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Assessment of Soil Nutrients in Haryana: An Inter-District Level Analysis

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A B S T R A C T

Soil is considered as a storehouse of various macro and micro nutrients that provide a backbone to the agricultural activities. It also lends a natural base to support spatial economic ventures of human beings. As far as the question of crop productivity is concerned, it gets highly influenced by the availability of nutrients in the soil. Needless to mention, certainly a healthy soil with adequate nutrient balance helps the plant to withstand certain level of calamities and also possess the capacity of higher production than a poor soil. To evaluate the status of nutrients in Haryana, the nutrients index at the district level is constructed for the two times periods (2015-17, 2017-19). In general, the whole state is deficient in micronutrients. The availability of phosphate has reduced to the half of the value in the successive cycle. In paddy cultivation areas, intensive paddy cultivation has caused zinc deficiency. The other micronutrients are depleting at a faster rate. Therefore, it has been seen that multi-nutrient deficiency has emerged as a serious threat for the farmers and policy makers alike across the districts of Haryana.

***Key words*:** Soil nutrient, Nutrient index, Soil fertility, Deficiency, Agricultural activities

The state of Haryana has a significant share in the national food basket particularly in the cereal crops of rice and wheat. The tracts of land available for agriculture are limited and accelerating population growth rates has given birth to the expansion of human settlement units and led to the accentuation of the problem of food availability and hence security. Soil is a naturally available resource for various agricultural activities. In the past few decades, the intensive cultivation has helped to achieve higher crop productivity rate but the management of soil has largely been neglected. The practice of crop rotation for replenishment of nutrients has been limited and use of organic manure has also become almost negligible. These phenomena have together led to the substantial decline in the availability of nutrients in the soil. The soil degradation is not a naive problem to the agricultural base in the state of Haryana. Initially, the soil fertility could be regained by using the nitrogenous (N) fertilizers alone, as the other essential nutrients were already stored in the soil. However, within a short span of period, the nutrient reserves of soil were exhausted and it was no longer possible to sustain the higher yields even by applying both N and phosphorus (P) [1-2]. The nature and extent of micronutrient deficiencies vary with soil type, crop genotype, management and agro-ecological situations. With the intensive cropping of high yielding varieties of rice and wheat in Haryana, deficiency of zinc (Zn) initially, and subsequently deficiencies of iron (Fe) in rice and manganese (Mn) in wheat emerged as threats to sustaining high levels of food grain production [3]. In the high cropping intensity areas, the deficiency of micro and macro nutrients is crucial for analysis. The spatial and temporal status of nutrients in soil, determines the competency of soils to fulfill the nutrient requirement of the crops adequately.

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MATERIALS AND METHODS

Haryana stretches over an area of 44,212 square kilometers, which constitutes 1.34 percent of India's total geographical area. The latitudinal (27°39' N to 30°35' N) and longitudinal extent (74°28' E to 77°36' E) of the study area is depicted in the below given (Fig 1).

The study is based on secondary data obtained from Ministry of Agriculture and Farmers Welfare, Government of India. The nutrient index of soil has been evaluated for the two time periods (2015-17 and 2017-19) at the district level. The data for Charki Dadri district is included in Bhiwani as former was recently carved out of later in the year 2016. The year 2015 earmarked as International Year of Soil was also the foundation year of Soil Health Card (SHC) scheme in the country. It is in this milieu; the present study has been carried out to ascertain the soil nutrient status across the districts of Haryana state. Thus, the same year i.e., 2015 have been taken as base year in this study. The

district wise nutrient index has been evaluated by using the following formula:

$$\text{Nutrient Index (N.I.)} = (NL \times 1 + NM \times 2 + NH \times 3) / NT$$

NL: Indicates number of samples falling in low class of nutrient status.
NM: Indicates number of samples falling in medium class of nutrient status.
NH: Indicates number of samples falling in high class of nutrient status.
NT: Indicates total number of samples analyzed for a given area.

