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Spatial variability of soil properties of Mirzapur district of Uttar Pradesh

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Soil which is a natural resource has variability inherent to how the soil formation factors interact within the landscape. Spatial variability of soil properties has been long known to exist and has to be taken into account every time field sampling is performed and investigation of its temporal and spatial changes is essential. Geographical information system (GIS) technologies has great potentials in the field of soil and has opened newer possibilities for improving soil statistic system as it offers accelerated, repetitive, spatial and temporal synoptic view. It also provides a cost effective and accurate alternative to understand landscape dynamics. It facilitates manipulation of spatial and attributes data useful for handling multiple data of diverse origin (Mandal and Sharma 2010). Several databases are available at global and national level for planning and management of soil resources. It has got great significance in agriculture for future monitoring of soil nutrient status of different locations/villages. Georeferenced maps also help in monitoring changes in nutrient status over a period of time by revisiting with the help of GPS. In this paper assessment of spatial variation of soil chemical characteristics using GIS techniques around the Mirzapur District of Uttar Pradesh is presented.

Study Area: Mirzapur is an Eastern most district of Uttar Pradesh state in North India. The town of Mirzapur is the district headquarters and located between geographical area of Mirzapur is 4521 km^2 (latitude 230 52″to 250 32″N and longitude 820 72″to 830 33″E).

Collection of soil samples: Soil samples (0–15 cm) were collected from cultivated area of the Mirzapur during September-Decmber in 2018. The co-ordinates were recorded using GPS for all the soil samples collected in the study area.

Analysis of samples: The collected soil samples were air-dried, ground with wooden pestle and mortar and sieved through 2-mm sieve (0.2 mm sieve for organic carbon), labelled and stored. The samples were analyzed for chemical parameters, viz. *p*H and electrical conductivity (EC) (Jackson 1973), organic carbon (OC) (Walkley and Black 1934), available nitrogen (N) (Subbiah and Asija1956), available phosphorus (P) (Bray and Kurtz 1945, Olsen *et al.* 1954), available potassium (K) (Hanway and Heidal 1952) and available zinc (Zn), iron (Fe), copper (Cu) and manganese (Mn) (Lindsay and Norvell 1978).

Preparation of Thematic maps: The Thematic maps showing nutrient status was generated using the analytical data of individual nutrient. The point data collected using GPS was then transformed into polygon data using kriging interpolation technique in Arc GIS software 10.3.

Soil reaction (pH) and electrical conductivity (EC): The soil reaction in surface soils of Mirzapur ranged from 5.0–10.4 (Table 1, Fig 1) which might be due to the higher degree of base saturation (Waghmare *et al.* 2008, Sharma *et al.* 2008). The EC of surface soil samples varied from 0.002–0.631 dS/m with a mean of 0.09 dS/m (Table 1, Fig1) due to proper management and inherent properties of soil as also reported by Sharma *et al.* (2008).

Organic carbon content: The OC content of the surface soils ranged from 0.5–21.9 g/kg with mean of 5.4 g/kg in Mirzapur district (Table1, Fig 1). These results were in assenting with results reported by Waikar *et al*. (2004).

Available primary nutrient: The available N content of surface soil samples in Mirzapur varied from 37.64–275.97 kg/ha with mean 128.08 kg/ha, available P ranged from 1.73–233.81 P_2O_5 kg/ha and available K content of surface soil samples varied from 54.88–899.3 K_2O kg/ha (Table 1, Fig 1). Shukla (2011) found that the available potassium content is generally medium to high.

DTPA extractable micronutrients: The available Fe in these soils varied from 0.055–228.6 mg/kg with mean of 37.70 mg/ kg (Table 2, Fig 2). This high Fe content in soil may be due to presence of minerals in soils (Vijaya Kumar *et al*. 2013). The available Mn content found to be

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Table 1 Status of major nutrients in surface soil samples of Mirzapur district (*n=625)

	*p*H	EC (dS/m)	OC (g/kg)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Mean	7.5	0.092	5.4	128.08	37.01	338.65
Range	5.0–10.4	0.002–0.631	0.5–21.9	37.64–275.97	1.73–233.81	54.88–899.3
SD	0.87	0.08	0.23	32.72	37.29	567.18

*n, Number of samples

Table 2 Status of micronutrient nutrients in surface soil samples of Mirzapur District (*n=625)

	DTPA-Fe (mg/kg)	DTPA- Mn (mg/kg)	DTPA-Cu (mg/kg)	DTPA-Zn (mg/kg)
Mean	37.70	12.97	1.38	1.30
Range	0.055–228.6	0.07–141.1	0.019–7.58	0.01–7.7
SD	48.20	17.46	0.92	1.02

*n, Number of samples

ranged from 0.07–141.1 mg/kg with mean of 12.97 mg/kg (Table 2, Fig 2). The relative high content of Mn in these soils could be due to the soils derived from basaltic parent material which contained higher ferromagnesium minerals (Hundal *et al*. 2006). The available Cu content in surface soil samples varied from 0.019–7.58 mg/kg with mean of 1.38 mg/kg (Table 2, Fig 2). Brady and Weilm (2002) indicated that the solubility, availability of Cu is more under acidic conditions (*p*H 5.0–6.5). Available Zn content in these soils varied from 0.01–7.7 mg/kg with mean of 1.30 mg/kg (Table 2, Fig 2).

