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Policy Planning for Scaling Up of System of Crop Intensification by Adaptation of Climate Resilient Practices Towards Food Security and Improving Agricultural Production

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Abstract

Climate change is one of the most extreme challenges Indian agriculture is facing today and will have to deal with in future. There have been overwhelming and growing scientific evidences to establish that the world is getting warmer due to climate change and such increasing weather variability and worsening extremes will impact the agriculture sector more and more adversely. The sheer scale of involvement of the poor in agriculture calls for an effort to meet the challenge of climate change head-on through resilience building measures that work through a system of adaptive and mitigation strategies. Considering that new approaches are needed, development and deployment of new technologies, advocacy and capacity building have an extremely important role to play not only to build farmer's capability but to help in changing the mind-set as well. Both short term and long terms outputs are expected from the project in terms of new and improved varieties of crops, management practices that help in adaptation and mitigation and inputs for policy making to mainstream climate resilient agriculture in the developmental planning. The overall expected outcome is enhanced resilience of agricultural production to climate variability in vulnerable regions.

Keywords: Climate resilient agriculture, system of crop intensification, custom hiring centers (CHCs), crop residue management.

Introduction

A high-chemical and high-irrigation based modern-day agriculture while giving short-term returns, damages soil-health, eco-balance and agricultural sustainability in the long run. Contemporary strategy for crop intensification that depends primarily on making genetic improvements and increasing external inputs is, however, not the only kind of intensification that warrants consideration - especially given growing concerns about the sustainability of current agricultural practices and about their impacts on climate change. An alternative strategy for intensification that can be broadly characterized as agro-ecological strategy that seeks to make the most productive use of available natural resources. System of Crop Intensification (SCI) refers to an increase in agricultural production per unit of inputs. The input includes labour, land, time, fertilizer, seed, feed or cash. The aim is to achieve higher output with less use of or less expenditure on land, labor, capital, and water. Crop intensification technique includes intercropping, relay cropping, sequential cropping, ratoon cropping, etc. In recent years, something called the system of crop intensification (SCI) has emerged in a number of Asian and African countries, raising the productivity of the land, water, seed, labor, and capital resources that farmers invest can for growing a wide range of crops. System of crop intensification practices enable farmers to mobilize biological processes and potentials that are present and available within crop plants and within the soil systems that support them by altering the traditional practices of crop, soil, water and nutrient management. System of crop intensification principles can be applied for variety of crops which include System of rice intensification (SRI), System of wheat intensification (SWI), System of sugarcane intensification (SSI), and System of mustard intensification (SMI).

System of Rice Intensification

This system is a low water requiring, labor-intensive method that uses younger seedlings widely planted singly and typically hand-weeded with special tools. It is an evolving set of principles and practices which aims to enhance the rice productivity by changing the management of plant, soil, water and nutrient.

System of root intensification

In the state of Bihar, SCI was at first referred to as the system of root intensification. This designation does not, however, give concurrent credit to the contributions to crop productivity that beneficial soil organisms make. These are equally important and interact synergistically with root systems. Through their chemical and physical impacts on soil systems, roots help to sustain an abundance of life in the soil. These organisms, in turn, provide nutrients and protection to the roots and through them to the plant itself.

System of wheat intensification

System of Wheat Intensification which is based on the principles of system of rice intensification is a new wheat cultivation technique which demands to maintain plant of 20 cm × 20 cm. This kind of sowing with proper plant density allows for sufficient aeration, moisture, sunlight and nutrient availability leading to proper root system development from the early stage of crop growth.

System of sugarcane intensification

This system or sustainable sugarcane initiative is yet another practical approach to sugarcane production which is based on the principles of 'more with less' in agriculture like system of rice intensification. Sustainable sugarcane initiative is a method of sugarcane production which involves using less seeds, less water and optimum utilization of fertilizers and land to achieve more yields.

System of mustard intensification

System of Mustard Intensification is the system of transplanting mustard seedlings with wide spacing is similar to the system of rice intensification. Both systems depend on low density of crops and seek to utilize the full potentiality of each plant, rather than on communities of plants as done with high-density planting.

