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Soil Health Security in India: Insights from Soil Health Card Data

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ABSTRACT

This study has made an attempt to assess the soil nutritional status of various states in India using secondary data collected from the Soil Health Card portal. The study finds that due to the unbalanced use of micro and macro fertilizers, the health of the soil is continuously deteriorating across the states and ecological regions. Farmers are deliberately using chemical fertilizers in the states, where insured irrigation is available. This not only deteriorating soil health but also increasing input cost and causing long chronical diseases. Lack of awareness also a vital reason behind the unbalanced use of fertilizers. The farmer is injecting the same amount of fertilizers in the soil as they injected 20 years ago. However, soil chemical property has been changed, when land is either converted from irrigated to rainfed or rainfed to irrigate. Therefore, this study recommends that there is a need of adopting a holistic approach to match the soil fertilizer demand with supply.

1. Introduction

Agriculture is the backbone of Indian economy as it contributes about 13.9% to the total gross domestic product (GDP) and provides employment to over 54.6% of the total population. Over the last few decades India has successfully transformed itself from a food deficit country to one which is essentially self-sufficient in availability of food grains. This success resulted from the 'Green Revolution' (GR), technological interventions in agriculture. Expansion of irrigation, hybrid crops and use of chemical fertilisers and pesticides were the major technological interventions of GR which boosted Indian agriculture (Ali et al., 2015). Although, GR has played a leading role in making the country self-sufficient in food grains, it has created some adverse effects, which are of serious concern.). Since the inception of GR there has been a race for increasing food grain (mainly cereals) production using chemical fertilisers in India. However, cereal production in the country increased only fivefold, while consumption of fertilisers increased 322 time during 1951-2007-08 period, implying a very low fertiliser use efficiency (Prasad, 2009). The negative effects includes, soil degradation, increased salinity, desertification, destruction of soil fertility, micronutrient deficiency, soil toxicity, insect resistance to pesticides and contamination of water bodies, which are challenging the sustainability of conventional agriculture (Chakraborty et al., 2016). Large-scale applications of fertiliser nitrogen have also shown deleterious effects on groundwater quality, especially its nitrate content, which is harmful to health. Also, gaseous losses of H as NH_3 resulting from N fertilization have adverse effects on the environment.

Moreover, soils of agro-ecosystems of India are degraded, depleted and severely devoid of the soil organic carbon (SOC) pool which is often <1g Kg^{-1} or barely 10 to 15 Mg C ha^{-1} to 40 cm depth (Lal, 2015). Thus crop yields are low, water and air resources are polluted, and the overall environment is degraded. Indeed, environmental sustainability in India remains a major issue to be addressed. Concentration of SOC is a strong determinant of soil quality. Further, soil quality also impacts those of plants and animals, and thus, health of human population.

With the relevance of soil nutrition security in the agriculture, there is a need to identify those areas, where soil severely affected to excess use of micro-macro fertilisers. Also, there is need to identify areas, where soil has deficiency of micro-macro nutrients. With these key concern issues keeping in mind, this study made an attempt to identify soil nutritional vulnerable area in India.

2. Materials and Method

2.1 Study Area

India, located in South Asia, is bordered by the Bay of Bengal, the Arabian Sea, the Indian Ocean, Pakistan, Bhutan, China, Nepal, Burma and Bangladesh. India is the world's 7^{th} largest country by area and 2^{nd} most populous country with more than 1.3 billion residents (world population reviewer, 2018). It has 3287469 square kilometre area with 943 gender ratio and 382 population density per square kilometre (Census, 2011). Further, India has geographically divided into 15 agro-climate zones (ACZs), 36 states and 640 districts.

2.2 Data Sources

This study uses secondary data collected from Soil health card (SHC)and Fertilisers Quality Control System (FQCS) portals. The SHC is a printed report that will be given to farmers once in three years for each of his or her land holding. It will include all the essential information on macro nutrients in the soil, secondary nutrients, micro nutrients, and physical parameters. Finally, the cast will also contains an advisory on the corrective measures that a farmer should follow up to improve soil health and crop yield. Further, the FQCS provides information on the quality of imported fertilisers at ports while states check the quality of indigenously manufactured fertilisers. Maintaining the soil health is a worrying issue that is needed to be worked upon in our country to improve food security, enhance agricultural productive and create rural employment opportunities.

