**Impact of prevalent cropping systems on status and distribution of micronutrients in subtropical region of Himachal Pradesh**


## ABSTRACT

Globally, the majority of farmers use various cropping systems. In order to increase the production of food grains, the adaptation of these cropping systems necessitates intensive cultivation, which eventually calls for a greater quantity of macronutrients as well as micronutrients. The availability of micronutrients is greatly influenced by cropping practices, their distribution by profile and chemical pools, and their accessibility to plants. Many crops can reach beneath the soil layers and access the micronutrients with their deep roots, which they require to grow. The present study was conducted to quantify the impact of different cropping systems on DTPA extractable micronutrients viz., Zn, Fe, Cu, and Mn over time. Soil samples were collected from the surface layer (0-15 cm) of four cropping systems *i.e.*, cereal-cereal (CC), cereal-oilseed (CO), vegetable-vegetable (VV), and fodder-fodder (FF). The micronutrient cations were found highest under the VV cropping system when compared with all four cropping systems. The results illustrate that availability of micronutrients affected by the presence of high organic carbon content and favourable soil reaction.



Keywords: Cropping system, Micronutrients, soil organic carbon


## INTRODUCTION

Micronutrients play a crucial role in preventing micronutrient deficiencies in humans and improving crop yields and sustainability of crop production. Due to the global soil micronutrient deficiency, harvested grains lacking in Zn, Fe, Mn, and Cu have a negative impact on both animal and human health. Micronutrient deficiencies also limit sustainable crop yields. According to Welch and Graham (2004), the high consumption of cereals deficient in micronutrients has an impact on roughly half of the world's population who live in developing nations. The status of DTPA-extractable micronutrients in soil varies significantly under various nutrient management techniques along with changes in the fundamental chemical characteristics of the soil, including pH, cation exchange capacity, and soil organic carbon (Moharana *et al.*, 2017). For instance, iron deficiency causes about 800,000 deaths annually and zinc deficiency affects over two billion people worldwide (Mayer *et al*., 2008).

Cropping systems and fertilisation have an impact on micronutrients in the soil and as well as on crops (Wei *et al*., 2006). Micronutrients accumulate along with macronutrients as a result of crop practises like incorporation of crop residue in soil. On the other hand, when crop residues are burned, some nutrient losses happen via volatilization (Biederbeck *et al*., 1980). Micronutrient addition through commercial fertiliser is not well documented and is frequently ignored, whereas micronutrients are primarily added to the soil through organic amendments like manure and green manures. Farmyard manure (FYM), according to numerous studies, boosts the availability of soil micronutrients (Li *et al*., 2010). On the other hand, excessive FYM application may cause Zn to precipitate with $PO_4^{2-}$, $H_2PO_4^-$, or $HPO_4^{2-}$ anions and reduce the mobility of Zn in soil. The dynamics of micronutrient availability to crops change with pH changes, changes in soil organic matter (SOM), nutrient interactions, and nutrient responses to long-term fertilisation (Li *et al*., 2007). As an illustration, increased soil pH reduces the availability of Cu, Zn, and Fe as a result of precipitation (Li *et al*., 2010). Application of organic matter increases the amount of micronutrients in available and exchangeable form. The redistribution of micronutrients within soil systems is caused by differences in the concentrations of micronutrients in the horizontal and vertical directions. (Zu *et al*. 2010).

Naturally, nutrient status in soil varies significantly over time and space due to management (uneven fertiliser application, natural deposition or occurrences), environmental factors (temperature and precipitation), and their availability is dependent on interactions with other soil nutrients (Bhriguvanshi *et al*., 2014). Despite the crucial roles that micronutrients play in agriculture and human nutrition, little is known about how agricultural practises affect the dynamics of micronutrients in soil and wheat. Therefore, it is crucial to investigate how agricultural management practises affect the availability of micronutrients and their accumulation in commonly consumed food crops (Kumar *et al*., 2015).

After taking into account the aforementioned contexts, the current study has been conducted to address the goal: to investigate the impact of prevailing cropping systems on soil availability of micronutrient cations (Zn, Cu, Fe, and Mn) and basic soil properties.