The ideas and practices that have given rise to SCI have derived from farmers' and others' experience with the system of rice intensification (SRI). The principles constituting both SCI and SRI, based on demonstrated agronomic theory and practice, are shared with other agro-ecological domains of innovation such as agro-forestry, conservation agriculture, integrated pest management, and integrated range and livestock management. The common elements involved in SCI crop management, extrapolated by farmers and others from what has been learned from their SRI experience, can be summarized as:

- Establishment of healthy plants both early and attentively, taking care to conserve and nurture their potential for root system growth and for associated shoot growth.
- Significant reductions in crop density, transplanting or sowing individual plants with wider spacing between them, giving each plant more room to grow both above and below ground.
- Enrichment of the soil with organic matter, and keeping the soil well-aerated to support the better growth of roots and of beneficial soil biota;
- Application of water in ways that favor plant-root and soil-microbial growth, avoiding hypoxic soil conditions that adversely affect both roots and aerobic soil organisms.
- *Starting with high-quality seeds or seedlings*, well-selected and carefully handled, to establish plants that have vigorous early growth, particularly of their root systems.
- *Providing optimally wide spacing of plants* to minimize competition between plants for available nutrients, water, air, and sunlight. This enables each plant to attain close to its maximum genetic potential.
- *Keeping the topsoil around the plants well-aerated* through appropriate implements or tools so that soil systems can absorb and circulate both air and water. Usually done as part of weeding operations, this practice can stimulate beneficial soil organisms, from earthworms to microbes, at the same time that it reduces weed competition.
- If irrigation facilities are available, these should be used but sparingly, keeping the soil from becoming waterlogged and thus hypoxic. A combination of air and water in the soil is critical for plants' growth and health, sustaining both better root systems and a larger soil biota.
- Amending the soil with organic matter, as much as possible, to enhance its fertility and structure

and to support the soil biota. Soil with high organic content can retain and provide water in the root zone on a more continuous basis, reducing crops' need for irrigation water.

- *Reducing reliance on inorganic fertilizers and pesticides*, and to the extent possible, eliminating them. This will minimize environmental and health hazards and avoid adverse impacts on beneficial soil organisms, which are essential for SCI success.

The careful transplanting of young rice seedlings, a key practice for SRI methodology, has been found to have strong beneficial effects on some other crops such as finger millet and mustard but not for all. Direct-seeding in conjunction with the other practices can be part of SCI, reducing labor requirements or with some crops like wheat it is simply more successful. Careful crop establishment is an essential part of agro-ecological management, whether for SRI or SCI.

Road Map for Accelerated Adoption of System of crop intensification in India

Before considering the range of SCI innovations that can contribute to sustainable food and nutrition security with less vulnerability to abiotic and biotic stresses, we give an overview of it that spans its varying manifestations. SCI is an agricultural production strategy that seeks to increase and optimize the benefits that can be derived from making better use of available resources: soil, water, seeds, nutrients, solar radiation, and air. There is always need to consider agricultural options in context, taking full account of the factors and interactions of time and space so that field operations are conducted in a timely way, with land area optimally occupied by crops, and not just by a single crop. SCI principles and practices build upon the productive potentials that derive from plants having larger, more efficient, longer-lived root systems and from their symbiotic relationships with a more abundant, diverse, and active soil biota. It is unfortunate that both roots and soil biota were essentially ignored by the green revolution. Road map one of the best ways to accelerate the SCI as follows:

Establish database repository for India

Currently, there is no structured mechanism for tracking the adoption and maintaining database on system of crop intensification/resource conservation technologies (RCTs) in different crops/cropping systems/ecologies of the region. Quality data on availability of Agricultural machinery/custom-hiring centers, area under combine harvesting machinery, amount of crop residues left in field in different crops and cropping systems, farmers practice for management of these crop residues, etc. is also lacking. ICAR Research Complex for Eastern Region in collaboration with CGIAR Centers, SAUs and other institutions should initiate focused programme on data base creation along with collection and collation of statistical information on land use pattern, area under rice-fallow, Agricultural machineries available, important distributers of machineries including repair and maintenance centers. A systematic study on constraints in adoption of Climate resilient technologies in different crops and ecologies of the region also need to be prepared. An urgent action is therefore needed to map the Agricultural research under all initiatives in India to define recommendation domains considering soil, climate, cropping systems as well as socio-economic conditions of the stakeholders.

Setting-up common learning platform and sites of science-based evidence generation on system of crop intensification

The most important limiting factor in adoption of Crop intensification is lack of synthesized knowledge on locally adapted improved agronomic practices which leads to perceived risks among the farmers who feel that puddling/ intensive tillage is essential for cultivation of crops. In India, large chunk of the farmers are even unaware of the resource conservation technologies which accelerate the system of crop intensification. Some of them even have not heard about the Zero-till seed drill/Happy seeder. There is a need to create mass awareness of the technologies and demonstration of their benefits through creating a common platform of learning and knowledge sharing. All stakeholders need to be involved for creating the awareness and providing opportunities for sharing.

