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STATUS OF SECONDARY AND MICRONUTRIENT OF BLOCK HATHIN OF DISTRICT PALWAL (HARYANA)

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SUMMARY

Micronutrients play an important role in plant growth and required for the quality produce of food and fodder. To examine the secondary and micronutrient status of Hathin block soils of Palwal (Haryana), 50 surface soil samples were collected with the help of an auger and the coordinates of each sample were recorded with global positioning system. The results revealed that the mean exchangeable calcium and magnesium contents in soil were 4.64 and 9.19 cmol (p^-)/kg, respectively, while the mean sulfur content was 58.16 mg/kg. The average concentrations of DTPA-extractable zinc, iron, copper, manganese, and hot water-soluble boron was 0.47, 6.67, 0.69, 5.35, and 1.40 mg/kg, respectively. Most of the soil samples were deficient in DTPA-extractable zinc and iron. Significant positive correlation of organic carbon was observed between copper and boron.

Key words: Zinc, copper, iron, manganese, sulfur and hot water-soluble boron

The significance of balanced plant nutrition in achieving sustainable agricultural production is well recognized. However, modern agricultural practices often deplete soil nutrients due to intensive tillage, continuous monocropping, the use of high-yielding varieties, imbalanced fertilization, limited application of organic manures, minimal recycling, crop residue burning, soil erosion, uneven topography, and unregulated irrigation practices. To sustain soil fertility in the long term, it is crucial to integrate the balanced use of organic amendments, chemical fertilizers, and biofertilizers. The availability of both macro and micronutrients to plants is significantly affected by various soil characteristics, and different cropping systems are better suited to specific soil types for optimal production and productivity. To identify the causes of nutrient deficiencies, it is essential to establish correlations between the physico-chemical properties of soils and the availability of secondary and micronutrients (Singh *et al.*, 2014). The widespread need for the micronutrients observed in recent years can be accounted for in three ways viz. i) Naturally deficient in some soil types ii) their deficiency has been brought out by crop removal and iii) widespread erosion together with destruction of soil organic matter has also brought about their removal from the soil. (Vijayakumar *et al.* 2011) Considering all the above facts a study was made in Hathin block in Palwal district of Haryana. This study aims to assess the soil nutrient status along with their spatial variability and to establish their relationship with soil properties. The results will provide valuable insights for site-specific nutrient management strategies, ensuring sustainable agricultural productivity and long-term soil health improvement. Furthermore, the findings will contribute to the growing body of research on soil fertility in semi-arid regions, offering scientific guidance for policymakers, researchers, and farmers to adopt improved soil management practices. Since, the nutrient status of soil reflects its capacity to supply nutrients to crops hence this approach aims to provide a comprehensive understanding of the region's soil health and support the development of targeted nutrient management strategies.

MATERIALS AND METHODS

Site description

The study was carried out in the Hathin block of Palwal district, situated in the southern region of Haryana. Geographically, Hathin is positioned at 28°05′00″N latitude and 77°23′33″E longitude, with an average altitude of 190 meters (about 620 feet). The area experiences an extreme climate, with summer temperatures averaging 36°C and winter temperatures typically around 15°C. The soils in this region are predominantly alluvial belonging to the productive Indo-Gangetic plain. Major crops cultivated in this area are wheat, rice, sugarcane and cotton along with substantial cultivation of pulses, vegetables, and fruits. Approximately 90% of the agricultural land is irrigated, primarily using groundwater and the western Yamuna canal.

Soil Sampling and Analysis

Fifty surface soil samples (0-15 cm depth) randomly collected from farmers' fields of different villages of Hathin block. Location of each sample was georeferenced with handheld GPS device. Collected soil samples were air-dried, crushed with a wooden pestle and mortar, and sieved through a 2 mm sieve. Processed soil samples were analysed for pH and electrical conductivity (EC) by method given by Jackson, 1973, organic carbon (OC) was determined by wet digestion method (Walkley and Black, 1954), calcium carbonate ($CaCO_3$) was determined according to (Puri, 1930). Available Ca and Mg determined by versenate titration method given by (Cheng, 1951). Sulfur (S) was estimated by using calcium chloride and analyzed using spectrophotometer at 420 nm (Chensin and Yien, 1950). The DTPA-Extractable micronutrients (Zn, Fe, Cu and Mn) were determined using the method given by Lindsay and Norvell, 1978 and their content was estimated on an atomic absorption spectrophotometer (AAS). The hot water-soluble boron was estimated by method given by Berger, 1939 and content was estimated on UV-VIS spectrophotometer.