2.3 Estimation Method

The indicator-based approach is used in a specific set or combination of indicators, measures the vulnerability by computing indices, average or weighted averages for those selected variables or indicators. The suitability of this approach is that it can be applied at any scale, such as household, district and country level (Malone and Engle, 2011). Using Iyenger and Sudharshan (1982) methodology, indicators were first normalized to the scale of 0 and 1, premised on their functional relationship with the dimension. For positive indictor equation (1) was employed.

$$CZI_f = \frac{K_i - K_{min}}{K_{max} - K_{min}} \qquad (1)$$

Here CZI_f is the original sub component for the district ***i*** and $K_{max} - K_{min}$ are the minimum and maximum values respectively. For each subcomponent determined using data from all the states. Further, if predicted value of a subcomponent is negatively associated with soil nutritional security, the standardization- the index is calculated using equation (2).

$$CZI_f = \frac{K_i - K_{max}}{K_{min} - K_{max}} \qquad (2)$$

After each component was standardized, the mean of each sub-components is estimated by using the equation 3 to calculate the value of each major component.

$$K_h = \frac{\sum_{i=1\ index}^{n} K_f^i}{n} \qquad (3)$$

Where, K_h is one of the two components of the state h, micro nutrientsand macro nutrients, index K_f^i represents the sub-components indexed by *i*, that make up for each major component, and *n* is the number of subcomponents in each major component. Lastly, quantile estimation also done to categorise states into four categories, low (0-25th percentile), medium (26-50th percentile), high (51- 75th percentile) and Very high (76-100th percentile) based on nutritional status.

3. Results and Discussion

3.1 Status of Micro nutrients in India

Six micro nutrients viz., boron, manganese copper iron zinc and sulphur are taken as a minor nutrients to assess the nutritional status of the various states (Table 1). States pertaining in the north-eastern part of Indian show low nutritional status. Also, high yielding states, viz., Punjab and West Bengal show low nutritional status. Low nutritional status is also highly irrigated states, that means high yielding and high irrigational states are injecting major fertilisers, viz., nitrogen, phosphorus, and potassium to enhance productivity of the crops. Further, rainfed states, viz., Chhattisgarh, Gujarat, Haryana, Jammu & Kashmir, Jharkhand, Tripura and Uttar Pradesh are find medium status of minor nutrients in the soil. While, state, which have high yield, but low irrigation coverage, deliberately injecting macro fertilisers to boost productivity. Lastly, states pertaining in the southern peninsula, soil has highest nutritional security.

Table 1: State wise state wise status of micro nutrients in the soil

State	Boron	Manganese	Copper	Iron	Zinc	Sulphur	Minor Nutrients	Degree of Nutrition
AndhraPradesh+ Telangana	0.468	0.745	0.638	0.043	0.511	0.340	0.427	Low
Bihar	0.189	0.189	0.162	0.757	0.243	0.054	0.253	Low
Manipur	0.125	0.063	0.125	0.125	0.188	0.063	0.116	Low
Meghalaya	0.182	0.273	0.273	0.273	0.273	0.318	0.351	Low
Mizoram	0.625	0.625	0.625	0.375	0.625	0.250	0.482	Low
Punjab	0.320	0.480	0.480	0.480	0.960	0.200	0.441	Low
West Bengal	0.217	0.522	0.652	0.957	0.435	0.130	0.478	Low
Arunachal Pradesh	0.100	0.600	0.500	0.750	0.550	0.275	0.496	Medium
Assam	0.029	0.706	0.794	0.794	0.794	0.397	0.569	Medium
Karnataka	0.500	0.933	1.000	0.567	0.533	0.350	0.594	Medium
Maharashtra	0.914	0.914	0.914	0.286	0.571	0.400	0.595	Medium
Odisha	0.267	0.567	0.767	0.933	0.900	0.417	0.573	Medium
Rajasthan	0.559	1.000	1.000	0.618	0.588	0.250	0.585	Medium
Tamil Nadu	0.500	0.938	1.000	0.781	0.750	0.422	0.637	Medium
Chhattisgarh	0.857	0.679	0.714	0.964	0.857	0.411	0.668	High
Gujarat	0.971	0.794	0.794	0.912	1.000	0.471	0.750	High
Haryana	0.773	0.955	0.955	0.864	0.955	0.477	0.713	High
Jammu & Kashmir	0.864	0.545	0.909	0.773	0.818	0.432	0.735	High
Jharkhand	0.739	0.783	0.826	0.913	0.696	0.326	0.663	High
Tripura	0.875	0.500	0.500	0.875	0.875	0.438	0.656	High
Uttar Pradesh	0.851	0.851	0.959	0.878	0.784	0.351	0.671	High
Himachal Pradesh	0.833	0.833	0.917	0.833	0.917	0.500	0.815	Very High

Kerala	0.286	1.000	1.000	1.000	1.000	0.214	0.776	Very High
Madhya Pradesh	0.880	0.900	0.920	0.920	0.740	0.450	0.751	Very High
Nagaland	0.545	1.000	0.727	1.000	0.818	0.500	0.799	Very High
Sikkim	0.750	0.750	1.000	1.000	1.000	0.250	0.821	Very High
Utttarakhand	0.692	1.000	1.000	1.000	1.000	0.462	0.824	Very High

Source: Estimated from Soil Health Card Portal.