Development of effective and productive supply chain system for Agricultural machinery

India has negligible presence of manufactures dealing with Agricultural machineries. Even for spare parts and repair & maintenance of existing machineries, the stakeholders have to depend on the markets available elsewhere in India, especially Punjab. Even for operating combine harvester, the farmers of eastern India rely on the trained manpower, available in Punjab, Haryana and Western UP. Agricultural Mechanization Development Centers (AMDC) needs to be established in each eastern Indian state, particularly for strengthening the small farm mechanization including rigorous multi stake capacity building. Though Custom-hiring Centers (CHCs) are being established in Indian states, limited repair or maintenance support services and lack of spare parts are major limitations for potential use of CHCs. These issues create tangible barriers to adoption and wider acceptance of the benefits of Agronomic practices. Manufacturers and dealers must be provided the required incentives to stock machines as well as spare parts within the region. Similar to Small Farm Mechanization Mission (SFMM) at the Centre, states of the region should also create SFMM. There is also strong need to establish long-term field experiments for generating science based evidence on key performance indicators in diverse ecologies and cropping systems which can also serves as sites of learning and capacity development of range of stakeholders. The platform can also facilitate organizing inter-state travelling seminars for participatory learning on CA technologies to expose the farmers of eastern India to understand the climate smart agriculture interventions going on especially in Haryana, Punjab and in other states.

Addressing subsidies for CA machinery as incentives to the farmers

The slow pace of adoption of Climate resilient based practices in the India may be due to earlier subsidies which have distorted the market price. High empanelment costs created disincentives for manufacturers to engage more widely in the program. Subsidies have resulted in mal practices, and access has been limited to certain sections of society. The farmers are not financially positioned to purchase ZT drills/Happy seeders, and will access the technology primarily through CHCs. In order to promote on large scale, subsidy/incentives needs to be extended to the farmers. However, subsidy should be released based on ground compliance monitoring and assessment. It is also envisaged that there is a need to incentivize the purchase of happy seeder/turbo seeder/and zero-till seed-cum-fertilizer drill to facilitate *in-situ* management of crop residue and retaining the straw as surface mulching. Refinement is needed in current prototypes of Agricultural machineries (ZT drills, Happy seeders, etc.) in accordance with the farmers' need in eastern India besides cost reduction without compromising the quality of machine. Zero-till multi-crop and multi-utility planters need to be developed and popularized.

Pricing strategies to achieve market demand driven approaches for long-term sustained adoption of Climate resilient practices

It has also been deliberated that subsidy extended on purchase of machineries should be based on quality of the machines. In general, bids for the supply of machines invited are generic in nature. Detailed specifications along with brand/mark need to be mentioned in the bid itself, in order to ensure the supply of quality machines. Similar is the case with spares. National and State GST charges also need to be waved off on Agricultural machineries to reduce price barriers to adoption.

Sustainable crop intensification of rice-fallows with suitable crops and crop establishment techniques

India has 11.695 million ha (Gumma *et al.* 2016) area under rice-fallow due to lack of irrigation, late harvesting of long-duration high yielding rice varieties, moisture stress at the sowing time, water logging and/ or excessive moistures in November/December *etc*. Adoption of resource conservation technologies (RCTs) involving suitable crop varieties would offer opportunities to cultivate at least 50% of rice-fallow area. Pulses such as chickpea, lentil, lathyrus and black gram, and oilseeds such as safflower, mustard and linseed through rotation or relay with rice are the candidate crops for efficient utilization of conserved and scarce resources including soil moisture. Crop establishment of these crops has a potential for sustainable intensification of rice-fallows in India which not only will have economic benefits to farmers but also can help country to achieve self-sufficiency in pulses and oil seeds. A systemic future research on nutrient management, crop/ cultivar combination, and farm mechanization is warranted that may further help to upscale system productivity potential in rice-fallow agro-ecosystem.

Cropping system approach and pest dynamics

Soil biology and pest (including insects, pathogens, nematodes and weeds) dynamics under crop intensification is the subject matter of a thorough investigation due to change in hydrothermal regime of the soil in presence of crop residue cover and non-disturbance of soil. Changes in community structure of microbes, microbial dynamics (beneficial *vs.* pathogenic) and microbial mediated processes need to be studied. Intensive research programmes also need to be initiated on sustainable use of crop residues, use of micro-organisms for faster degradation of crop residues, quantification of crop residues suitable for mulching in different crops and cropping systems, development of climate smart crop varieties, crop diversification, *etc*.

Crop residue management

About 650 million tons of crop residue is generated every year in India (NPMCR, 2014). Large portion of crop residue is burnt 'on-farm' primarily to clean the field for sowing of the next crop. Rice, wheat and sugarcane are prone to crop residue burning. There is need to develop, disseminate and incorporate technological options for sustainable management of crop residues; and to formulate and implement suitable law and legislations/policy measures to curb burning of crop residue. Diversified uses of crop residue for various purposes primarily for *in-situ* recycling and also other purposes *viz.,* animal fodder, power generation, as industrial raw material for production of bioethanol, packing material for fruits and vegetables, and glassware, utilization for paper/board/panel industry, biogas generation/bio char production/straw bale for animal feed/ composting and mushroom cultivation in Public Private Partnership (PPP) mode need to be promoted.