Data Visualization: Site map (Fig. 1) was prepared using ArcGIS software (Esri). The correlation graph were prepared using *corplot* package (Simko,W. T., 2024) in R Software (Team R, 2021) and other graphs were prepared using Micrsoft excel software (2021).

RESULT AND DISCUSSION

Soil pH

In the Hathin block, soil pH ranged from 8.50 to 9.40, reflecting slightly to moderately alkaline conditions (Table 2). This alkalinity may result from the interaction between applied fertilizers and soil colloids, which enhances the retention of basic cations within the soil's exchange complex (Prem *et al.*, 2017).

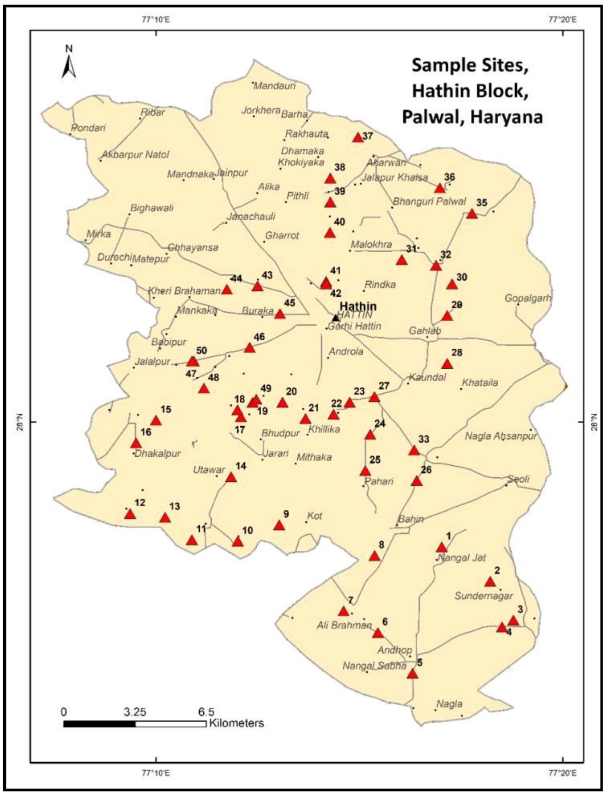

Fig. 1. Sample site map of Hathin block (Palwal).

Electrical conductivity

Electrical conductivity varied between 0.12 and 4.41 dS/m, with an average value of 1.79 dS/m (Table 2). The generally normal EC levels can be associated with the leaching of salts into deeper soil layers, indicating good soil quality and suitability for agricultural use (Prem *et al.*, 2017).

Soil organic Carbon

In the soils of Hathin block, organic carbon content ranged from 0.38% to 1.17%, with an average value of 0.77% (Table 2). Taking in to account the critical limits of organic carbon as low (<0.4%), medium (0.4– 0.75%), and high (>0.75%), it has been observed that only 2% soil samples had low organic carbon content, 46% in medium and 52% in high category (Fig. 2). The low organic carbon content in 2% of the samples may be due to the rapid decomposition of organic matter under hyperthermic conditions, leading to highly oxidative soil environments (Singh *et al.*, 2014).

Calcium carbonate

In the soils of Hathin block, calcium carbonate content ranged from nil to 3.10%, with an average of 0.06% (Table 2). The absence of calcium carbonate in most of the samples may be linked to intensive agricultural practices and the use of tubewell irrigation, which likely enhance the leaching of calcium carbonate, causing its accumulation in the deeper soil layers (Dinesh *et al.*, 2017).

Soil texture

In the Hathin block, soil texture was classified as sandy loam to loam (Table 2). This variation in texture can be attributed to differences in parent material and varying degrees of weathering (Sawhney *et al.*, 2000).

Status of secondary nutrients in Hathin block

Calcium and Magnesium

In the soils of Hathin block, Ca and Mg content ranged from 2.50 to 8.20 and 5.00 to 20.00 cmol (p^-)/kg, with a mean of 4.64 and 9.19 cmol (p^-)/kg, respectively (Table 2). None of the samples were found deficient in Ca and Mg. The sufficiency of these cations is attributed to minimal leaching of bases, moderate to high organic carbon levels. The high soil pH and calcareous nature further enhances cation retention (Pulakeshi *et al.*, 2012).