## MATERIALS AND METHODS

### Site description

The Hamirpur district is located between latitudes 31° 52° and 31° 58° North and longitudes 76° 13° and 76° 44° East. The district is between 400 and 1,232 metres above mean sea level. It is located in the state's centre and has the smallest area of the state's twelve districts (Mehra and Bala, 2014). The region is located in Himachal Pradesh's sub-montane low hill zone (Zone-I), which has a sloping and undulating topography, and is surrounded by the middle and upper Shivalik ranges, which have the most delicate ecosystems. The district covers 1,118 $km^2$ of land. Its neighbours' districts of Mandi to the east, Bilaspur to the south, Una to the west, and Kangra to the north all share borders with it. Hamirpur and Kangra are separated by the River Beas, which is the parent river of the two tributaries Maan and Kunah that run along either side of the Hamirpur district (Kumar, 2013).

### Sample collection and analysis

A sum of one hundered and ninety two soil samples were collected from different cropping systems of Bamson, Bijhari, Bhoranj, Hamirpur, Nadaun and Sujanpur block of Hamirpur district of Himachal Pradesh, India during 2021. Soil samples from 0 – 15 cm (surface) layer were processed (<2 mm) and air dried. pH and electrical conductivity (EC) of the soil were determined in 1:2 and 1:2.5 soil water (w/v) suspension following half an hour equilibrium given by Jackson (1973). Soil organic carbon (SOC) content was estimated using wet digestion method (Walkley and Black, 1934). Availability of Zn, Cu, Fe and Mn, was assessed by using the method suggested by Lindsay and Norvell (1978). The analytical determination of these micronutrients cations was performed on atomic absorption spectrophotometer.

## RESULTS AND DISCUSSION

**Table 1: Status of soil pH, EC and available micronutrients in prevailing cropping systems in subtropical area of Himachal Pradesh**

| Soil parameters | | Mean | Range | SD | CV% |
|---|---|---|---|---|---|
| **pH** | C-C | 7.03 | 6.55 - 7.48 | 0.32 | 4.55 |
| | C-O | 6.93 | 6.50 - 7.48 | 0.31 | 4.47 |
| | V-V | 7.13 | 6.55 - 7.51 | 0.29 | 4.06 |
| | F-F | 6.91 | 6.50 - 7.46 | 0.31 | 4.48 |
| **EC ($dS\ m^{-1}$)** | C-C | 0.195 | 0.13 - 0.25 | 0.02 | 10.20 |
| | C-O | 0.172 | 0.11 - 0.21 | 0.02 | 11.60 |
| | V-V | 0.225 | 0.13 - 0.29 | 0.03 | 13.30 |
| | F-F | 0.147 | 0.10 - 0.20 | 0.02 | 13.60 |
| | C-C | 11.10 | 8.40 - 14.70 | 1.59 | 14.32 |

| | | | | | |
|---|---|---|---|---|---|
| **SOC (g kg$^{-1}$)** | C-O | 9.55 | 6.70 - 13.50 | 1.57 | 16.44 |
| | V-V | 14.05 | 9.50 - 19.20 | 2.08 | 14.80 |
| | F-F | 7.96 | 5.10 - 11.70 | 1.57 | 19.70 |
| **Available Zn (mg/kg)** | C-C | 1.84 | 1.24 - 3.23 | 0.45 | 24.45 |
| | C-O | 1.55 | 1.17 - 2.75 | 0.35 | 22.58 |
| | V-V | 2.05 | 1.32 - 3.51 | 0.52 | 25.36 |
| | F-F | 1.26 | 0.85 - 2.36 | 0.28 | 22.22 |
| **Available Fe (mg/kg)** | C-C | 10.04 | 7.52 - 12.32 | 1.05 | 10.45 |
| | C-O | 9.19 | 6.89 -11.22 | 0.95 | 9.79 |
| | V-V | 10.84 | 8.60 - 12.74 | 1.07 | 9.87 |
| | F-F | 8.38 | 6.87 - 11.14 | 1.04 | 12.41 |
| **Available Cu (mg/kg)** | C-C | 1.17 | 0.68 -2.18 | 0.37 | 31.62 |
| | C-O | 0.94 | 0.58 - 1.65 | 0.26 | 27.65 |
| | V-V | 1.39 | 0.91 - 2.32 | 0.34 | 24.46 |
| | F-F | 0.78 | 0.52 - 1.52 | 0.21 | 26.92 |
| **Available Mn (mg/kg)** | C-C | 2.25 | 1.39 - 3.16 | 0.39 | 17.33 |
| | C-O | 1.90 | 1.25 - 2.59 | 0.32 | 16.84 |
| | V-V | 2.64 | 1.68 - 3.52 | 0.40 | 15.15 |
| | F-F | 1.55 | 1.10 - 2.03 | 0.24 | 15.48 |