The GPS and GIS based soil fertility maps help in online soil test based fertilizer recommendation for intensive cropping system for scientists, planners and farmers. Maps may be used for site specific nutrient management and monitoring the soil health for present and future agriculture.

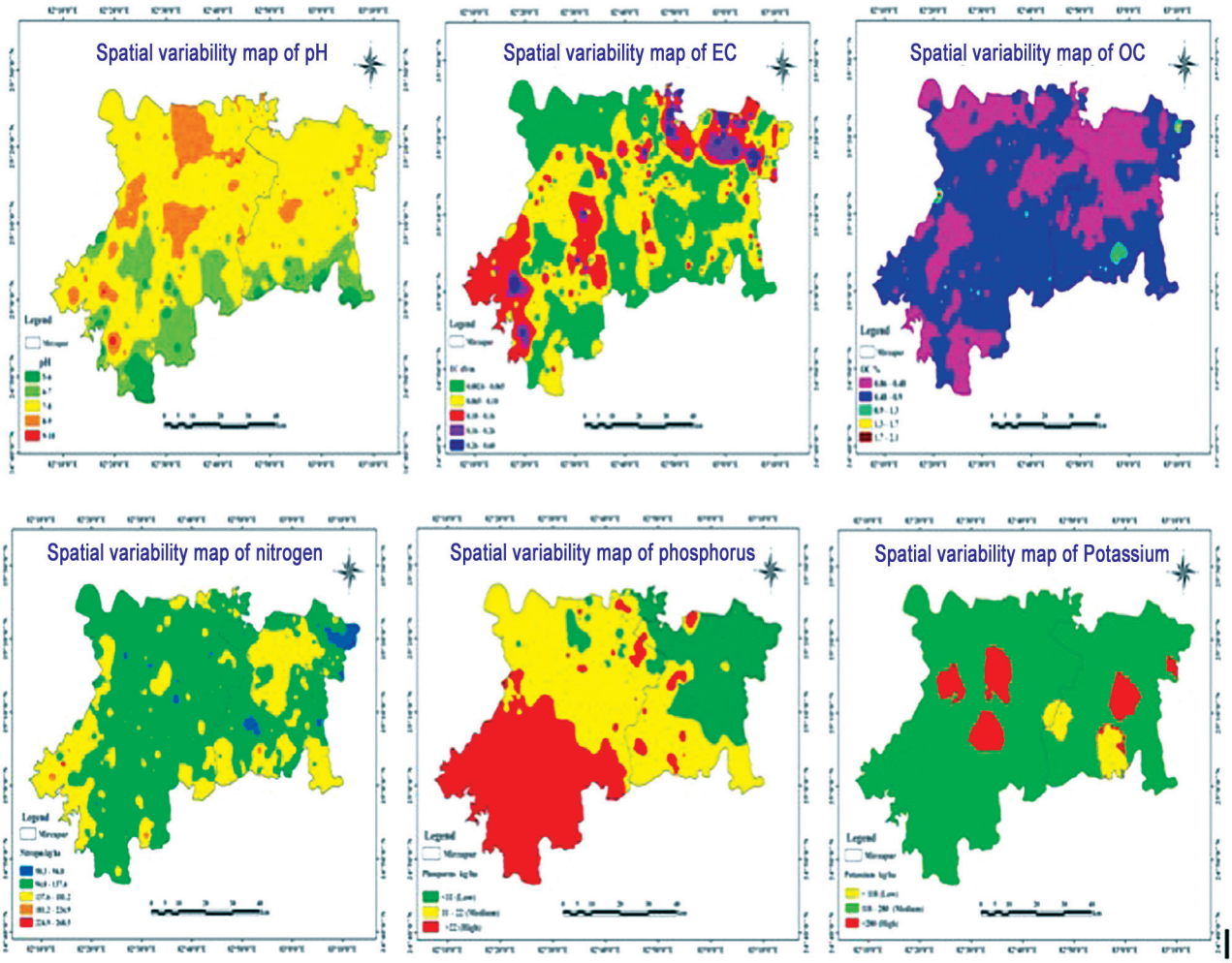

Fig 1 Spatial variability map of *p*H, EC, organic C and primary nutrient.