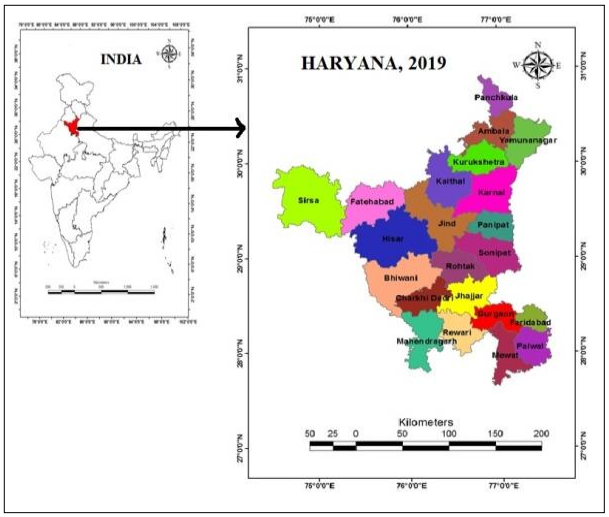

Fig 1 The location of study area

Nutrient index value (NIV) is the measure of nutrient supplying capacity of soil to plants [4]. Nutrient index analysis for the study area revealed that soil status was low to medium. The nutrient index approach was first introduced by Parker *et al*. [5] which has been adopted by many scholars.

Table 1 Rating chart of nutrient index

Index	Range	Remarks
I	< 1.67	Low nutrient status
II	1.67 – 2.33	Medium nutrient status
III	>2.33	High nutrient status

Source: Parker *et al*. [5]

RESULTS AND DISCUSSION

Fertility is a major outcome of the available nutrients in the soil. In order to evaluate the nutrient status in Haryana, the nutrient index values of various macro (N, P, K) and micro nutrients (Zn, Fe, Cu, Mn, B, S) are analyzed and presented in the (Fig 2, Table 2-3).

A: Status of nutrients

Nitrogen: Soil is a major reservoir of all essential nutrients for the plant. The deficiency of nitrogen is ubiquitous. The nitrogen is used in abundance by most of the crop plants. Due to the low status of nitrogen availability in Haryana, crops (which one mention) show diminishing response to nitrogenous fertilizers. The deteriorating soil health can be naturally fixed by growing leguminous crops but the pulses have been overtaken by rice-wheat pattern cultivation in the area.

Phosphorous

All the districts except Panchkula during the cycle 2015-16 to 2016-17 shows low status of phosphorous in the soil. When compared to the next cycle (2017-18 to 2018-19), the values have marginally fluctuated. In general, all the districts have declined in soil nutrient of phosphorus barring ten districts. These are Ambala, Bhiwani, Jhajjar, Karnal, Kurukshetra, Mahendragarh, Palwal Panipat, Rewari, Sirsa and Sonipat. The increase in the nutrient content of the soil can possibly be ascribed to the better soil and water management practices like, organic manure, crop residue, improved irrigation system-sprinklers and drip irrigation. In addition, use of organic manure and compost, enrich the soil with minerals and makes it easy for plants to absorb. Phosphorous is a water-soluble nutrient. It is very essential for the plant growth and photosynthesis process but the application of phosphate fertilizer has to be limited. Over the period of time, phosphate fertilizers cause cadmium to accumulate in the soil which increases the risk of uptake by crops and transfer through the food chain [6]. Application of excessive fertilizer to a soil can result in losses of phosphate to ditches, streams and rivers and lakes, causing negative effects on ecosystem due to excessive nutrients and eutrophication [7]. These have also been noticed significantly.

Potassium: Potassium is one of the three essential nutrients along with nitrogen and phosphorous. The nutrient index values indicate low status of nutrient but to surprise potassium availability in the soil is declining at such a faster rate that in all the districts the availability has reduced to almost half the value in the next cycle. The probable cause is the increasing pH value of soil due to inappropriate doses of potassium along with nitrogen and phosphorous. Farmers aiming high net return use fertilizers beyond the recommended doses. The overdose of potassium is more threatening for soil management practices, then nitrogen and phosphorous. The nitrogen and phosphorous fertilizers show their immediate benefits to the plant while potassium benefits are realized at the maturity which takes longer times.