**General soil properties**

Data on soil pH, EC and organic carbon are presented in Table 1. Soil had pH ranging from under different cropping system varied from 6.55 to 7.48, 6.50 to 7.48, 6.65 to 7.51 and 6.50 to 7.46 with mean values of 7.03, 6.93, 7.13 and 6.91 under cereal – cereal, cereal – oilseed, vegetable - vegetable and fodder - fodder cropping system, respectively. Mean soil pH value was found little higher under vegetable – vegetable cropping system as compared to other cropping systems of the district, this could be due to less base leaching and the moderating impact of organic matter, which reduces the activity of exchangeable $Al^{3+}$ ions in soil solution via chelation (Hue 1992) and the production of alumino-phosphate complexes. Similar results on the moderating influence of farm yard manure on soil pH were also reported by Pathak *et al*. (2005) and Urkurkar *et al*. (2010). Coefficient of variation for all the cropping systems was recorded as 4.55, 4.47, 4.06 and 4.48 per cent under cereal – cereal, cereal – oilseed, vegetable – vegetable and fodder – fodder cropping systems, respectively which signifies that the soil pH varied spatially. The soils of Hamirpur district under different cropping systems were found to be neutral in reaction. Similar findings of soil reaction in Central Himalayas of Himachal Pradesh were also reported by Chandel *et al.* (2017) and Suri (2018) also reported similar soil pH ranges in different areas of Himachal Pradesh.

High variability was found in fodder – fodder (13.6 %) followed by vegetable – vegetable (13.3 %), cereal – oilseed (11.6 %) and cereal – cereal (10.2 %) and showed that electrical conductivity varied spatially. Mean electrical conductivity was found to be comparatively higher (0.225 dS $m^{-1}$) under vegetable – vegetable cropping system over other cropping systems of the Hamirpur district. The data on electrical conductivity of the examined soils revealed that none of the cropping systems have a salinity problem. Electrical conductivity values were under normal range may be ascribed to leaching of salts to lower horizons of soil due to light texture. According to Richard (1954), an EC value of less than 0.8 dS $m^{-1}$ is considered normal and suitable for all crops, and in this present study, the EC ranges from 0.102 to 0.292 dS $m^{-1}$, which is relatively safe for cultivation. A little higher salt buildup, as demonstrated by EC values (0.225 dS $m^{-1}$) was seen under vegetable - vegetable cropping systems, which could be attributed due to frequent fertilizer applications. The results clearly showed that there was no salinity risk. Shi *et al*. (2009) and Ammari *et al*. (2015) found similar results for soil electrical conductivity. Similar values for electrical conductivity were observed in different areas of Himachal Pradesh by Kyandiah (2012), Chandel *et al*. (2017).

Mean organic carbon content of soil was found comparatively higher in vegetable - vegetable cropping system as compared to the other cropping systems. Cropping system affects organic carbon content of soil due to changes in inputs of nutrients, water, biomass addition and tillage (Mendes *et al*., 2015; Singh *et al*., 2020. Higher organic carbon content in vegetable – vegetable cropping system may be attributable to more frequent additions of FYM and more biomass addition (Chen *et al*., 2011; Ryals *et al*., 2014). Comparatively lower organic carbon content in other cropping systems might be due to less amount of biomass addition (Hajduk *et al*., 2015). Pal *et al*. (2013) and Biswas *et al*. (2017). Similar values of organic carbon were also reported by Kumar (2019) under different cropping systems of Himachal Pradesh.

**Distribution of Micronutrients**

Descriptive statistics of DTPA-extractable Zn, Fe, Cu and Mn in soils is presented in Table 1. The content of Zn in soil varied widely from 1.24 – 3.23 mg $kg^{-1}$ (mean 1.84 mg $kg^{1}$), 1.17 – 2.75 mg $kg^{-1}$ (1.55 mg $kg^{-1}$), 1.32 - 3.51 mg $kg^{-1}$ (2.05 mg $kg^{-1}$) and 0.85 -2.36 mg $kg^{-1}$ (1.26 mg $kg^{-1}$) under cereal – cereal, cereal – oilseed, vegetable – vegetable and fodder – fodder cropping systems, respectively (Figure 1). The highest zinc content in vegetable – vegetable cropping system might be the result of favorable soil pH which increased solubility due to high desorption and low adsorption (Bradl, 2004). The distribution showed wide variability among all cropping systems.

