2015 International Year of Soils
healthy soils for a healthy life

National Dialogue on Efficient Nutrient Management for Improving Soil Health

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Book of Extended Summaries

Editors:

ML Jat, Kaushik Majumdar, Andrew McDonald
Alok K Sikka and RS Paroda

Organizers:

Trust for Advancement of Agricultural Sciences
Indian Council of Agricultural Research
International Maize and Wheat Improvement Center
International Plant Nutrition Institute
Cereal Systems Initiative for South Asia
The Fertiliser Association of India

taas Progress Through Science
ICAR
CIMMYT International Maize and Wheat Improvement Center
25 years IPNI South Asia
CSISA
FAI Ensuring Food Security

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4.4 Conservation Agriculture and Soil Health vis-à-vis Nutrient Management: What is Business Unusual?

By M.L. Jat*[1]*, R.K. Jat*[2]*, H.S. Sidhu*[2]*, C.M. Parihar*[3]*, Tek B. Sapkota*[1]*, H.S. Jat*[1]*, Mahesh K. Gathala*[4]*, Y.S. Saharawat*[5] *and* ***Yadvinder-Singh[6]

[1]International Maize and Wheat Improvement Centre (CIMMYT), New Delhi, India, [2]Borlaug Institute for South Asia (BISA), [3]ICAR-Indian Institute of Maize Research, New Delhi, [4]CIMMYT, Dhaka, Bangladesh, [5]International Centre for Research in the Dry Areas (ICARDA), Kabul, Afghanistan, [6]INSA Senior Scientist, PAU, Ludhiana, Punjab

Introduction

The challenges for agricultural scientists, farmers and policy planners for sustainable increase in food production to meet future food security needs are quite different and complex compared to that of pre-Green Revolution era. Nearly 94% of the agriculturally suitable land in South Asia is already under cultivation with limited scope for further horizontal expansion except rehabilitation of degraded land. Hence, the pressure on land will increase to produce more from the same area under cultivation.

During past half century, the transformation of agriculture from 'traditional animal based subsistence' to 'intensive chemical and machinery based' production paradigm have though led to multifold increase in food production but also multiple problems associated with sustainability of natural resources especially deterioration in soil health. The soil organic carbon (SOC) contents in most cultivated soils of India is less than 5 g/kg compared with 15-20 g/kg in uncultivated virgin soils (Bhattacharyya, et al., 2000), attributed mainly to intensive tillage, removal/burning of crop residues, mining of soil fertility and intensive monotonous cropping systems. Large acreage of cultivated lands shows fertility fatigue and multiple nutrients deficiency in many intensively cropped areas of the region. This adds to our challenge of making farming more profitable and resilient for future food security. For example, during last five decades nutrient use in India has increased by 1573% with only 125% increase in food grain yield. Therefore, the use efficiency of inputs particularly nutrients has been declining at faster rate, posing a threat to future food security and environmental sustainability. In addition, still there exist large 'management yield gaps' in India ranging from 14 to 47%, 18 to 70% and 36 to 77% in wheat, rice and maize, respectively, significant portion of which is attributed to nutrient management (Jat et al; 2011).

The non-sustainability of agricultural systems is primarily governed by 3 key factors (i) soil erosion, (ii) soil organic matter decline and (iii) salinization; and all are related to soil health. These problems are mainly caused by (i) tillage induced soil organic matter decline, soil structural degradation, water and wind erosion, reduced water infiltration rates, surface sealing and crusting, soil compaction, (ii) insufficient or non-return of organic materials and (iii) mono cropping in addition to other associated factors of water, labour and energy shortages and emerging challenges of climatic change induced weather variability. Therefore, we need to take immediate actions to take out the unsustainable elements of conventional agriculture systems such as intensive tillage, removing all the crop residues/non-return of organic material to the soils and monoculture. Simple step to eliminate the non-sustainable components of conventional tillage (CT) based agriculture, will result into Conservation Agriculture (CA). The CA based on 3 key and interrelated principles (minimal disturbance of soil, rational organic soil cover and efficient and viable crop rotations) is a resource-saving and production optimizing agricultural system that aims to achieve sustainable intensification while enhancing economic profits, improve natural resources and efficiency of external production inputs with environmental stewardship. CA principles are universally applicable to all agricultural landscapes, and land uses, with locally formulated adapted practices. With farm-typology specific adaptations and refinements, the CA systems have worked in all kind of environments/ecologies (Derpsch et al., 2010) and adopted over 11% of the global crop land and helped millions of farmers through arresting land degradation, improve input use efficiency, adapt and mitigate climatic extremes, and improve farm profitability (Kasam et al, 2014). CA based management practices have been practiced in over 2 million ha of irrigated intensive as well as rainfed extensive production ecologies of India and have paid dividends to farmers, small scale entrepreneurs and policy planners. Science based scalable evidence on CA revealed high rate of returns over investments, adaptation to climate risks, improved use efficiency of precious water, nutrient, energy, labour resources and reduced environmental footprints of food production compared to conventional tillage based practices.