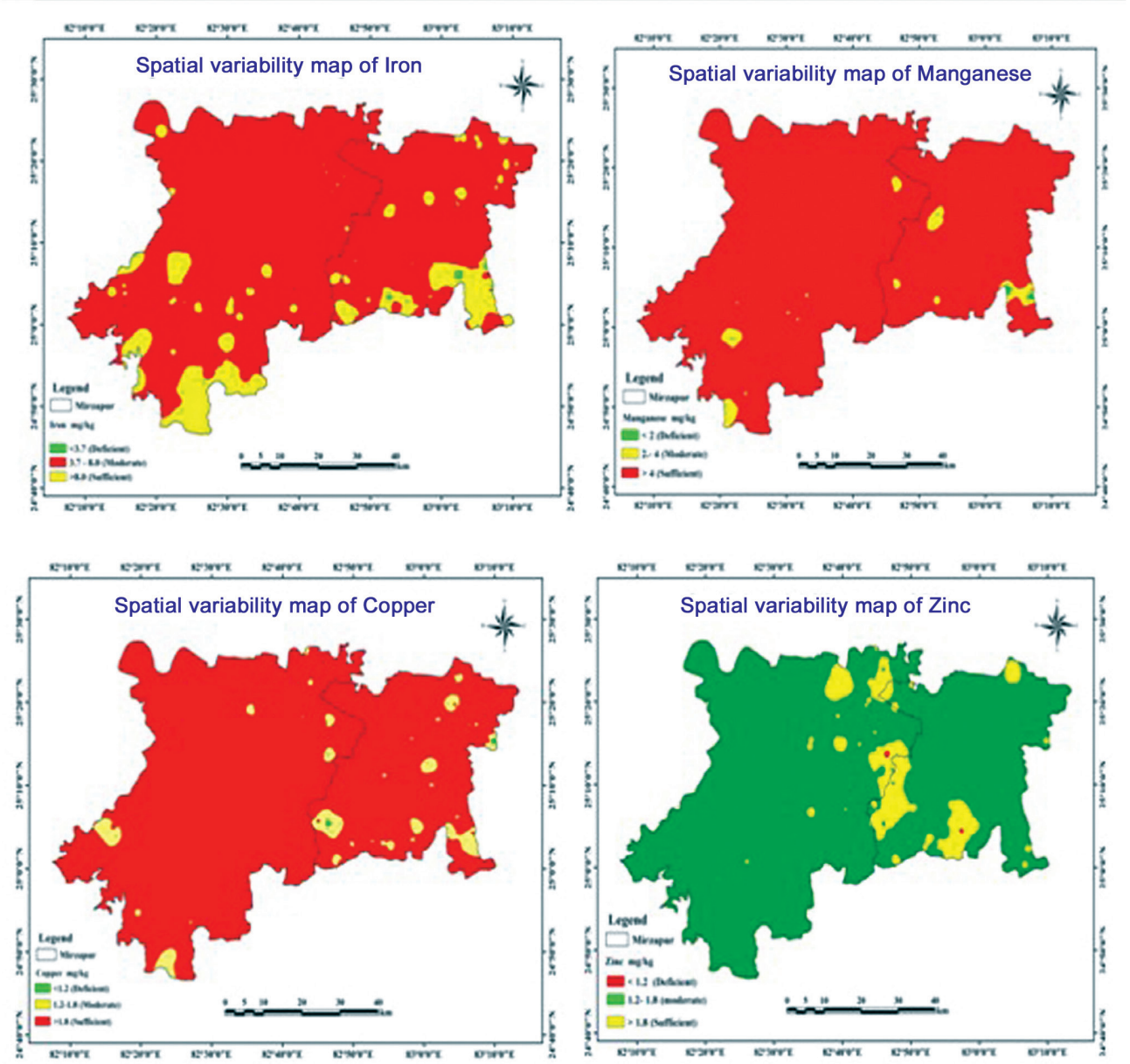

Fig 2 Spatial variability map of cationic micro nutrients

The results shows that the spatial distribution and spatial dependence level of soil properties can be different even within the same local government area. These results can be used to make recommendations of best management practices within the locality and also to improve the livelihood of smallholder farmers.

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SUMMARY

To assess the chemical characterization of soils of Mirzapur District of Uttar Pradesh, the present investigation was undertaken using GPS and GIS techniques. In this study, 625 georeferenced soil samples were collected from different block of Mirzapur following random sampling approach in month of September–Decmber 2018. The soil samples were analyzed for different chemical parameters and the data along with GPS reading were used for the preparation of soil thematic maps using interpolation method and the interpolated maps were analysed with geostatistical parameters and the corresponding kriging maps for *p*H, electrical conductivity (EC), soil organic carbon (SOC), and available nitrogen, phosphorus, potassium and cationic micronutrients (Zn, Fe, Cu, Mn of cations) were prepared. The soil thematic maps clearly shown that a major area of the Mirzapur was alkaline, non-saline, low in OC, medium in available Potassium. The mean content of soil *p*H, EC, Organic Carbon, available Nitrogen, phosphorus and Potassium in surface soils were 7.5, 0.09 dS/m, 5.4 g/

kg, 128.08, 37.01 and 338.65 kg/ha respectively.

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