Percent distribution of DTPA – extractable zinc content under cereal – cereal cropping system most (95.83 %) of the soil samples were in medium category and few (4.17 %) fall under high category of zinc availability. In cereal – oilseed cropping system, all (100

%) the samples reported to fall under medium category of availability. In vegetable –

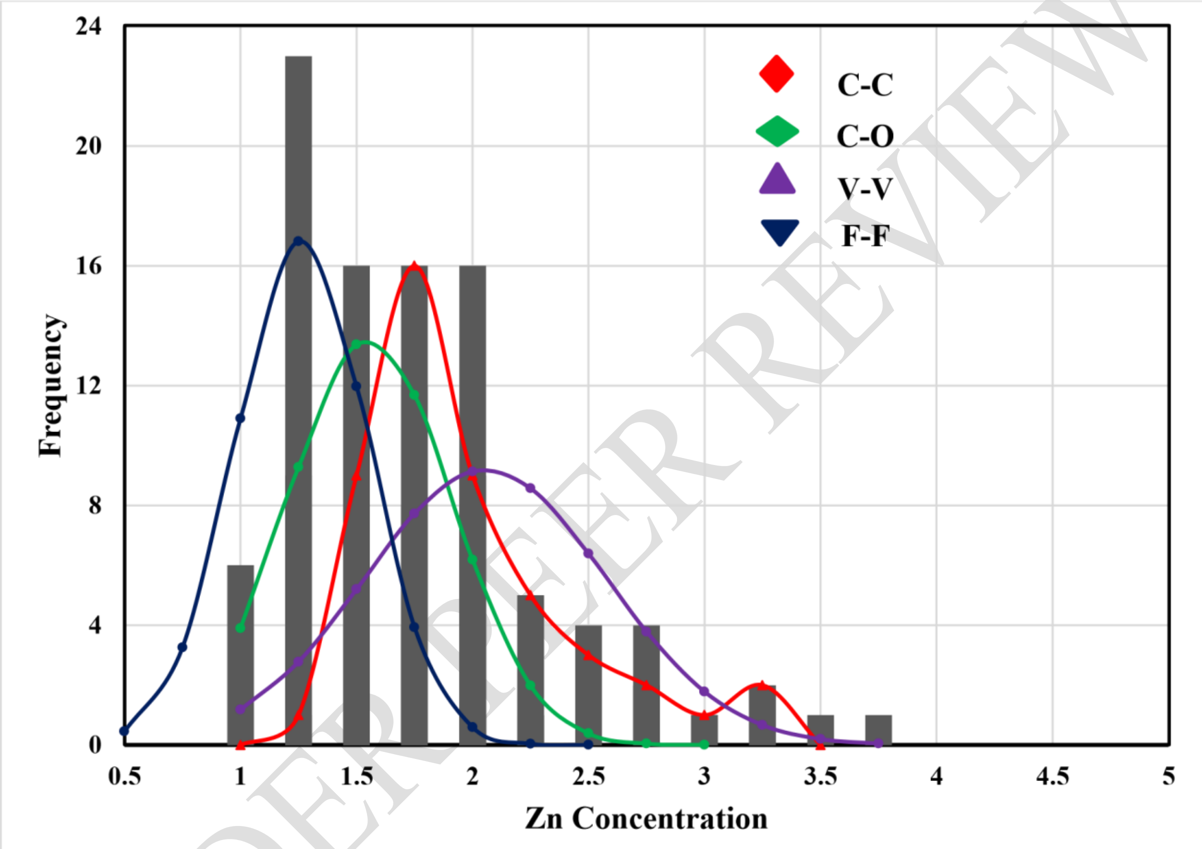


**Figure 1** Frequency distribution of Zinc under prevalent cropping system

vegetable cropping system, 91.67 per cent of soil samples were reported in medium category and 8.33 per cent soil samples under high category. In case of fodder – fodder cropping system 87.50 and 12.50 per cent fall under medium and high category, respectively. The coefficient of variation was found 24.45 for cereal – cereal, 22.58 for cereal – oilseed, 25.36 for vegetable – vegetable and 22.22 per cent for fodder – fodder cropping system indicating the spatial variability of DTPA extractable zinc in Hamirpur district.

