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Development of soil health card (SHC)

using GIS technique

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Plant needs at least 16 nutrient elements for proper growth and development. To know the status of these nutrient elements in soils of Kelapur block of Yavatmal district of Maharashtra, soil fertility maps and Soil Health Cards (SHC) were generated. More than 5,000 surface soil samples (0-15 cm depth) were collected at a distance of 325 m × 325 m using Global Positioning System (GPS) techniques. Information related to name of farmers, address, present land use, crop history, traditional fertilizer use, irrigated or rainfed status and coordinates were collected for implementing the concept of precision agriculture in Kelapur block. Samples were analyzed for the available major nutrients (N, P, K), micronutrients (Fe, Mn, Zn, Cu) and sulphur. Soil samples were also analyzed for soil reaction (pH), organic carbon and salinity (EC). Soil fertility maps were generated using GIS techniques.

Keywords: Fertilizer recommendations, GIS techniques, Soil Fertility Mapping, Soil Health Cards

THE Green Revolution, probably the greatest achievement for food security of post-independence India, heralded an era of food sufficiency riding on the use of chemical fertilizers. Now, 50 years on, soil health is rapidly declining due to indiscriminate use of fertilizers. Indian farmers apply around 66 million tonnes of fertilizers every year, which accounts for a significant share of India's imports and subsidies.

Government of India launched a massive programme on soil health management (SHM) to promote Integrated Nutrient Management (INM) through judicious use of chemical fertilizers. Essential plant nutrients including secondary and micronutrients in conjunction with organic manures and bio-fertilizers improve soil health and its productivity. A Soil Health Card is used to assess the current status of soil quality, capability of soil to supply nutrients and to recommend site specific nutrient management plan for each farmer of India. This programme has been launched in all states of India for sustainable crop production and as a step for practice of precision farming.

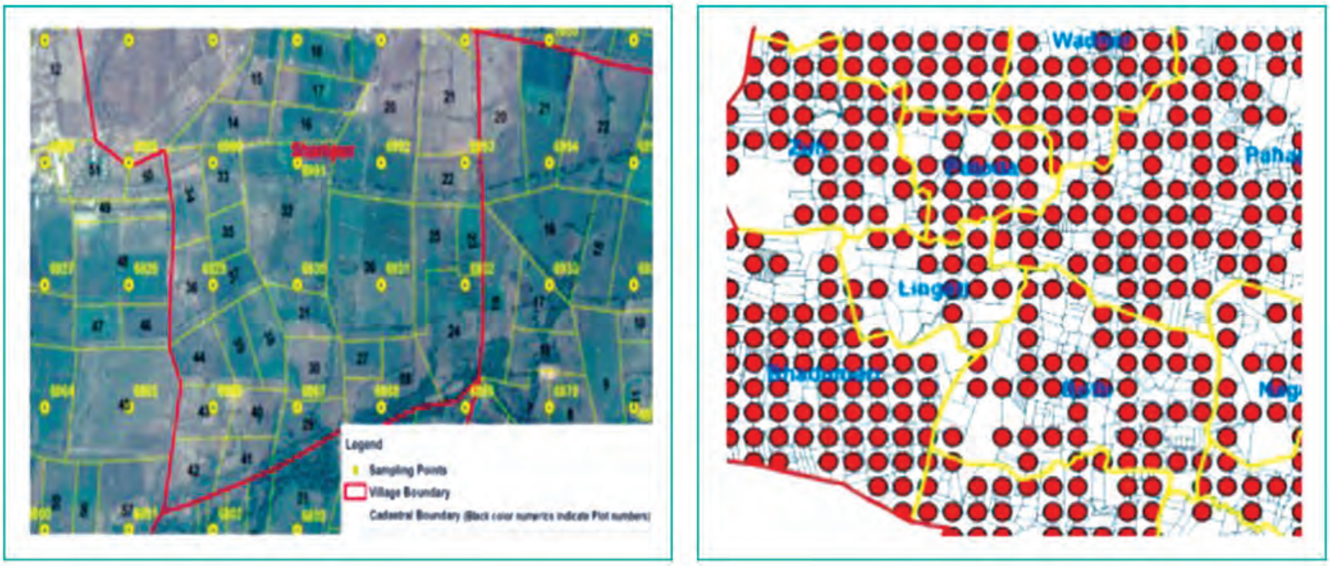
Soil nutrient imbalance is the result of intensive crop production systems in India especially in irrigated agro-ecosystem. Using a grid-wise approach, representative soil samples from the fields should be tested for issuing SHCs to farmers. In addition to this approach we have applied GIS techniques to issue SHCs with more precise information. Kelapur block of Yavatmal district of Maharashtra has been selected for development of Soil Health Cards (SHC) and soil fertility mapping using GIS techniques.

