Vol.1 Issue-2, October 2020

Precision Nutrient Management in Conservation Agriculture Systems

Amit Kumar[1], R. Singh[2], R.K. Avasthe[3], Subhash Babu[4], B.A. Gudade[5], Gaurendra Gupta[6], Adarsh Kumar[7] and Gaurav Verma[8]

Scientist[1], Senior Scientist[2], Principal Scientist[3], Scientist[4], Scientist-C[5], Scientist[6], Scientist[7], PhD Scholar[8]

[1,2] and [3] ICAR–National Organic Farming Research Institute, Tadong, Sikkim-737102
[4]ICAR–Indian Agricultural Research Institute, New Delhi-110012
[5]ICRI, Regional Research Station, Spices Board, Tadong, Gangtok, Sikkim-737102
[6]ICAR–Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh-284003
[7]ICAR–National Bureau of Agriculturally Important Microorganisms, Uttar Pradesh-
[8]Department of Agronomy, CCS Haryana Agriculture University, Hisar,Haryana -125004

ARTICLE ID: 016

Introduction

Global food security, environmental preservation as well as farmer's level increased livelihood should be the main goals of a sustainable farming system in today's world plagued by degraded soils as a result of unsustainable crop management practices (Kumar *et al*., 2018). Under conservation agriculture (CA), a special attention has been given to crop and nutrient management with particular emphasis on the three major CA principles–minimal tillage, crop rotation and crop residue management. Keeping in view the distinct influence of CA on plant nutrient dynamics, now the nutrient management has become the 4th principle of CA. The NPK ratio is likely to vary with crops, cropping systems, management practices and there is a need to work out the NPK ratios for basing fertilizer allocations for different regions especially in the CA based systems. Therefore, the paradigm shift from conventional tilled to no-till CA systems require a serious thrust on nutrient management research to improve soil and crop productivity and environmental quality.

Why does CA represent a new paradigm?

Attaining food security for a growing population and alleviating poverty while sustaining agricultural systems under the current scenario of depleting natural resources, negative impacts of climatic variability, spiralling cost of inputs and volatile food prices are the major challenges before most of the Asian countries. These are caused mainly by intensive tillage induced soil organic matter decline, soil structural degradation, water and wind erosion, insufficient return of organic material and mono-cropping. Therefore, a paradigm shift in farming practices through eliminating/upgrading unsustainable parts of conventional agriculture such as ploughing/tilling the soil, removing all organic material and monoculture is crucial for future productivity gains while sustaining the natural resources. Conventional agriculture over the years leads to threats:

- Declining factor productivity
- Declining ground water table
- Development of salinity hazards
- Deterioration in soil fertility
- Deterioration in soil physical environment
- Biotic interferences, declining biodiversity
- High energy requirements
- Reduced availability of protective foods
- Air and ground water pollution
- Stagnating farm incomes

Conservation Agriculture

Conservation agriculture (CA) can be defined by a statement given by the Food and Agricultural Organization of the United Nations as "a concept for resource saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment" (FAO, 2008)**.** Conservation has become critical because the global population has increased over the years and more food needs to be produced every year.

Status of conservation agriculture in India and abroad

According to FAO, 2016, globally, CA is being practiced on about 156.99 M ha and major CA practicing countries are USA (35.61 M ha), Brazil (31.81 M ha), Argentina (29.18 M ha), Canada (18.3 M ha) and Australia(17.0 M ha).In India, CA adoption is still in the initial

JUST AGRICULTURE
multidisciplinary e-Newsletter

phases. Over the past few years, adoption of zero tillage and CA has expanded to cover about 2.0 M ha (FAO, 2016). The major CA based technologies being adopted is zero-till (ZT) wheat in the rice-wheat (RW) system of the Indo-Gangetic plains (IGP). In other crops and cropping systems, the conventional agriculture based crop management systems are gradually undergoing a paradigm shift from intensive tillage to reduced/zero-tillage operations. The CA adoption also offers avenues for much needed diversification through crop intensification, relay cropping of sugarcane, pulses, vegetables etc. as intercrop with wheat and maize and to intensify and diversify the RW system.