Zinc: Zn is ranked as fourth essential element next to N, P and K for the growth of agricultural crops [8]. Zinc and phosphorus have a relationship with the soil. Several studies indicate that excessive application of phosphorus fertilizer causes the zinc deficiencies in the soil. The data in (Table 1) explicitly depicts the increase in phosphorus which is corresponding with the decrease in zinc during the cycle 2017-18 to 2018-19 when compared to previous study cycle. In the two districts of Karnal and Panipat, the value of nutrient index has increased because of application of zinc fertilizer during the paddy season. The other districts of the rice belt in Haryana have shown a slower rate to the decrease in deficiency of nutrient level in the soil. The zinc sulphate consumption in the state is reported to be 14,651 tonnes making it third largest zinc sulphate user state after Punjab and Andhra Pradesh [9]. However, detailed soil and crop analysis can predict the other probable causes for the occurrence of deficiencies. Most of the farmers use chelated zinc to overcome the deficiency, but the poultry and piggery manure can be a sustainable way to supply the soil nutrients in the longer run. This practice may be beneficial as far as environmental sustainability of agricultural practices is concerned.

Table 2 District-wise distribution of nutrient index values in Haryana

Districts	Nitrogen		Phosphorus		Potassium		Zinc		Iron		Copper		Manganese		Boron		Sulphur	
	2015-17	2017-19	2015-17	2017-19	2015-17	2017-19	2015-17	2017-19	2015-17	2017-19	2015-17	2017-19	2015-17	2017-19	2015-17	2017-19	2015-17	2017-19
Ambala	1.00	1.03	1.43	1.63	1.32	0.59	1.91	1.46	1.88	1.78	1.88	1.93	1.38	1.30	1.79	1.66	1.87	1.77
Bhiwani	1.00	1.00	1.29	1.41	1.27	0.47	1.65	0.92	1.47	1.43	1.47	1.93	1.30	1.44	2.00	1.57	1.78	1.90
Faridabad	1.00	1.01	1.01	1.00	1.61	0.45	1.96	1.96	1.98	1.97	1.98	2.00	1.98	1.99	2.00	2.00	2.00	2.00
Fatehabad	1.00	1.00	1.25	1.26	1.37	0.56	1.71	1.33	1.53	1.33	1.53	1.95	1.31	1.38	0.40	1.96	1.96	1.90
Gurgaon	1.00	1.00	1.43	1.23	1.27	0.50	1.93	1.57	1.64	1.79	1.64	1.95	1.79	1.75	1.98	1.97	1.97	1.94
Hissar	1.00	1.00	1.48	1.29	1.34	0.42	1.81	1.39	1.69	1.44	1.69	1.98	1.71	1.71	1.73	1.99	1.99	1.97
Jhajjar	1.00	1.02	1.10	1.33	1.42	0.60	1.79	1.20	1.72	1.61	1.72	1.94	1.71	1.61	2.00	1.93	1.93	1.90
Jind	1.00	1.00	1.07	1.11	1.22	0.40	1.90	1.45	1.93	1.82	1.93	1.99	1.77	1.68	1.92	1.99	1.99	1.92
Kaithal	1.00	1.00	1.43	1.08	1.41	0.55	1.90	1.24	1.92	1.58	1.92	1.99	1.49	1.27	1.00	1.95	1.95	1.89
Karnal	1.00	1.00	1.11	1.58	1.32	0.44	1.73	1.79	1.67	1.85	1.67	1.98	1.06	1.73	1.77	1.75	1.75	1.96
Kurukshetra	1.00	1.02	1.05	1.09	1.37	0.54	1.95	1.73	1.86	1.86	1.86	1.98	1.63	1.59	1.99	1.97	1.97	1.92
Mahendragarh	1.00	1.00	1.03	1.14	1.51	0.54	1.94	1.38	1.66	1.32	1.66	1.95	1.72	1.82	1.98	1.95	1.95	1.83
Mewat	1.00	1.00	1.29	1.28	1.31	0.56	1.86	1.59	1.70	1.73	1.70	1.94	1.54	1.76	1.98	1.77	1.77	1.88
Palwal	1.00	1.00	1.01	1.26	1.40	0.44	1.97	1.46	1.92	1.60	1.92	1.97	1.82	1.50	1.93	1.98	1.98	1.88
Panchkula	1.00	1.00	1.85	1.11	1.31	0.47	1.93	1.92	1.93	1.95	1.93	1.99	1.66	1.81	0.75	1.93	1.93	1.97
Panipat	1.00	1.00	1.29	1.48	1.24	0.58	1.82	1.97	1.82	1.83	1.82	1.99	1.69	1.66	2.00	1.89	1.89	1.97
Rewari	1.00	1.00	1.10	1.18	1.15	0.70	1.91	1.33	1.70	1.71	1.70	1.95	1.67	1.72	2.00	1.93	1.93	1.96
Rohtak	1.00	1.00	1.33	1.29	1.41	0.60	1.65	1.58	1.54	1.62	1.54	1.94	1.28	1.57	1.56	1.81	1.81	1.85
Sirsa	1.00	1.02	1.13	1.27	1.57	0.43	1.61	1.39	1.47	1.41	1.47	1.95	1.46	1.54	0.53	1.93	1.93	1.94
Sonipat	1.00	1.00	1.05	1.08	1.56	0.50	1.65	1.19	1.63	1.38	1.63	1.98	1.19	1.35	1.00	1.99	1.99	1.99
Yamunanagar	1.00	1.00	1.21	1.02	1.23	0.93	1.86	1.45	1.96	1.93	1.96	1.99	1.52	1.83	1.99	1.96	1.96	1.94