How soil health cards are useful?

In the soil testing laboratories, macro and micro nutrients needed by the soil are identified. It is translated into specific, measured quantities of fertilizers required for specific crop by applying the concept of soil test based fertilizer recommendation (STCR) techniques. This information, printed on the SHC, is made available to the farmers in that grid through the state agricultural departments. Fourteen crore SHCs have been issued till May 2017 and the Ministry of Agriculture aims to cover the entire farming population. In addition, on pilot basis, the soil health information is made available at fertilizer purchase points, Primary Agricultural Credit Societies (PACS) and POS devices-enabled fertilizer retail shops. However, farmers still buy large amount of fertilizer, disregarding SHC recommendations. Researchers are in the opinion that soil quality will improve after a certain period of time if farmers are ready to apply it as per the recommendation in SHCs.

Farmers opinion about SHCs

After green revolution farmers are continuously increasing the dose of fertilizers in their fields for better output. They plan to put a 5-10% increment in capital investment to be used for fertilizer applications in irrigated areas. Farmers appear



Soil sampling points at a distance of 325 m × 325 m.

convinced that there is a perfect causal correlation between high fertilizer usage and more output. As a corollary, they believe their farmlands have 'good soil health' if they yield the desired output. Farmers are not concerned that they need not use higher amount of fertilizer to ensure this 'good soil health'! In fact, they are not sure that the advice based on the SHC can be relied upon; especially when they perceive that the yield might improve by using 'just a little more' fertilizer. Further, farmers told that SHCs are not easy to use; it gives general recommendations regarding the quantity of fertilizers required over the entire crop season whereas, in reality, fertilizers should be used in varying amounts over the different stages of the crop growth. So, even those farmers who start with the intention to use less fertilizer as a result of the SHCs ultimately have to fall back on their own judgment to decide the amount of fertilizer to be used at each stage of the cropping cycle.

What is reality about SHCs?

Farmers are more concentrated on major nutrients specially nitrogen and phosphorus whereas potassium is used to a limited extent. If the soils are deficient in micronutrient(s) and if it is not replenished with that particular nutrient then plant may not be able to give desired results *i.e.* higher production. Therefore, SHCs play very important role in management of limiting nutrients in soil. If this limiting nutrient is applied to soil then production may increase from 10-25% depending on management levels.

GIS techniques in development of SHCs

Sampling scheme

Soil sampling is the first step in generating field-specific information on fertilizer recommendation and monitoring the soil nutrient status over time. Technological advances in GPS (global positioning systems) and GIS (geographic information systems) precise design for more intensive soil sampling schemes for precision agriculture. A network of grid lines was superimposed on a base map at a distance of 325 m × 325 m to assist sample positioning. According to this scheme, one sample per 10 ha area was collected for fertility mapping in Kelapur block.

Analysis of samples in laboratory

After processing, the soil samples were analyzed for the available major nutrients (N, P, K), micronutrients (Fe, Mn, Zn, Cu) and sulphur. Soil samples were also analyzed for soil reaction (*p*H), organic carbon and salinity (EC). Advanced analytical Instruments (ICP, AAS etc.) were used for soil analysis for getting higher precision and accuracy

