

# Adoption of modified agronomic approaches for sustaining crop productivity

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*Agronomy feeds the world as it is the applied science for management of natural resources to improve the production of crops for ensuring a sustained supply for the growing global population. Agronomists focus on efficient crop and soil management, nutrient, weed and water management as well as climate to develop suitable practices to boost yields and enhance food quality while protecting the natural resource base. An analysis shows that more than half of the total increase in foodgrain production in India during the Green revolution period (mid-1960s to mid-1970s) was attributed to efficient nutrient and water management. However, the productivity levels started stagnating or even declining during the 1990s owing to resource degradation and several other challenges including the climate change in the present times. There is now an urgent need to revise our strategies and adopt modified agronomic approaches for more efficient management of crop, soil, nutrient, weed, water and energy for sustaining crop productivity.*

**Keywords:** Conservation agriculture, Crop residues, Integrated management, Sustainability, Zero tillage

INDIA faced acute food shortages before and also after independence, leading to widespread hunger, malnutrition and dependence on imports. During the mid-1960s, there was a quantum jump in foodgrain production, often termed as the green revolution. This was possible due to the introduction of high-yielding varieties of major crops like rice and wheat, duly supported by increased use of chemical fertilizers and expansion of irrigation facilities. It is often said that if the HYV seeds were the vehicle, fertilizers proved to be the fuel, which led to the Green revolution. By early 1980s, India achieved complete self-sufficiency in foodgrain production and also started building the capacity to have sufficient buffer stock and some exports as well.

Degradation of natural resources and deterioration of soil health have emerged as a major issue in the past two decades due to the adoption of Green revolution technologies. These practices have led to emerging challenges such as declining factor productivity, deterioration of soil health, surface and groundwater pollution, thus increasing cost of production and lower profitability. It is said that our soils have become addicted to chemical fertilizers and further getting impoverished due to imbalanced use of fertilizers, discontinuation of traditional practices like mulching, intercropping and inclusion of legumes in cropping systems. Organic manures like FYM were traditionally

used for meeting the nutritional requirement of crops for a subsistence level of crop production, but their use decreased substantially for various reasons.

Competing demands for water and excessive exploitation of groundwater resources have led to lowering of ground water table, and pollution of water bodies due to various human interventions. Climate change has emerged as the biggest threat in the present times owing to the emission of greenhouse gases, which is partly due to the burning of fossil fuels for meeting the energy demands of higher crop production. Faulty cultivation practices such as burning of crop residues, puddling for rice cultivation, excessive dependence on chemical fertilizers and flood irrigation are responsible for global warming. There has been reports of stagnating trend in crop productivity since the 1990s, raising serious concerns about sustainability. There is growing realization that a change is needed in the present system of crop production so that the natural resources are not harmed, and the production levels are not only sustained but also improved for meeting the demands of the posterity.

## Agronomic approaches for sustaining crop productivity

In the later part of the previous century, improved agronomic technologies were developed for increasing agricultural production. This in a way led to a sort of

another revolution as it changed the way the crop production was carried out in many regions of the world. Firstly, the new generation farm machinery was developed and made available at affordable cost, which replaced the dependence on manual or animal-drawn power for tilling the land and various other farm operations. Secondly, innovations in chemical-based herbicides led to efficient weed control at nominal cost, and virtually replaced the arduous task of manual weeding in most crops. Further, other triggering factors for shift towards new innovative approaches are labour scarcity, deteriorating soil health, declining factor productivity, rising cost and low income. Thus, the modified agronomic approaches are needed in overcoming the problems being experienced in conventional farming systems.

**Tillage and crop establishment:** The first essential requirement of successful crop production is to ensure good initial crop stand and vigour. If this requirement is not met, all other operations later often fail to compensate for the loss in yield. Broadcasting, still prevalent in most areas, or sowing with manually- or animal-drawn implements often fails to ensure good crop stand. Besides ensuring good quality seeds, sowing must essentially be done by the seed drills, which can place the seed as well as basally-applied fertilizer close to each other.

Most tractor-drawn drills are so designed as to place the fertilizer typically 2–3 cm below the seed. Zero-till seed-cum-fertilizer drills of normal type (knife-type) for sowing in residue-free or in anchored residue conditions, and Happy Seeder in anchored or loose residue conditions are now available. Conservation agriculture involving zero/ minimum tillage, residue mulching and crop rotations has been found to result in equally good or even better crop stand and higher productivity. This technology has been adopted globally on a large scale, and must also be followed in all possible domains in India for efficient management of natural resources and sustaining crop productivity.