Conservation agriculture and soil health

Understanding the continued capacity of soil to function as a vital living system, by recognizing that it contains biological elements critical to ecosystem function within land-use boundaries is important. These functions are able to sustain biological productivity of soil, maintain or enhance water and air quality, as well as promote plant, animal, and human health. To define this, the terms soil quality and soil health are used interchangeably although it is important to distinguish that, soil quality is related to soil function, whereas soil health presents the soil as a finite non-renewable and dynamic living resource. Soil health is an integrated function of biological, chemical and physical properties of soil. Healthy soils maintain a diverse community of soil organisms that help to control plant disease, insect and weed pests, form beneficial symbiotic associations with plant roots (e.g., nitrogen-fixing bacteria and mycorrhizal fungi); recycle essential plant nutrients; improve soil structure with positive repercussions for soil water and nutrient holding capacity, and ultimately improve crop production. To produce enough food to keep pace with growing population, maintaining soil health is important. The food production is the end product of soil degradative or conserving processes and is controlled by chemical, physical, and biological components of a soil and their interactions. The CA (as defined above) is not a single technology, but a direction towards sustaining soil health and other natural resources following key elements having flexibility in their applications suited to specific production systems, ecologies and farmer circumstances and have short to long-term benefits to ecosystem and farmers. Jat et al (2014) reviewed the role of Conservation Agriculture based management practices on soil health using published literature of large number of on-station as well as on-farm experimentations across range of soil types, cropping systems and agro-ecologies of India. They suggested that under most cases, CA based management practices led to significant improvement in physical, chemical and biological properties of the soils. However, the degree of improvement varies with different factors particularly recycling of residues and duration of CA.

Conservation agriculture, soil health vis-a-vis nutrient management

Traditionally, farmers in India as well as other South Asian nations apply fertilizer nutrients based on ad-hoc blanket recommendation for large area. Many farmers often use uniform rates of fertilizers that could be inconsistent from field-to-field and year-to-year depending on factors that are difficult to predict prior to fertilizer application and also no matter what crop management practices they have adopted. Also, farmers often apply fertilizer nutrient in doses much higher than the blanket recommendations to ensure high crop yields. Large temporal and spatial variability of soil nutrient supply restricts efficient use of fertilizer nutrients when broad based blanket recommendations are used even under contrasting management scenario. This leads to sub-optimal crop yields, low nutrient use efficiency, lower economic profitability and greater environmental footprints. Under such situations, in season site-specific nutrient management can effectively replace the blanket fertilizer nutrient recommendations for achieving high nutrient-use efficiency, economic profitability with lower environmental footprints. With 84% or more operational land holdings in India having less than 2 ha (remaining 10-15% up to 10 ha), it seems that high fertilizer nutrient-use efficiency can be achieved through field-specific fertilizer nutrient management considering both spatial and temporal variability in soil nutrient supply. However, quantifying the spatial and temporal variability of soil properties at scale using soil test based approach seems a wearisome task keeping in view of number of holdings and available resources in the region. However, the national mission on soil health launched by Government of India is welcome step in this direction. However, capturing temporal variability created due to contrasting management by the farmers and account that in fertilizer nutrient recommendations has to go a long way. Large studies on CA based system across a range of geographies suggests positive effects on soil health over a period of time and hence the fertilizer nutrient prescriptions has to be dynamic under those situations. Also, its just not only the rate of fertilizer nutrient application but method and time of application having congruence with soil moisture has to do a lot for improving efficiency as well as soil health. The changes in physical and biological properties of the soil associated with CA practices are expected to modify the direction and kinetics of the chemical and biochemical processes significantly affecting nutrient dynamics in the soil. Therefore, we need to have a paradigm shift in fertilizer nutrient management strategies (rate, time, method) under CA when we move from conventional tillage based management. In this paper, we attempted to provide evidence which suggests that we need a 'business unusual approach' for nutrient management when we move from CT to CA based production.