Interpretation of data

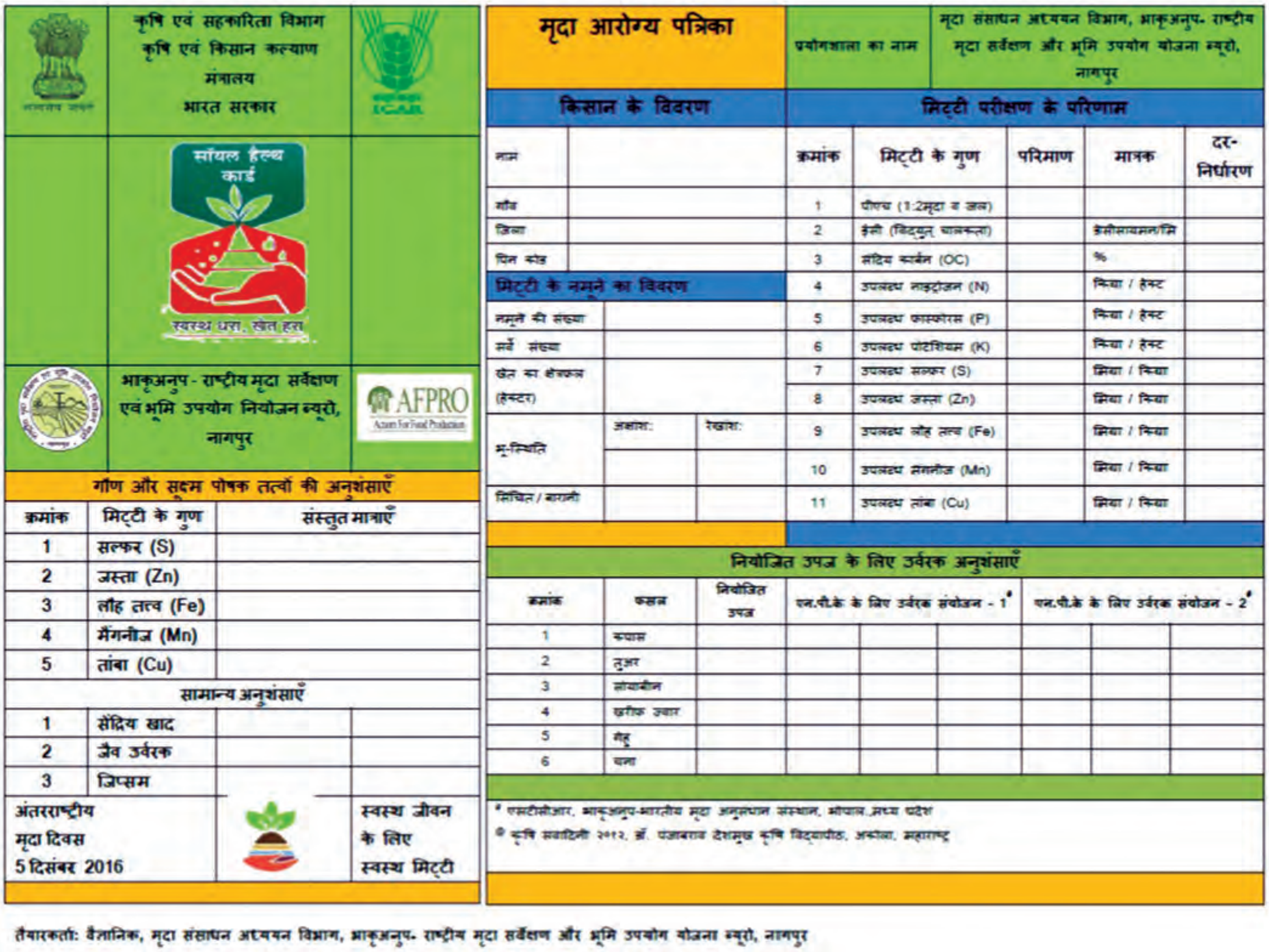
Analytical data were interpreted as per the response of the field trials in the region. Soil test values were used for interpretations as per soil fertility ratings suggested by PDKV, Akola.

Table 1. Ratings for available nutrients (N, P, K and S) and organic carbon in soils

Soil test	Very Low	Low	Medium	Slightly High	High	Very High
Organic C (%)	0.20	0.21-0.40	0.41-0.60	0.61-0.80	0.81-1.00	>1.00
Available N (kg/ha)	140	141-280	281-420	421-560	561-700	>700
Olsen P (kg/ha)	15	16-30	31-50	51-65	66-80	>80
Available K (kg/ha)	120	121-180	181-240	241-300	301-360	>360
Av. sulphur (ppm)	-	<6.0	6.0-12.0	-	>12.0	-

Table 2. Ratings for available micronutrients in soils (Fe, Mn, Zn and Cu)

Soil test (ppm)	Deficient	Marginal	Sufficient
Iron	<4.5	4.5-7.5	>7.5
Manganese	<2.0	2.0-4.0	>4.0
Zinc	<0.6	0.6-1.2	>1.2
Copper	<0.2	0.2-0.5	>0.5



Format of soil health card in Hindi.