**Crop residue recycling:** It is often argued that crop residues are not available for recycling in crop production as these are meant for animal fodder in most regions of the country. But the reality is that with combine harvesting of most crops with now easily available custom hiring services, the crop residues are left in the field. The easiest way for the farmers to dispose of these residues for preparing the field for the next crop is to burn *in situ*. This has emerged as a national problem as it not only pollutes the environment but also destroys the beneficial soil microflora and fauna, and deprives the soil of plant nutrients. It is now being advocated that 'grains for human beings and crop residues for the soil', and first claim on the crop residues is of the soil so as to replenish its fertility status.

Residue retention on soil surface, and not necessarily its incorporation into the soil, which is energy-intensive process and causing immobilization of native nutrients, brings about enormous changes in the rhizosphere beneficial for crop growth. It promotes

biological tillage through the activity of earthworms and soil microorganisms, and the soil in fact becomes more porous and friable over a period of time. Residue retention also modifies the micro-climate, and helps in soil moisture conservation, weed control, temperature moderation in the soil as well as within the crop canopy, and enhances the fertility of the soil. The Government of India has formulated a policy to dissuade the farmers from burning the crop residues and providing various incentives for their alternative and beneficial utilization.

**Integrated weed management:** Weeds are considered even a greater constraint in crop production than meeting the nutritional and water requirement of crops. It was perceived since the ancient times that the soil should be well pulverised before sowing, primarily to control weeds. However, with intensive tillage operations, the soils became more prone to erosion hazards due to wind and water. This emerged as the major issue in the advanced countries during the 1970s which led to innovation of ploughless cultivation systems. Evidently, such systems required alternative and more efficient strategies for weed control.

Conservation agriculture involving zero tillage requires placement of seed and fertilizer close to each other below the soil, the inter-row spaces remain virtually undisturbed, rather these are covered with the mulch of crop residues. Weed seeds lying in the upper soil layer (0–5 cm) emerge in the first flush after sowing, which are easily killed with a pre-emergence or early post-emergence herbicide application. There is relatively lower emergence of weeds in the subsequent flushes after a month or so, by which time the crop has also developed adequate canopy to suppress their growth. A suitable post-emergence herbicide is also applied as per availability and requirement of the situation. Season-long weed control is needed, and the old concept of managing weeds only during the period of critical crop-weed competition is not relevant in the long-term.

Integrated weed management is the solution for holistic weed control in crop production systems. In view of the concerns being expressed for using agro-chemicals including herbicides in a rather indiscriminatory manner and the associated residues and health hazards, there is certainly a need to reduce the chemical load in crop production systems. However, it is also a reality that herbicides have now become indispensable for large scale weed control in view of their greater efficiency and much lower cost compared with manual or mechanical weeding. It is essential that we must integrate all the available methods of weed control including the non-chemical measures involving minimum tillage, cover cropping and crop rotations. A greater focus is also required on the preventive methods of weed management so that the control measures are needed minimum in crop production system.

**Integrated nutrient management:** Efficient nutrient management is an essential requirement for successful crop production. Conventional practice for fertilizer application advocates 4R stewardship— Right kind, right dose, right time, and right method, but quite



Wheat sowing in rice residues with Happy seeder

often, there is greater emphasis on dose and time of application/splits. Further, the fertilizer use is highly imbalanced (N : P : K ratio of 12 : 5 : 1 instead of the generalized norm of 4 : 2 : 1). Surface broadcasting of fertilizers and blanket application without any regard to the inherent soil fertility is the most inefficient practice. The new approaches to fertilizer application involve soil-test based balanced fertilization including use of secondary/micro-nutrients, greater emphasis on method of application—placement close to the seed/plant roots even while top dressing of urea fertilizer before irrigation.

Integrated nutrient management is the key to sustain soil health and crop productivity. It is not possible to ensure continued nutrient supply with chemical fertilizers alone and long-term soil fertility. All the available sources of plant nutrients including the available organic manures, crop residues, green manures, tree loppings, weed biomass, and biofertilizers must be integrated with chemical fertilizers. In fact, an ideal approach is to combine 50% each of chemical fertilizers and non-chemical sources for meeting the nutritional requirement of crops.

Precision nutrient management practices involving various sensors and modelling approaches have been worked out and shown to be promising. However, despite decades of research, these have hardly found any acceptance and adoption on the farmers' fields due to lack of awareness, inconsistent response and poor delivery systems. Liquid fertilizers have been shown to have better efficiency in advanced countries but these are yet to be tested on a large scale under Indian conditions.

**Irrigation management:** Conventional practice of irrigation involves flooding which results in lot of wastage of water, increases weed infestation and lowers nutrient use efficiency. This practice can no longer be afforded in view of the competing demands for water, and we must go in for more efficient water-saving

technologies. Retention of crop residues on the soil surface, as under conservation agriculture, prevents evaporation loss of soil moisture, and keeps the soil in relatively wetter condition for a longer period of time. Crop residues remaining as mulch on the surface gradually decompose through the action of water applied through irrigation, N fertilizer as top dressing, and build-up of microbial populations in the soil.