Principles of CA

1. Minimum mechanical soil disturbance
2. Residue retention
3. Crop rotation

Benefits of conservation agriculture

Agronomic benefits- It improves soil productivity by enhancing the soil physical, chemical, biological properties. It increases organic matter content of soil by adding crop residue continuously. Due covering of soil by crop residue it conserve moisture thereby increase water use efficiency.

Environmental benefits- Conservation agriculture involving zero-till and surface managed crop residue systems are an excellent opportunity to eliminate burning of crop residue which contribute to large amounts of greenhouse gases like CO_2, CH_4 and N_2O, sequester carbon, improve biodiversity and to improve air and water quality.

Economic benefits- CA practices reduce cost of production which is attributed to savings on account of diesel, labour and input costs, particularly herbicides Most studies showed that the cost of wheat production is reduced by Rs. 2,000 to 3,000.

Limitations related to nutrient management in conservation agriculture

Precision nutrient management under CA is more comprehensive and difficult task. Strategies of nutrient management under CA depend upon certain factors which affects efficacy of nutrient management practices. Therefore, it is recommended to keep in mind, the following things before making a sound nutrient management programme under conservation agriculture:

- Difficult to handle crop residues during sowing and other operations
- Surface acidification
- Nitrogen loss due to volatilization and leaching
- Run-off loss of P and K
- Nutrient immobilization in the initial phase
- Presence of surface residues which limit contact between the soil and the fertilizer

Precision nutrient management strategies in CA

Conventional agricultural practices depends upon certain classical approaches of nutrient management such as blanket recommendation but nutrient management under CA is more comprehensive and require diverse knowledge of certain things such as soil fertility status, crop nutrient removal, crop nutrient response, sensitive stage of nutrient demand etc. An integrated and comprehensive nutrient management under conservation agriculture systems could be possible by following strategies:

1. **Crop residue management:** If the crop residue retention on the soil surface after some time they decompose, add organic matter in the soil that results improve the physical, chemical and biological properties of soils (Kumar *et al.*, 2014). SOM content and quality affects many soil functions which are related to soil health such as moisture retention, infiltration, release, availability of nutrients and plant health (Behera *et al.*, 2007).
2. **Management of soil acidity:** Soil acidity has a major influence on the availability of essential nutrients. Soil acidity is caused by hydrogen (H^+) and aluminium (Al^{+3}) ions in the soil solution. Most of the soil microorganisms are sensitive to soil acidity, which has an influence on nutrients availability (especially nitrogen, phosphorus and sulphur), soil organic matter and soil health(Kinsey and Walters, 2006). The most beneficial soil fungi, for instance, do not like a high pH and soil bacteria have problems at lower pH. Where soils are acidic managed by applying liming materials, primarily ground limestone. The carbonates in these materials react to neutralize the acidity in the soil.

$$CaCO_3+2H^+=Ca^{2+}+CO_2+H_2O$$

3. **N losses management strategies**

Nitrogenous fertilizer applied on the soil surface Nitrogen (N) can be lost from the field through three principal pathways: denitrification, leaching and surface volatilization. These losses can be minimised through various ways-

- Split application of nitrogenous fertilizer
- Banding liquid UAN is a common practice in no till for reducing N loss
- Injecting the fertilizer below the surface residue
- Increase the basal dose of nitrogenous fertilizer
- Place the fertilizer closer to the plant root zone
- Use of variable rate applicators
- Use of slow release nitrogenous fertilizer
- Use of fertilizer additives (urease inhibitors, nitrification inhibitors, etc.)
- Urease inhibitors –NBPT, Thiosulphate
- Nitrification inhibitors-Nitrapyrin, DCD

4.Management of other nutrients

Phosphorus and Potassium:

- Shallow band placement of P and K
- Higher levels of P and K fertilisation in low soil temperature and excessively wet soils
- Knifing in fertilizer reduced losses of total P, bio-available P and soluble P
- Reduce the K-dose when crop residues are incorporated

Calcium and Magnesium: Application of dolomite lime

Sulphur: Applications of sulphate-S fertilizers such as Ammonium Sulphate (24.2% S), Urea Sulphur (10% S) and Potassium Magnesium Sulphate (22.3% S) etc.