Relatively high availability of Zn in vegetable – vegetable cropping systems may be also be closely associated with SOC content and more favourable soil reaction. This is in agreement with the findings of Biswas *et al*. (2017), Chandel *et al*. (2017) in soils of Himachal Pradesh.

**DTPA extractable iron**

Average content of available iron was 10.04 mg kg$^{-1}$ (7.52 - 12.32 mg kg$^{-1}$), 9.19 mg kg$^{1}$ (6.89 -11.22 mg kg$^{-1}$), 10.84 mg kg$^{-1}$ (8.60 - 12.74 mg kg$^{-1}$) and 8.38 mg kg$^{-1}$ (6.87 - 11.14 mg kg$^{-1}$) under cereal – cereal, cereal – oilseed, vegetable – vegetable and fodder – fodder cropping systems, respectively (Figure 2).

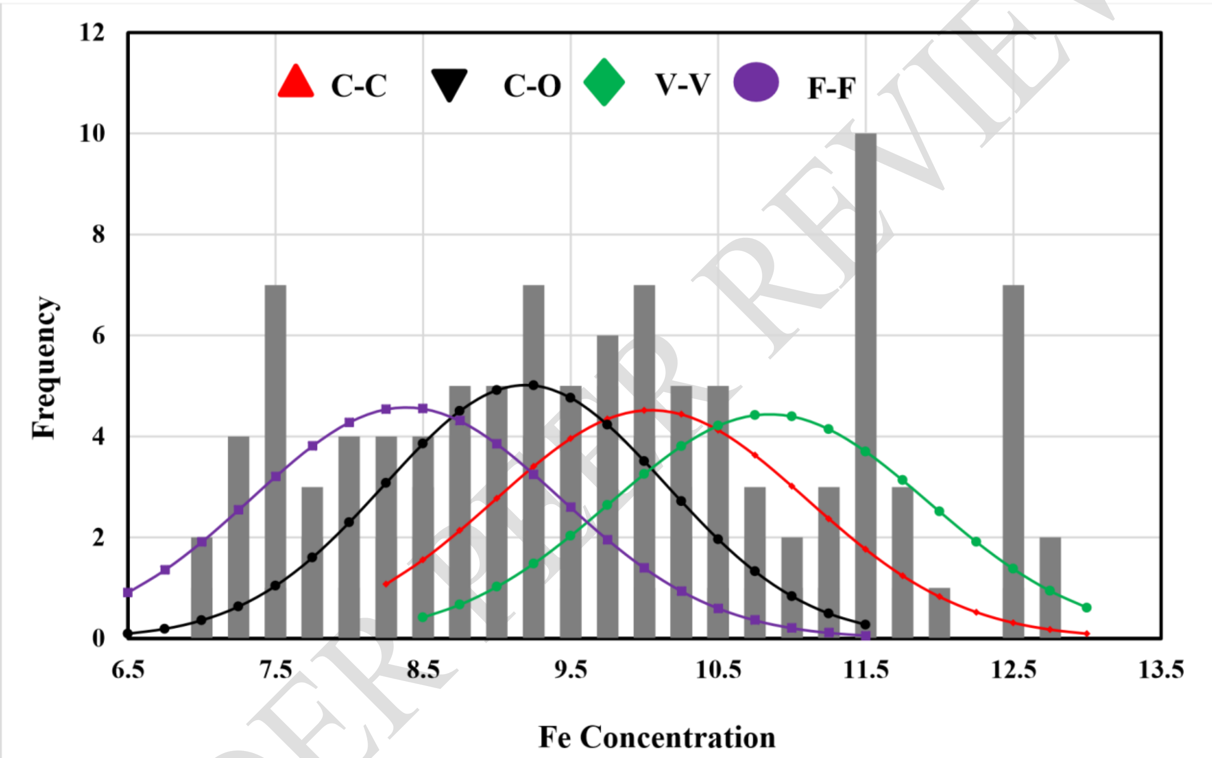


**Figure 2** Frequency distribution of Iron under prevalent cropping system

The percent sample distribution under cereal – cereal cropping system, 54.17 per cent of the soil samples were in medium category and 45.83 per cent fall under high category. In cereal – oilseed cropping system, 79.17 per cent of the samples reported to fall under medium category and 20.83 per cent soil samples were in high category. In vegetable – vegetable cropping system, 68.75 and 31.25 per cent of soil samples reported under high and medium category, respectively. In case of fodder – fodder cropping system, 87.50 and 12.50 per cent fall under medium and high category, respectively.