Non-conventional approach of scheduling irrigation involves adoption of micro-irrigation systems—sprinkler and drip including sub-surface drip irrigation. These systems improve efficiency of water and nutrient use and weed control, leading to saving of water, fertilizer and herbicide. The luxury of flood irrigation can no longer be afforded, rather it should be banned, and micro-irrigation systems should be promoted in all possible domains. Conjunctive use of problem waters along with good quality waters is necessary for meeting the water requirement of plants. Collecting, conserving, and utilizing 'every drop of water for more crop' should be the motto for efficient water management.

**Integrated farming systems:** 'Business as usual' will not work in the context of crop production as well. In many areas, there has been a significant shift in the cropping system over the years due to non-profitable farming, changing weather patterns, irrigation water availability, easiness of weed control, mechanization, labour scarcity and market demand. In the Bundelkhand region, the traditional crops in the rainy season like mungbean, urdbean, sesame and millets have virtually disappeared from many areas, and replaced by groundnut, maize and rice. Similarly in Himachal Pradesh, the farmers are even abandoning cultivation of traditional maize, rice and wheat crops due to the growing menace of domestic and wild animals, non-availability of manpower and other local constraints, and going in for high-value horticultural crops. There is an urgent need to diversify the cropping system as

per the changing needs in order to remain relevant and make farming sustainable on a long-term basis.

Agriculture does not involve crop production alone but also a host of other activities like animal husbandry, fisheries, bee keeping, mushroom, horticulture, agroforestry, etc. These need to be integrated well based on location-specific requirements and availability of resources to provide security and ensure sustainability. Circular economy by utilizing byproducts of one enterprise into another, and the concept of 'waste-to-wealth' is very relevant for optimizing returns, conserving natural resources, mitigating climate change and associated risks for ensuring water and food security.

**Small farm mechanization:** Conventional production systems have relied on manual labour or bullock energy for most field operations, which is no longer relevant in the present context due to non-availability of labour and resulting high cost. Near complete mechanization is the need of the hour for making crop production profitable and competitive in the local and global market. New machines such as Happy seeder which sows in no-till residue-mulch conditions, super seeder which mixes the residue in the top soil layer before placing seed and fertilizer, and roto-double disc drill which can work with less energy requirement and in heavy residue load have been developed and perfected for sowing. Similarly, innovative farm machines are available for weeding, interculturing, irrigation scheduling, fertilizer application, spraying, harvesting and post-harvest operations. Drones and artificial intelligence-based robots are likely to become a reality in the coming years, which will change the complexion of crop production scenario in the country.

It is no longer possible to do crop production with the traditional way of farming using the manpower resources even by the small holder farmers. Previously, it was thought that only the big farms need mechanization, but in the present times, small and marginal farmers equally need to adopt labour-saving technologies. While big machines may not be applicable in all situations, the small farm machinery is needed suited to local

requirements, even in the hilly and inaccessible terrains. This is now possible with the establishment of custom-hiring centres in most states and provision of subsidy for procurement of farm implements. Government of India has introduced various policy reforms to provide easy access to quality farm machinery, which can do the required operations timely and more efficiently at much lower cost.

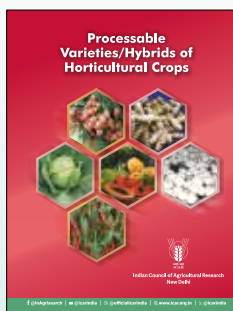
### SUMMARY

Agronomy has played a significant role in developing improved production technologies through efficient utilization of natural resources and external inputs since the green revolution. The various agronomic interventions enabled the HYVs to exhibit their near full production potential and eliminated the acute food shortages in the country. However, now with the emergence of post-Green Revolution and other 21<sup>st</sup> century challenges including the climate change, there is required to be a renewed thinking to suitably modify the agronomic interventions for sustained productivity. We need to reorient our strategies aimed at more efficient utilization of resources, reducing the cost of production and enhancing profitability, ensuring climate resilience and quality produce for domestic as well as export purposes.

There is a need for thorough testing and verification of the research findings in the real farming situations on a large scale before translating these into technologies and making recommendations to the farmers. Tall claims made by the agronomists based on short-term small-plot on-station experimentation often fail to produce the desired results on the farmers' fields. Therefore, farmer-centric research in close association with all the stakeholders must be undertaken for technology generation. Further, necessary back-up in the form of suitable policies for farm machinery procurement, subsidised and assured input supply, and market access is required to be provided to enable farmers adopt modified agronomic approaches.

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