Micronutrients: Foliar applications-correcting in-season deficiency

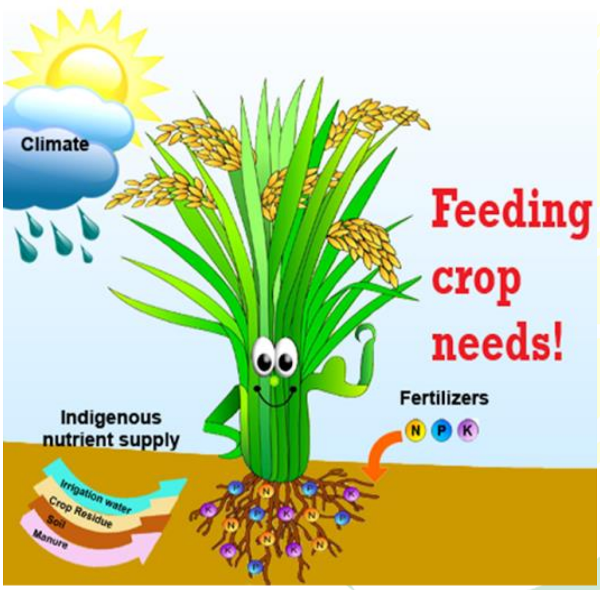
5. Adoption of efficient crop rotation:

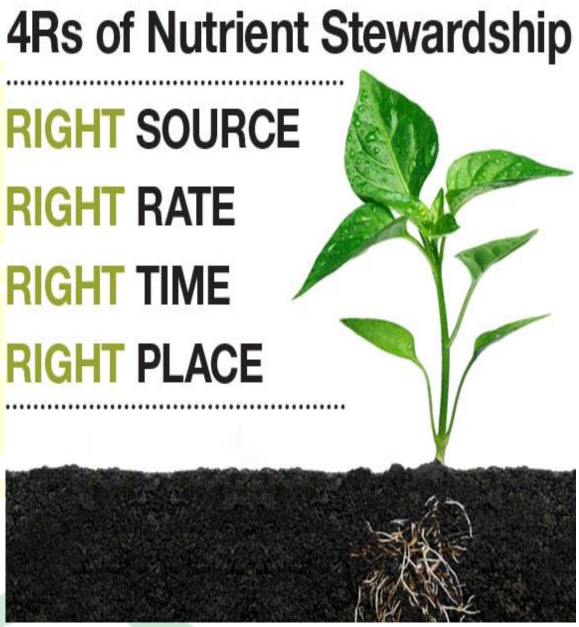
Crop rotation is the practice of growing a sequence of different crops on the same field. In crop rotation inclusion of legumes (crops andgreen manure) can affect the availability of N and other nutrients such as P and K (Parihar *et al*., 2016). Most green manure species can fix

N with N-fixing bacteria and increase soil N levels by 459 kg N/ha. Green manures can also affect the availability of other nutrients such as P, Mn, Zn, which can affect disease and pest tolerance and crop growth and yield.

6. Site-specific nutrient management:

SSNM is dynamic, plant-based, farm-specific management of nutrients in a particular crop or cropping system to optimize the supply and demand. SSNM based on principles of 4R i.e. right source, right amount, right time and right place. It requires 3 steps.





Nitrogen application based on LCC: The leaf color chart (LCC) is an innovative cost effective tool for real-time or crop need-based N management. It measures leaf color intensity that is related to leaf N status. LCC is an ideal tool to optimize N use at high yield levels, irrespective of the source of N applied, viz., organic manure, biologically fixed N or chemical fertilizers.