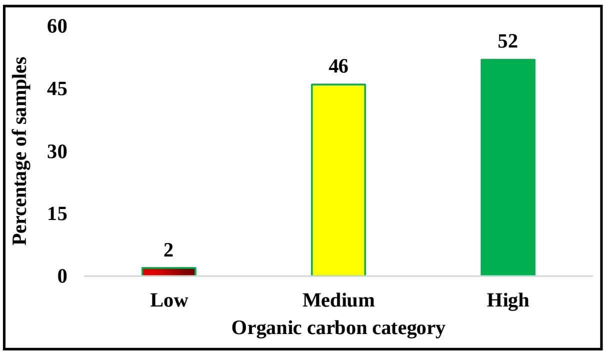

Fig. 2. Organic carbon status of Hathin block.

Sulphur

Sulfur content in the soils varied between 38.18 and 89.28 mg/kg, with an average of 58.16 mg/kg (Table 2). Based on the established soil test ratings for sulfur (Table 1), 6% of the samples were

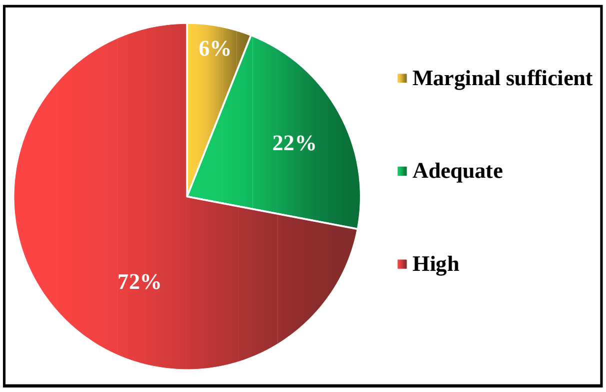

Fig. 3. Number of samples of sulphur (%) under different category in Hathin block.

TABLE 1

Critical limits of secondary and micronutrients in the soil (Shukla et al.,2019)

Nutrients	Acute	Deficient	Latent deficient	Marginal sufficient	Adequate	High
CaCl2-S	≤ 10	> 10 - ≤ 20	> 20 - ≤ 30	> 30 - ≤ 40	> 40 - ≤ 50	> 50
DTPA- Zn	≤ 0.3	> 0.3 - ≤ 0.6	> 0.6 - ≤ 0.9	> 0.9 - ≤ 1.2	> 1.2 - ≤ 1.8	> 1.8
DTPA- Fe	≤ 2.5	> 2.5 - ≤ 4.5	> 4.5 - ≤ 6.5	> 6.5 - ≤ 8.5	> 8.5 - ≤ 10.5	> 10.5
DTPA- Cu	≤ 0.2	> 0.2 - ≤ 0.4	> 0.4 - ≤ 0.6	> 0.6 - ≤ 0.8	> 0.8 - ≤ 1.0	> 1.0
DTPA- Mn	≤ 1	>1- ≤ 3	> 3 - ≤ 5	> 5 - ≤ 7	> 7 - ≤ 9	> 9
HWS- B	< 0.2	> 0.2 - ≤ 0.5	> 0.5 - ≤ 0.7	> 0.7- ≤ 0.9	> 0.9 - ≤ 1.10	> 1.10

TABLE 2

Soil fertility status of Hathin block

Parameters	Range	Mean	Parameters	Range	Mean
pH	8.50-9.40	8.23	S (mg/kg)	38.18-89.28	58.16
EC (dS/m)	0.12-4.41	1.79	Zn (mg/kg)	0.20-0.93	0.47
OC (%)	0.38-1.17	0.77	Fe (mg/kg)	2.21-12.39	6.67
CaCO3 (%)	Nil-3.10	0.06	Cu (mg/kg)	0.13-1.81	0.69
Ca {cmol (p) kg}	2.50- 8.20	4.64	Mn (mg/kg)	2.23-6.78	5.35
Mg {cmol (p^-)/kg}	5.00 -20.0	9.19	B (mg/kg)	0.23- 2.56	1.40

categorized as marginally sufficient, 22% as adequate, and 72% as high in sulfur content (Fig. 3). Since the majority of samples fell into the high category, it suggests an ample supply of this nutrient. The elevated sulfur levels in the soil may be due to favorable conditions, such as high pH and calcareousness, which enhance sulfur availability (Kondvilkar and Thakare, 2018).