Coefficient of variation was observed as 10.45 for cereal – cereal, 9.79 for cereal – oilseed, 9.87 for vegetable – vegetable and 12.41 for fodder – fodder cropping systems indicating spatial variability of DTPA extractable iron content in the district. Higher mean extractable Fe content was recorded under vegetable – vegetable cropping systems which might be due to higher organic carbon content which might have resulted in higher production of complexing agents which promoted better extractability of Fe in these soils. Sidhu and Sharma (2010) reported similar results in the soils of Indo-Gangetic plains of India. Similar results were also reported by Kumar (2019) under different cropping systems of Himachal Pradesh.

### xii. DTPA extractable copper

Wide variability of the copper content was found indicating differences in management practices adopted by farmers for different cropping systems. A range of from 0.68 to 2.18 mg $kg^{-1}$ with an average of 1.17 mg $kg^{-1}$, 0.58 to 1.65 mg $kg^{-1}$ with average value of 0.94 mg $kg^{-1}$, 0.91 to 2.32 with mean value 1.39 mg $kg^{-1}$ and 0.52 to 1.52 mg $kg^{-1}$ with average value 0.78 mg $kg^{-1}$ under cereal – cereal, cereal – oilseed, vegetable – vegetable and fodder – fodder cropping systems, respectively (Figure 3).