Fertilizer recommendation

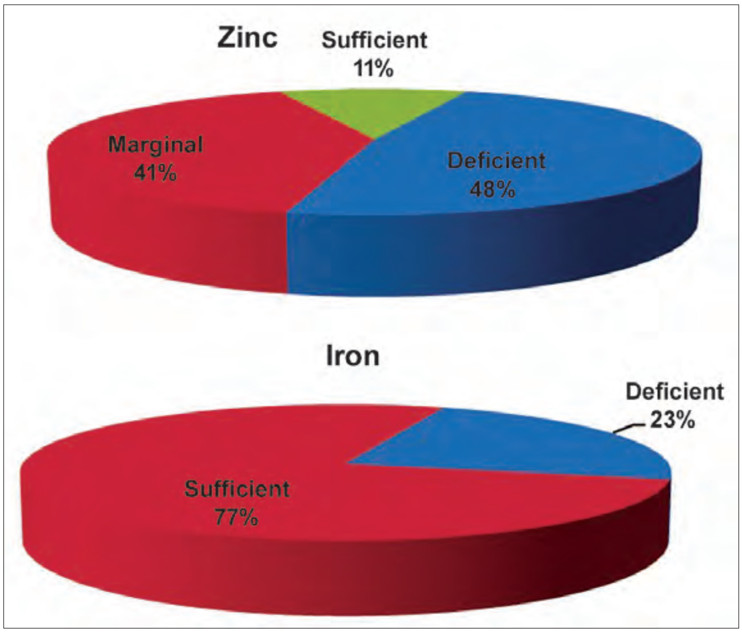
Fertilizers were recommended as per the STCR techniques for major crops under rainfed and irrigated conditions.

Generation of SHCs

SHC were generated in the following format as per the standards of Department of Agriculture Cooperation and Farmers Welfare, Government of India.