Status of micronutrients in Hathin block

Zinc

The DTPA-extractable zinc content in the soils of Hathin block ranged from 0.20 to 0.93 mg/kg, with an average value of 0.47 mg/kg (Table 2). Based on the soil test ratings for zinc (Table 1), 12% of the samples were categorized as acutely deficient, 62% as deficient, 24% as latently deficient, and 2% as marginally sufficient (Fig. 4). None of the sample was found under the adequate or high zinc category. A significant proportion, accounting for 98% of the samples (acute deficient + deficient + latent deficient), indicated a widespread zinc deficiency. Zinc deficiency is more prevalent in arid regions where soils typically have low organic carbon content and high pH levels (Sharma *et al*., 2016). The 2% of samples categorized as marginally sufficient were likely collected from areas where farmers have recently adopted zinc fertilizer application.

Iron

The DTPA-extractable iron content in the soils of Hathin block varied from 2.21 to 12.39 mg/kg, with an average of 6.67 mg kg. According to the soil test ratings for available iron (Table 1), it has been reported that about 4% were found under acute deficient, 38% in deficient, 24% in latently deficient, 14% in marginally sufficient, 14% in adequate, and 6% in high iron content (Fig. 4). A significant portion of the samples, totaling 66% (acute deficient + deficient + latent deficient), exhibited iron deficiency. The limited availability of iron in these soils can be attributed to their alkaline nature and light-textured classification (Malik *et al.*, 2017). Additionally, moisture stress conditions may further contribute to low iron levels by facilitating the conversion of ferrous (Fe^{2-}) iron into its less available ferric (Fe^{3-}) form (Shukla *et al.*, 2021).

Copper

The DTPA-extractable copper content in the soils of Hathin block ranged from 0.13 to 1.81 mg/kg, with an average value of 0.69 mg/kg. According to the soil test ratings for available copper (Table 1), only 2% of the samples were categorized under acute deficient category, 6% in deficient, 26% in latently deficient, 26% in marginally sufficient, 20% in adequate, and 20% in high Cu category (Fig. 4). A majority of the soil samples (66%), classified under marginally sufficient, adequate, or high categories, were found to have sufficient copper levels, likely due to effective management practices, as also reported by (Malik *et al.*, 2017). However, 34% of the samples exhibited low copper availability, which may be attributed to the relatively high soil pH, a known factor contributing to copper deficiency.

Manganese

The DTPA-extractable manganese content in the soils of Hathin block ranged from 2.23 to 6.78 mg/kg, with an average value of 5.35 mg/kg (Table 2). Based on soil test ratings for manganese availability

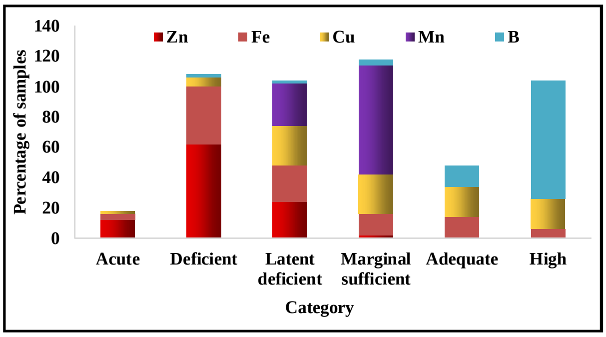

Fig. 4. Percentage of micronutrients under different category in Hathin block.

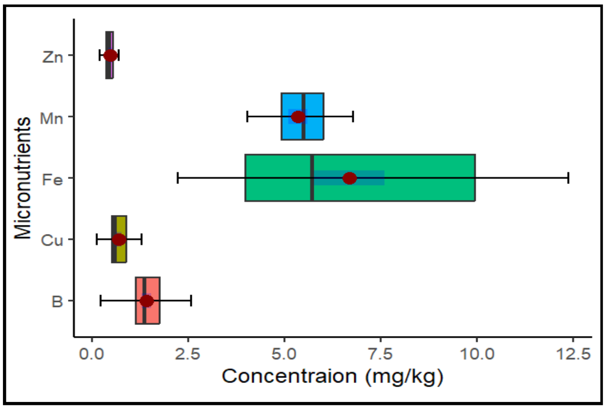

Fig. 5. Box plot of micronutrient (showing the confidence interval of mean for each nutrient).