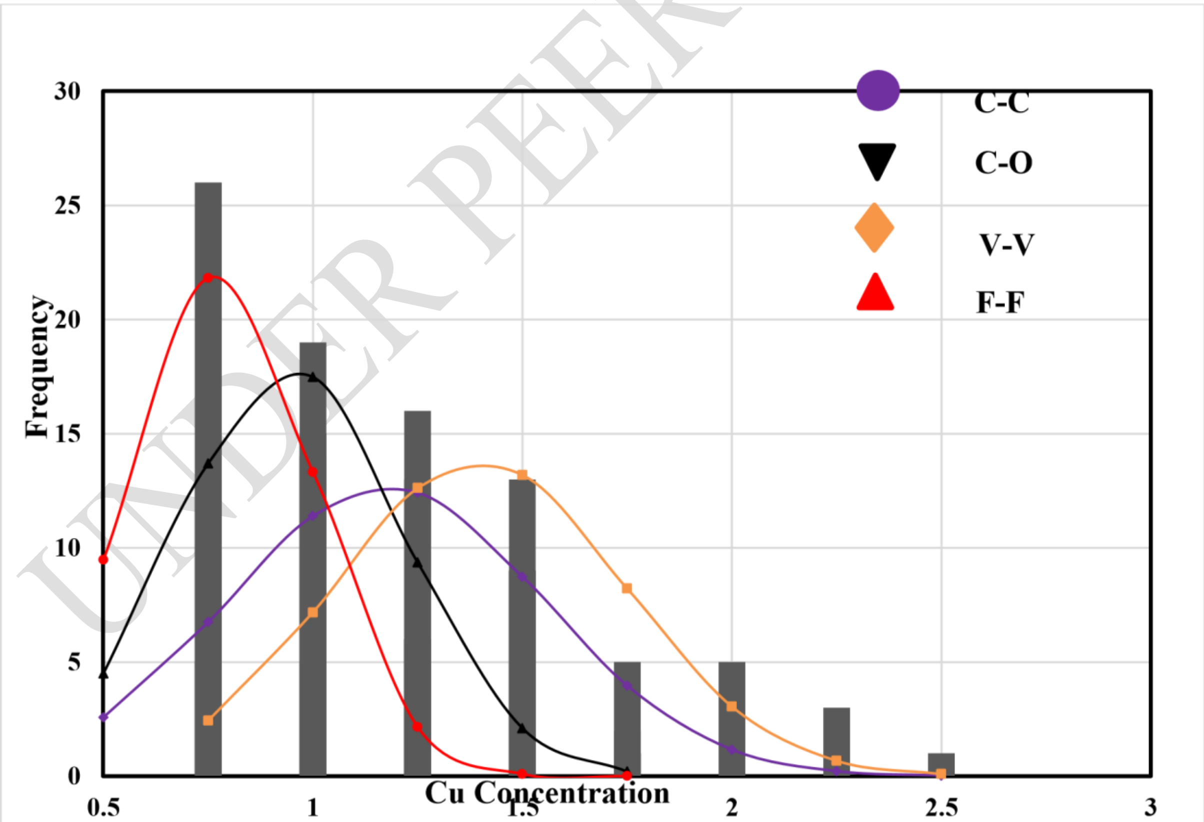


Figure 3 Frequency distribution of Copper under prevalent cropping system

Percent distribution of DTPA extractable copper in soil samples was medium to high in copper content in soil samples under all the cropping systems. In cereal – cereal cropping system, 81.25 per cent of soil samples were in high category and 18.75 per cent were reported in medium category of copper availability. In case of cereal – oilseed cropping system, 64.58 per cent of soil samples recorded under high category and 35.42 per cent of soil samples fall under medium category of copper availability. All the soil samples (100 %) under vegetable – vegetable cropping system reported high category of copper availability. In fodder – fodder cropping system, 68.75 and 31.25 per cent of soil samples reported medium and high category of copper availability, respectively.

The coefficient of variation was reported as 31.62 per cent for cereal – cereal, 27.65 per cent for cereal – oilseed, 24.46 per cent for vegetable – vegetable and 26.92 per cent for fodder – fodder cropping system which specifies the spatial variability of DTPA extractable copper in the Hamirpur district. Higher organic carbon may be the reason for higher DTPA extractable copper content in vegetable – vegetable cropping system, because copper forms copper-humus complex of relatively high stability with humus that decreases its susceptibility to fixation or precipitation in the soil. Chandel *et al*. (2017) also observed application of Blitox (copper containing fungicide used for controlling diseases in vegetables) as one of the reasons for comparatively higher copper content.

**DTPA extractable manganese**

The manganese content varied from 1.39 to 3.16 mg $kg^{-1}$ (2.25 mg $kg^{-1}$) 1.25 to 2.59 mg $kg^{-1}$ (1.90 mg $kg^{-1}$) 1.68 to 3.52 mg $kg^{-1}$ (2.64 mg $kg^{-1}$) and 1.10 to 2.03 mg $kg^{-1}$ (1.55 mg $kg^{-1}$) under cereal – cereal, cereal – oilseed, vegetable – vegetable and fodder – fodder cropping systems, respectively (Figure 4). Higher mean manganese content was found in vegetable – vegetable cropping system which could be attributed to greater organic matter content accumulation as a result of root biomass integration and a large amount of leaf litter as soil organic matter is known for enhancing the Mn availability to the crop plants (Reisenauer, 1988).

The coefficient of variation was recorded as 17.33 per cent for cereal – cereal, 16.84 per cent for cereal – oilseed, 15.15 per cent for vegetable – vegetable and 15.48 per cent for fodder – fodder cropping systems which directs the spatial variability of DTPA extractable manganese content in soils of Hamirpur district under different cropping systems. All the soil samples under cereal – cereal and vegetable – vegetable cropping system reported high level of manganese availability however, 93.75 and 6.25 per cent of soil samples under cereal –

oilseed copping system had high and medium Mn availability, respectively. In fodder – fodder cropping system, 68.75 per cent of soil samples recorded under high category and 31.25 per cent of soil samples were in medium category of Mn availability.

The critical observation of the data revealed that soils rich in organic carbon are less prone to Mn deficiency (Annepu *et al.*, 2017). In the present investigation, most of the soil samples falls under medium availability of manganese. Similar values of DTPA extractable manganese were also observed by Behera and Shukla (2014) and Kumar *et al.* (2022) in soils of Himachal Pradesh.