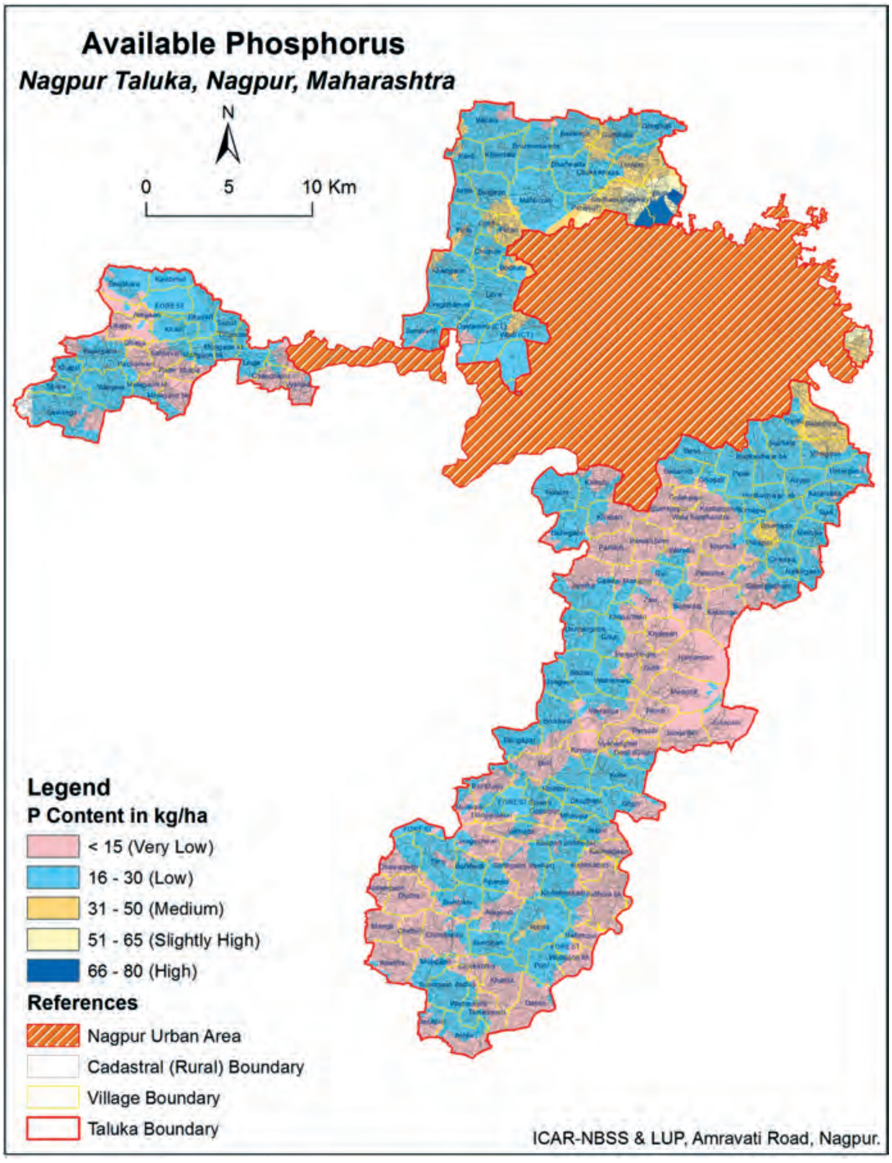
Generation of fertility maps

Soil fertility maps were generated using GIS software's and linked with institute web portal. Zinc and iron fertility status in soils is represented in the form of pie diagram.



Generation of SHCs by extrapolation

The features like slope, soil type, depth, texture, potential soil loss, land capability class and land irrigability class were extracted from soil map prepared by ICAR-NBSS & LUP, Nagpur. Soil nutrient database is classified into different class ranges suitable for local conditions. The classified data were interpolated following simple kriging in GIS environment. Raster file of each nutrient data was linked with cadastral map. Finally, plot wise and farmer wise soil health cards were prepared. For example, we have collected grid wise samples from 5,000 sites in Kelapur block. We were able to developed only 5,000 SHCs by actual soil testing. After extrapolating these results using GIS technique we would be able to issue SHCs to all the farmers (29,000 farmers) of Kelapur block.



Soil Fertility Maps of Kelapur Taluka, Yavatmal district (Maharashtra).

Field visits for technology dissemination

Capacity Building of NARS

ICAR sponsored short course training was imparted to the employees of ICAR and SAUs to replicate the technique in their respective regions.

SUMMARY

Grid wise soil sampling with geographical coordinates, analyzing the samples with great precision and accuracy give better results to produce digital soil fertility maps and SHCs. GIS techniques can reduce the cost of SHC generation and helps in fastening the process of dissemination in farming community and advance farm inputs planning.

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Microbial mediated *in situ* crop residue decomposition

In rice-wheat cropping system, huge quantities of rice straw are left for disposal after harvest of the crop and most of this remains unutilized in the field, encouraging the farmers to burn it especially in areas where the succeeding crop is to be sown only after a few days. The microbial consortia of two efficient and compatible halophilic bacterial lingo-cellulolytic strains having plant growth promotion traits were prepared in suitable standardized media as bio-formulation 'Halo-CRD' as decomposer for crop residues. These efficient degrading microbes can decompose crop residues and help in build up of soil carbon that can facilitate reclamation of sodic and saline-sodic soils.

Inocula of consortia of CDMs along with whey resulted in decrease of stubble weight by 46.7% with maximum reduction of 59.8% compared to the initial weight of stubble. The C:N ratio of the residue material (stubbles and straw) decreased to 24:1 from 66.5:1, 35 days after inoculation of consortia with whey. The *in situ* degradation of paddy residue also significantly enhanced the yield of succeeding wheat crop. Three season data indicated that inoculation of residue with consortia of degrading microbes along with whey helps in faster *in situ* degradation of paddy residues. The outcome of the study will facilitate utilization of the residues for recycling nutrients, enhance soil microbial activity and C enrichment to promote bio-remediation apart from saving energy that helps in achieving desired level of production and health management of salt-affected soils.

Source: DARE-ICAR Annual Report 2019-20