Developing synergies among institutional land-scapes

Keeping in view the fact that large numbers of research for development projects are being implemented by the CGIAR Centers including donors besides ICAR & SAUs, and state Governments, effective coordination between NARS and CGIAR Centers at regional level would greatly help in accelerated adoption through bringing more synergies and complementarily and bridging knowledge gaps. Therefore, there is a need to develop a mechanism for regular meetings and interactions at the regional level in different locations involving CGIAR partners, SAUs, ICAR institutions, State Govt. functionaries and other stakeholders. While strengthening the research platforms as sites of learning as well as new scientific insights and evidence generations, the on-farm research-cum-demonstration with farmers' participation involving KVKs is the key for its upscaling/out scaling and promotion on large areas. Duplication in research across the institutions/ organization also needs to be avoided.

Capacity building of stakeholders

Multistake capacity building of stakeholders is essentially required. Training programs to address the skill-gap could be based on existing arrangements elsewhere (e.g. NABARD, Skills Council, Agri-clinics *etc*.). A frequent demonstration of machines (ZT seed drills/Happy seeder/ Tractors/ Laser land levelers etc.) also needs to be arranged in order to increase awareness among stakeholders. Therefore, different training modules targeted to diverse stakeholders need to be developed. Based on the strengths on various aspects, key institutions should be identified to lead and facilitate the capacity development programs in areas of their expertise in different geographies. Different agricultural universities and institutions in the region should introduce a course as a part of course curriculum and also more students and young researchers should be trained through mainstreaming in the programmes like Rural Agricultural Work Experience (RAWE) and practical crop production (PCP) course at under-graduate level and increased post-graduate research.

Development of weather forecasting system and risk mitigation strategies

Weather is quite uncertain and impacts significantly agriculture and community. Therefore, establishment of a network of robust forecasting system and risk mitigation strategies (cold/heat tolerant cultivars, short duration alternative crops, post frost management) and analysis of extreme climatic variability (cold waves and frost/ heat stress) in hill farming is a must. Greater emphasis should be laid on precise information delivery system for climate change induced extreme weather variability for mitigating the risks. Also there is a need to strengthen the data generation system and develop database of climate, markets and other related aspects to support decision making for mitigating weather related market risks.

Promotion of conservation agriculture based sustainable intensification

Traditionally, agriculture is closely linked with forestry and based on biomass recycling. As such the nutrient requirement of the crop is met out either by the decomposition of leaf litter in improved organic matter content in soil. Also systematic information on intensive tillage mediated biomass incorporation v/s no-till/reduced till mediated biomass mulching and their effects on soil erosion, soil moisture retention, temperature buffering, yield, income, etc. is not available. There is a great role for Conservation Agriculture to play in sustainable intensification of crop production. However, in depth studies are required on conservation agriculture in low input and agriculture production systems for enhancing the service functions of hill agro-ecosystems.

Develop post-harvest management and value addition hubs

Since the region is bestowed with rich horticultural diversity, post-harvest technologies, particularly primary processing of perishable commodities in the cluster area of production of niche crops viz. pineapple, jackfruit, high value fruits and vegetables etc. is need of the hour besides infrastructure development for value addition and marketing. Large scale accreditation/certification of mother blocks is also required in order to ensure the supply of quality planting materials.

Promote agri-entrepreneurship and agri-startups to empower youth in agriculture

The region has high potential to harness the power of agricultural bio resources and also to motivate and attract rural youth. Concerted efforts to be made to promote agri-entrepreneurship through capacity building and training through agri-business incubators and such other mechanisms to enable agri-startups and improve employability in agriculture.

Conclusion

A high-chemical and high irrigation-based agriculture while giving short-term returns, damages soilhealth, eco-balance, and agricultural sustainability in the long run. Thus, there is an urgent need to build soil health systematically and maintain it. It is important to increase the productivity and resilience of land resources. System of crop intensification is one of those practices which aim to improve the productivity, sustainability, food security, and resilience to climate change by altering the traditional practices of crop, soil, water and nutrient management. Principles of the system of crop intensification can be applied in various crops such as rice, wheat, sugarcane, and mustard. System of crop intensification practices enable the crop to grow and develop potentially which provides enhanced production in a sustainable and eco-friendly manner. Therefore, classical crop cultivation practices need to overhaul by adopting the system of crop intensification for more profitable and sustainable agriculture.

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