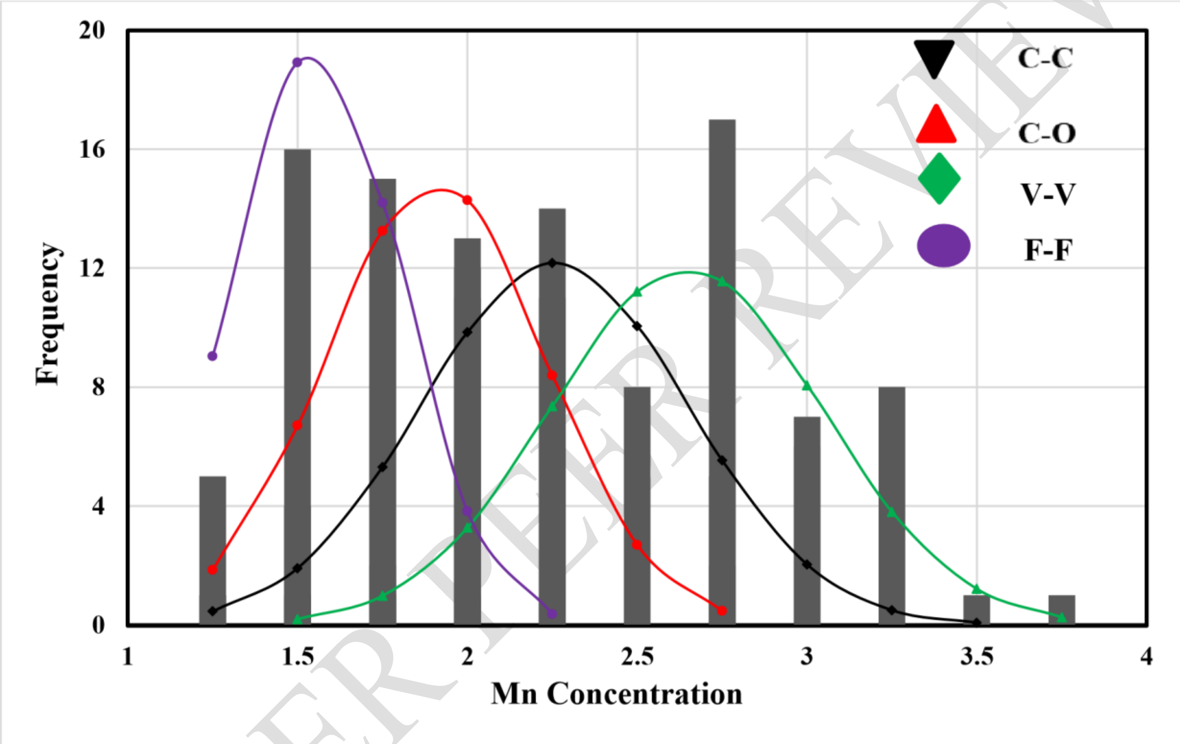


**Figure 4** Frequency distribution of Manganese under prevalent cropping systems



**Correlation of micronutrients**

| Parameters | pH | EC | OC | Zn | Fe | Cu | Mn |
|---|---|---|---|---|---|---|---|
| pH | 1 | 0.213** | 0.505** | 0.138** | 0.160** | 0.232** | 0.171** |
| EC | | 1 | 0.346** | 0.377** | 0.438** | 0.413** | 0.593** |
| OC | | | 1 | 0.426** | 0.555** | 0.536** | 0.598** |
| Zn | | | | 1 | 0.494** | 0.448** | 0.498** |
| Fe | | | | | 1 | 0.433** | 0.482** |
| Cu | | | | | | 1 | 0.554** |

| | |
|---|---|
| Mn | 1 |

***. Significant at the 0.05 level**
****. Significant at the 0.01 level**

The statistical significance and pearson's correlation coefficient amongst the soil factors presented in Table 2 indicated significant interaction among the soil micronutrients. Soil organic carbon also showed significant and positive correlation with the DTPAextractable zinc (0.426**), iron (0.555**), copper (0.536**), manganese (0.598**). Similar findings were also reported by Nath and Bhattachayya (2014), Gyawali *et al*. (2016), Annepu *et al.* (2017) and Kumar *et al*. (2017).

## CONCLUSION

The study concluded that variation in the availability of micronutrients in soil in response to different cropping systems varied quantitatively based on the type and practices being followed in the systems. Soil reaction across various sites under prevalent cropping systems of the district was neutral. Electrical conductivity values were within the safe limits. Soil organic carbon content was high under cereal – cereal and vegetable – vegetable cropping systems and medium to high under cereal – oilseed and fodder – fodder cropping systems. DTPA extractable micronutrients were medium to high under all the cropping systems and were positively and significantly correlated.

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