3.2 Status of Macro nutrients in India

After the GR, use of Nitrogen, Phosphate and potassium (NPK) contains fertilisers has been increased manifold. Because use of NPK is directly associated with the irrigation coverage. Therefore, high irrigation coverage states are the first gainers. Although, farmers in these states deliberately used Urea as a primary fertiliser to boost crop productivity. But once they realized that the unbalance of fertilizer, especially chemical fertilizers (NPK) are adversely affected to the soil quality and causing health diseases. They shifted their fertiliser consumption in favour of bio fertilisers. Data for macro nutrients is collected during 2017-19, which is most recent period. This trend is identified in the table 2. Haryana and West Bengal are the state, where farmers nowadays deliberately shifting their fertiliser consumption in favour of micro nutrients. While, Bihar and Rajasthan are the states where lack of timely accessibility of these fertilisers and black-marketing are two reasons for not a using balance NPK ratio. Further, it was found that north-eastern states also changing their fertiliser consumption in favour of bio fertilisers. Cropping pattern also has key determinant for soil nutritional security. Farmers in the states like, Arunachal Pradesh, Chhattisgarh, Jharkhand, Madhya Pradesh, Punjab, Tamil Nadu and Tripura grown medium yielding crops, viz., rice, wheat and sugarcane in the areas, where insured irrigation is available. In these states, farmers find that judiciously using macro fertilisers to maintain crop production and soil status balance. Interestingly, it finds that farmers in the costal and western Himalayan states, viz., Assam, Gujarat, Himachal Pradesh, Karnataka, Kerala, Odisha and Uttar Pradesh are using higher amount of NPK as require. These not only reducing soil fertility, but also major reason for long chronical diseases. Lastly, farmers in the Andhra Pradesh including Telangana, Jammu & Kashmir, Maharashtra, Mizoram, Nagaland, and Uttarakhand are using much higher amount of fertilisers from the recommended quantity. This not only reducing soil fertiliser, but also increasing input cost.

Table 2: State wise status of Macro nutrients in India

State	Nitrogen	Phosphorus	Potassium	Major Nutrients	Degree of Nutrient
Bihar	0.014	0.020	0.034	0.023	Low
Haryana	0.091	0.091	0.193	0.125	Low
Manipur	0.016	0.016	0.016	0.016	Low
Meghalaya	0.114	0.114	0.182	0.136	Low
Rajasthan	0.000	0.000	0.015	0.005	Low
Sikkim	0.000	0.000	0.000	0.000	Low
West Bengal	0.000	0.000	0.033	0.011	Low
Arunachal Pradesh	0.375	0.100	0.250	0.242	Medium
Chhattisgarh	0.036	0.054	0.607	0.232	Medium
Jharkhand	0.109	0.174	0.304	0.196	Medium
Madhya Pradesh	0.150	0.085	0.570	0.268	Medium
Punjab	0.180	0.180	0.230	0.197	Medium
Tamil Nadu	0.055	0.055	0.578	0.229	Medium
Tripura	0.188	0.188	0.156	0.177	Medium
Assam	0.287	0.338	0.235	0.287	High
Gujarat	0.103	0.132	0.691	0.309	High
Himachal Pradesh	0.146	0.292	0.583	0.340	High
Karnataka	0.233	0.233	0.550	0.339	High
Kerala	0.214	0.214	0.464	0.298	High
Odisha	0.208	0.208	0.467	0.294	High
Uttar Pradesh	0.233	0.233	0.459	0.309	High
Andhra Pradesh+ Telangana	0.037	0.585	0.649	0.424	Very High
Jammu & Kashmir	0.534	0.534	0.409	0.492	Very High
Maharashtra	0.171	0.157	0.943	0.424	Very High

Mizoram	0.375	0.438	0.438	0.417	Very High
Nagaland	0.432	0.432	0.205	0.356	Very High
Utttarakhand	0.346	0.346	0.519	0.404	Very High

Source: Estimated from Soil Health Card Portal

4. Conclusion and Policy Recommendation

This study has made an attempt to assess the soil nutritional status of various states in India using secondary data collected from the Soil Health Card portal. The study finds that due to the unbalanced use of micro and macro fertilizers, the health of the soil is continuously deteriorating across the states and ecological regions. Farmers are deliberately using chemical fertilizers in the states, where insured irrigation is available. This not only deteriorating soil health but also increasing input cost and causing long chronical diseases. Lack of awareness also a vital reason behind the unbalanced use of fertilizers. The farmer is injecting the same amount of fertilizers in the soil as they injected 20 years ago. However, soil chemical property has been changed, when land is either converted from irrigated to rainfed or rainfed to irrigate. Therefore, this study recommends that there is a need of adopting a holistic approach to match the soil fertilizer demand with supply.

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