Table 3 District-wise Distribution of Soil Nutrients in Haryana

Districts	2015-16 to 2016-17		2017-18 to 2018-19	
	Deficient	Moderate	Deficient	Moderate
Ambala	N, P, K, Mg	Zn, Fe, Cu, B, S	N, P, K, Zn, Mg, B	Fe, Cu, S
Bhiwani	N, P, K, Fe, Cu, Mg	Zn, B, S	N, P, K, Zn, Fe, Mg, B	Cu, S
Faridabad	N, P, K, Mg	Zn, Fe, Cu, B, S	N, P, K	Zn, Fe, C, Mg, B, S
Fatehabad	N, P, K, Fe, Cu, Mg, B	Zn, S	N, P, K, Zn, Fe, Mg,	Cu, B, S
Gurugram	N, P, K, Fe, Cu	Zn, Mg, B, S	N, P, K, Zn, Fe, B	Fe, Cu, Mg, S
Hisar	N, P, K	Zn, Fe, Cu, Mg, B, S	N, P, K, Zn, Fe	Cu, Mg, B, S
Jhajjar	N, P, K	Zn, Fe, Cu, Mg, B, S	N, P, K, Zn, Fe, Mg, B	Cu, S
Jind	N, P, K	Zn, Fe, Cu, Mg, B, S	N, P, K, Zn, B	Fe, Cu, Mg, S
Kaithal	N, P, K, Mg, B	Zn, Fe, Cu, S	N, P, K, Zn, Fe Mg, B	Cu, S
Karnal	N, P, K, Mg	Zn, Fe, Cu, B, S	N, P, K, B	Zn, Fe, Cu, Mg, S
Kurukshetra	N, P, K, Mg	Zn, Fe, Cu, B, S	N, P, K, Mg, B	Zn, Fe, Cu, S
Mahendragarh	N, P, K, Fe, Cu	Zn, Mg, B, S	N, P, K, Zn, Fe, B	Cu, Mg, S
Mewat	N, P, K, Mg	Zn, Fe, Cu, B, S	N, P, K, Zn	Fe, Cu, Mg, B, S
Palwal	N, P, K	Zn, Fe, Cu, Mg, B, S	N, P, K, Zn, Fe, Mg, B	Cu, S
Panchkula	N, K, Mg, B	P, Zn, Fe, Cu, S	N, P, K, Zn, B	Fe, Cu, Mg, S
Panipat	N, P, K	Zn, Fe, Cu, Mg, B, S	N, P, K, Mg, B	Zn, Fe, Cu, S
Rewari	N, P, K	Zn, Fe, Cu, Mg, B, S	N, P, K, Zn, B	Fe, Cu, Mg, S
Rohtak	N, P, K, Zn, Fe, Cu, Mg, B	S	N, P, K, Zn, Fe, Mg, B	Cu, S
Sirsa	N, P, K, Zn, Fe, Cu, Mg, B	S	N, P, K, Zn Fe, Mg,	Cu, B, S
Sonipat	N, P, K, Zn Fe, Cu, Mg, B	S	N, P, K, Zn Fe, Mg, B	Cu, S
Yamunanagar	N, P, K, Mg	Zn, Fe, Cu, B, S	N, P, K, Zn	Fe, Cu, Mg, B, S

