to CA technologies, etc. The area planted with wheat adopting zero-tillage drill has been rapidly increasing²¹. It is speculated that over the past few years, adoption of zero-tillage has expanded to cover about 1 m ha. The rapid adoption and spread of zero tillage is attributed to benefits resulting from reduction in cost production, reduced incidence of weeds and therefore savings on account of weedicide costs, savings in water and nutrients and environmental benefits. Adopting CA systems further offers opportunities for achieving greater crop diversification. Crop sequences/rotations and agroforestry systems, when adopted in appropriate spatial and temporal patterns, can further enhance natural ecological processes which contribute to system resilience and reduced vulnerability to yield, thus reducing disease and pest problems. Zero-tillage when combined with appropriate surface-managed crop residues sets in processes whereby slow decomposition of residues results in structural improvement of soil and increased recycling and availability of plant nutrients. Surface residues are also expected to improve soil moisture regime, improve biological activity and provide a more favourable environment for growth. These processes, however, are slow and results are expected only with time.

In India, CA is a new concept and its roots are only now beginning to find ground. Globally, CA is being considered a route to sustainable agriculture and offers opportunities for moving to the next phase in Indian agriculture.

Transition to CA will not be easy

Conservation agriculture offers an opportunity and a mission to move into the next phase in Indian agriculture in the specific context. It is a challenge for all stakeholders, the scientific community, farmers, extension agencies and industry to understand the opportunities, and calls for strategies different from those we have adopted over the past decades in conventional agriculture. The biggest challenge is to overcome the past mindset according to which agriculture is nearly synonymous with the practice of cultivating the soil. CA paradigm will call for an innovation systems perspective to deal with diverse, flexible and context-specific needs of technologies and their management for specific locations. An innovation systems perspective involves understanding of the organizations and individuals responsible for generation, diffusion, adaptation, use of knowledge of socio-economic significance and the institutional context that governs the way these interac-

tions and processes take place²². R&D for CA thus will need innovative features to address the challenges. Some of them include.

Technological challenges

The CA system constitutes a major departure from the past ways of doing things. This implies that the whole range of practices, including planting and harvesting, water and nutrient management, disease and pest control, etc. need to be evolved, evaluated and matched in the context of new systems. The key challenge relates to development, standardization and adoption of farm machinery for seeding with minimum soil disturbance; developing crop harvesting and management systems with residues maintained on soil surface and developing and continuously improving site-specific crops, soil and pest management strategies that will optimize benefits from the new systems.

Technology adoption

Strategies to promote CA will call for moving away from the conventional compartmentalized and hierarchical arrangements of research that generates and perfects technologies, extension that delivers it and farmers who passively adopt it. There will be need to bring all the involved stakeholders on a common platform to conceive end-to-end strategies. Institutionalizing the role of research, extension and farmers in such a way that the partnership among these stakeholders is strengthened right from the beginning, enabling a sense of ownership among them.

Long-term perspective

Conservation agriculture practices, e.g. no tillage and surface-managed crop residues set in processes which initiate changes in soil physical, chemical and biological properties, which in turn affect crop yields. Understanding the dynamics of these changes and interactions among physical, chemical and biological phases is basic to developing improved soil-water and nutrient management strategies. Similarly, understanding the dynamics of qualitative and quantitative changes in soil biodiversity, disease causing organisms, including weeds in relation to altered management practices is fundamental to evolving control measures with minimum use of environmentally harmful chemicals.

Site specificity

Adaptive strategies for CA will be highly site-specific, yet learning across the sites will be a powerful way in understanding why certain technologies or practices are effective in a set of situations and not effective in another

set. This learning process will accelerate building a knowledge base for sustainable resource management. Developing and promoting a networking to share information amongst farmers, scientists and other stakeholders would be critical in advancing the spread and continued upgradation of CA systems. Understanding the diversity and context-specific nature of processes would be important in learning and changing for the better.

CA implies a radical change from traditional agriculture. There is need for policy analysis to understand how conservation technologies integrate with other technologies, policy instruments and institutional arrangements that promote or deter CA²³. Accelerated development and adoption of CA technologies will call for greatly strengthened monitoring and evaluation along with policy research. Understanding constraints in adoption and putting in place appropriate incentives for adopting CA systems will be important.

Conclusion

Conservation agriculture offers a new paradigm for agricultural research and development different from the earlier one, which mainly aimed at achieving specific foodgrains production targets. A shift in paradigm has become a necessity in view of widespread problems of resource degradation, which accompanied the past strategies to enhance production with little concern for resource integrity. Integrating concerns of productivity, resource conservation and quality and environment is now fundamental to sustained productivity growth. Developing and promoting CA systems will be highly demanding in terms of knowledge base. This will call for greatly enhanced capacity of scientists to address problems from a systems perspective; be able to work in close partnerships with farmers and other stakeholders and strengthened knowledge and information-sharing mechanisms. Conservation agriculture offers an opportunity for arresting and reversing the downward spiral of resource degradation, decreasing cultivation costs and making agriculture more resource – use-efficient, competitive and sustainable. ‘Conserving resources – enhancing productivity’ has to be the new mission.

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