(Table 1), about 28% of the samples were categorized in latent deficient and 72% in marginally sufficient category (Fig. 4). A significant proportion of the soil samples exhibited marginally sufficient. So there is potential for improvement in manganese from marginally sufficient to adequate status in the region by doing good management practices and the low availability of manganese may be attributed to their alkaline nature, as higher pH levels typically reduce manganese solubility (Katyal and Sharma, 1991).

Hot water-soluble Boron

In the soils of Hathin block, hot water-soluble boron (HWS B) content ranged from 0.23 to 2.56 mg/kg, with an average of 1.40 mg/kg (Table 2). Based on soil test ratings for boron availability (Table 1), 2% of the samples were categorized as deficient, 2% as latently deficient, 4% marginal sufficient, 14% as adequate, and 78% as high in boron content (Fig. 4). The majority of the samples (96%), classified as marginal sufficient, adequate or high, indicated boron sufficiency. This sufficiency may be attributed to the tendency of water-soluble boron levels to increase with soil pH, though this relationship can vary (Tsalidas *et al.*, 1994). Additionally, as pH increases, boron adsorption by soil components also rises, peaking in alkaline soil conditions (Gu and Lowe, 1990; Goldberg *et al.*, 1993).

The box plot summary of micronutrient concentrations in the GZN soils reveals a wide range of values for zinc, iron, manganese, copper, and boron. Zinc concentrations vary from 0.20 to 0.93 mg/kg, with a mean of 0.47 mg/kg, indicating slightly right-skewed distribution. Iron content ranges from 2.21 to 12.39 mg/kg, with a mean of 6.67 mg/kg, showing moderate variability. Manganese levels vary between 2.23 and 6.78 mg/kg, with a mean of 5.35 mg/kg, indicating a nearly symmetric distribution. Copper concentrations range from 0.13 to 1.81 mg/kg, with a mean of 0.69 mg/kg, showing slight positive skewness. Boron content ranges from 0.23 to 2.56 mg/kg, with a mean of 1.40 mg/kg, indicating moderate variability. The data suggest that iron shows the greatest range and variability among the micronutrients, while zinc and copper display relatively narrow ranges.

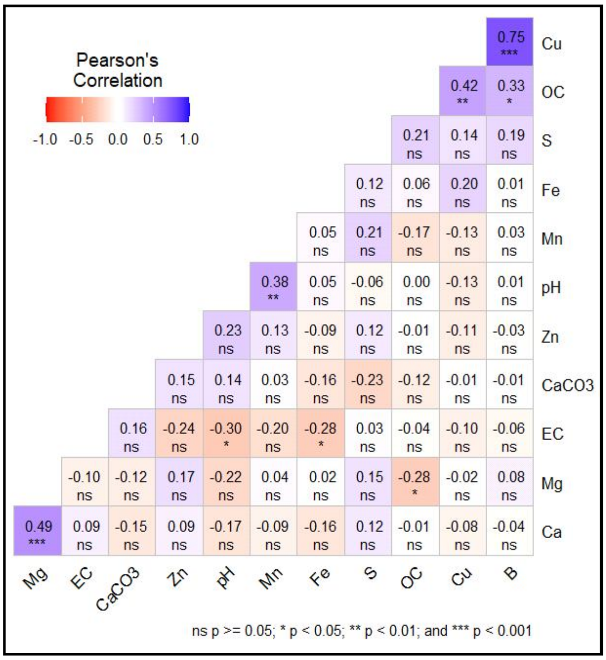

Fig. 6. Pearson's correlation between soil properties and nutrient content in soil of Hathin block.

Correlation between soil properties and nutrient content

Correlation studies, as presented in (Fig 6) revealed that organic carbon was positively correlated with copper (r= 0.42**) and boron (r= 0.33*) this is due to complexing agents generated by organic matter promote the availability of these nutrients in soil (Behera *et al.*, 2013). Copper was highly significantly positively correlated with boron (r = 0.75***), which could be due to chelation processes that ensure the co-availability of both elements in favorable soil conditions. (Dash *et al.*, 2023). Calcium and magnesium also showed a significant positive correlations of value (r = 0.49***).

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