Iron: Though the iron content is abundant in soil but it is not available for the plant absorption [10]. The districts of south western zone in Haryana are prone to iron deficiency. Owing to the calcareous nature of soil, districts namely Bhiwani, Fathebad, Mahendergarh and Sirsa have registered more problems of iron deficiency. Calcareous soil has high pH value and iron availability decreases with increasing pH.

Copper: The deficiency of copper in Haryana is generally attributed to high pH and calcareousness of soils [11]. Haryana doesn't have a severe problem of copper

deficiency. The fodder crops are more sensitive to copper deficiencies. The cropping pattern has substantially shifted to the rice-wheat pattern; hence copper deficiency has not gained much attention in the state.

Manganese: Manganese deficiency is a widespread problem especially in a geographical region having sandy-loamy soil. It gets typically further worsened by the cool and wet conditions [12]. The districts of Ambala, Kaithal, Karnal, Kurukshetra, Rohtak and Sonepat owe the deficiency to over irrigation during paddy. Bhiwani, Fathebad, Sirsa faces manganese deficiency due to the texture of soil to some extent.

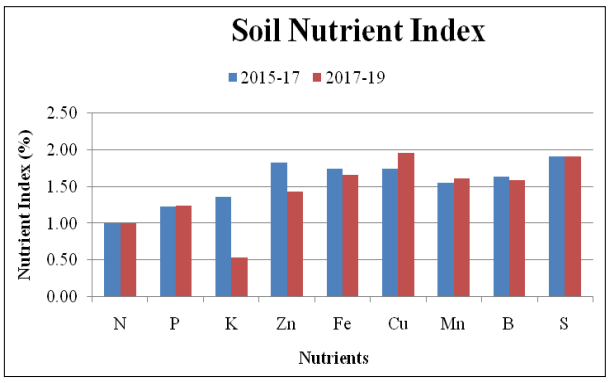

Fig 2 Graphical representation of nutrient index (2015-17 and 2017-19)

Boron: The boron requirement by the plant is less as compared to the other micronutrients. Generally, boron deficiency occurs in those soils which are highly leached and developed from calcareous alluvial and loess deposits [13]. The districts of Faridabad, Mewat and Yamunanagar show sufficient availability of soil nutrients during both the cycles under consideration.

Sulphur: The data shows that deficiency of Sulphur is not significant in the state of Haryana. It has the potential to meet the demands of the environmentally sustainable agricultural practices. If the current cultivation methods are not checked, then it may become susceptible to the deficiency problem in the future.

In general, the status of nitrogen and Sulphur has remained same during both the cycles. The values of phosphorus, copper and manganese have marginally increased during the second cycle while that of Potash, Zinc and Iron have drastically decreased over the period of time.

CONCLUSION

Macro nutrients are deficit ubiquitously in Haryana. During first cycle Zinc was found to be deficient only in three districts (Rohtak, Sirsa, and Sonipat) but in next cycle except Karnal, Kurukshetra and Panipat, the zinc deficiency has become a major problem in Haryana. The exception to Karnal, Kurukshetra and Panipat owes its cause to intensive paddy cultivation. A lot of fertilizers are used during paddy and some portions of fertilizers are preserved in soil as plant don't use whole of the nutrient in one agricultural season. Iron was in moderate quantity during the first cycle. However, during the second cycle, it was also found to be deficient mainly confined in the south-western parts of Haryana. The trio of soil nutrients encompassing Copper, Manganese and Boron didn't show deficiency problem during the two time periods taken in this study. However, they are also showing the sign of deficiency in some localized pockets with the passage of time. Sulphur is found to be available in moderate quantity during both the cycles.

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