Measuring SPAD values in the field: It is a simple, quick and non destructive in situ tool for measuring the relative leaf chlorophyll content that is directly proportional to leaf N content.

Optical sensor (Green-Seeker): Optical sensor used rapidly through measurement of visible and near infrared spectral response from plant canopies to detect the nitrogen status.

Nutrient-Expert based nutrient management: A recently developed decision support systems (DSS), Nutrient Expert is an easy-to-use. It is a computer-based decision tool that can rapidly provide nutrient recommendation for individual farmers' field in presence or absence of soil testing data.

7. Other agronomic management practices

Management of cover crops: Soil permanent/semi-permanent cover by green manure crops/crop residues. The principle of managing the top soil to create a permanent organic soil cover can allow for growth of organisms within the soil structure. The breaking down of this mulch will produce a high organic matter level which will act as a fertilizer for the soil surface. It raised cation-exchange capacity (CEC) for nutrient capture retention and slow-release in the soil (Singh *et al*., 2004).Placement of fertilizers: Improving the nutrients use efficiency because fertilizers are applied band placement that results reduce the loss of nutrients from the soil.

Summary

Conventional agricultural practices depends upon certain classical approaches of nutrient management such as blanket recommendation but nutrient management under CA is more comprehensive and require diverse knowledge of certain things such as soil fertility status, crop nutrient removal, crop nutrient response, sensitive stage of nutrient demand etc. Therefore, the paradigm shift from conventional tilled to no-till CA systems require a serious thrust on nutrient management research to improve soil and crop productivity and environmental quality. It shows that the use of some tools for *in-season* N management like Soil-Plant-Analysis-Development (SPAD) chlorophyll meter or green-seeker sensor or site-specific nutrient management (SSNM) through soil-test crop response (STCR) or nutrient expert, helps in fulfilling the crop nutrient requirement with more precision and less environmental footprints.

References

Behera, U.K., Sharma, A.R. and Pandey, H.N. 2007. Sustaining productivity of wheat-soybean cropping system through integrated nutrient management practices on the vertisols of central India. *Plant and Soil* **297**: 185–99.

FAO. 2008. Investing in Sustainable Agricultural Intensification: The Role of Conservation Agriculture–A Framework for Action' FAO Rome, August 2008 (available at www.fao.org/ag/ca/).

FAO. 2014. CA Adaptation Worldwide, FAO-CA website http://www.fao.org/ag/ca/6c.html)

Kinsey, N. and Walters, C. 2006.*Neal Kinsey's Hands-On Agronomy: Undersatnding Soil Fertility &Fertilzer Use.* Acres USA.391 pp.

Kumar, V., Singh, A.K., Jat, S.L., Parihar, C.M., Pooniya, V., Sharma, S. and Singh, B. 2014. Influence of site-specific nutrient management on growth and yield of maize (*Zea mays*L.) under conservation tillage. *Indian Journal of Agronomy* **59**(4): 657–60.

Kumar, A., Behera, U.K., Gupta, G., Bhatia, A., Shukla, L., Dhar, S., Meena, M.C. and Singh, R.K. 2018. Effect of tillage, crop residue and phosphorus management practices on the productivity and profitability of maize (*Zea mays*) cultivation in Inceptisols. *Indian Journal of Agricultural Sciences* **88**(10): 1558–67.

Parihar, C.M., Yadav, M.R., Jat, S.L., Singh, A.K., Kumar, B and Pradhan S, 2016.Long term effect of conservation agriculture in maize rotations on total organic carbon, physical and biological properties of a sandy loam soil in north-western Indo- Gangetic Plains. *Soil and Tillage Research* **161**:116–28.

Singh, R., Dabur, K. R. and Malik, R. K. 2004.Long-term response of plant pathogens and nematodes to zero-tillage technology in rice-wheat cropping system.Technical Bulletin (7), Regional Research Station, Kaul, Department of Nematology and Directorate of Extension Education. Hisar, India: CCS Haryana Agricultural University.