Way forward

CA with layering of adapted component technologies especially nutrient and water relevant to local circumstances can serve the foundation for our goal of improving soil health for resilient farming and future food security. However, business as usual approach may not help us meeting the goals and warrants following strategies for capitalizing the synergies in positive role of different elements of CA on soil health and efficient nutrient management practices relevant to those circumstances.

- Take a stock of the available technologies/practices for CA and nutrient management adapted to different production systems and define their recommendation domains for scaling and impact on smallholder farming systems.
- The innovation platform on CA with component technologies for nutrient and water management should have a continuum of 'strategic-applied research-capacity development-delivery'.
- Capture farmer innovations on CA and align them with scientific validation and refinements through participatory action research on layering efficient nutrient (and water) management portfolios for CA based production systems, for example, aligning 4R nutrient stewardship with CA and micro-irrigation.
- Create evidence base on complementarity of CA based systems with efficient nutrient management as indicators of improved soil health, food security, income and livelihoods over conventional farming practices and define their recommendation domains.
- Analyse adoption pattern and behavioural change of farmers under different farm typologies to understand adoption of CA in isolation vis-à-vis layered with precision nutrient and water management.
- Strengthen institutional arrangements and enabling policy environments for scaling CA systems through establishing a 'Farmer Centric' consortium of active and complementing stakeholders.
- Enhance capacity of stakeholders especially rural youth and women.
- Develop and demonstrate CA system led business cases to engage rural youth for scaling CA based innovation.

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5. Recent Advances in Nutrient Management

5.1 Fertilizer Policy and Nutrient Management: How to Connect?

By Brahma S. Dwivedi, R.K. Tewatia**[1] and **Mahesh C. Meena

Division of Soil Science and Agricultural Chemistry, ICAR-Indian Agricultural Research Institute, New Delhi-110 012

[1]The Fertiliser Association of India, 10, Shaheed Jit Singh Marg, New Delhi-110 067

Introduction

Soil fertility deterioration mainly due to excessive removal of nutrients by crops and their inadequate replenishment is considered one of the major constraints in attaining and sustaining high productivity. As a consequence of excessive nutrient mixing, widespread deficiencies of at least six nutrients viz. N, P, K, S, Zn and B have been recorded in Indian soils (Dwivedi, 2014). Unless plant nutrients are supplied in adequate quantities and balanced proportions, there will be much greater drain of native nutrients and the soil may not be able to support high yield, anymore in the times to come. There are adequate evidences to support that (i) crop nutrient demands could not be solely met through fertilizers, as an estimated annual gap of about 10 mt exists between nutrient removal and supply through fertilizers, and (ii) integrated nutrient supply through conjoint use of fertilizers and other nutrient sources of organic and biological origin is the best nutrient management strategy. Nonetheless, fertilizers remained major nutrient supplements in past half-century, and would continue to be so in the foreseeable future. Hence, fertilizer policies are inseparably linked with nutrient management, and any change brought in the former is likely to affect not only the rate and proportion of fertilizer input, but also nutrient use efficiency and overall economic returns. It is, therefore, imperative to understand as to what extent the recent change in fertilizer policies affected nutrient management, and suggest the way forward to ensure balanced and efficient use of fertilizers.

Fertilizer policies vis-à-vis nutrient management

The sale, price and quality of fertilizers is regulated under Fertilizer (Control) Order, popularly called FCO. With retention pricing scheme (RPS) implemented way back in 1977, fertilizer production and consumption increased significantly, although subsidy bill also increased simultaneously (Satish Chander, 2013) due to continuous rise in fertilizer production costs and relatively slow change in government controlled retail price of fertilizers. As there was abysmal investment in the fertilizer industry with less scope for any innovation, the need for policy reforms was badly felt. One of the major reforms took place in April 2010 with the introduction of nutrient-based subsidy (NBS), wherein the subsidy on P and K fertilizers was fixed annually, and the MRP was market-driven. Urea which constitutes more than half of the total fertilizer products used in the country, however, continues to be out of the ambit of NBS. With the implementation of NBS, the fertilizer subsidy load on the exchequer got reduced