Status of available sulphur and cationic micronutrients in cultivated soils of Banaskantha district of Gujarat

Dipali Desai, B.T. Patel*, Neha Chaudhary and Praveen Thakur

C.P. College of Agriculture, Central Instrumentation Laboratory, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar-385 506, Gujarat, India.

Received: 16-08-2017 Accepted: 20-01-2018 DOI: 10.18805/IJARe.A-4876

ABSTRACT

In order to assess the available sulphur and micronutrients (Fe, Mn, Zn and Cu) status in soils of Banaskantha district of Gujarat, five hundred and fifty six representative surface (0-15cm) soil samples were collected from farmer’s field of each taluka of Banaskantha district. All the collected soil samples were analyzed for available sulphur and DTPA-extractable cationic micronutrients (Fe, Mn, Zn and Cu) as per standard procedures. The available S content in soils of Banaskantha district varied from 4.98 to 66.89 mg kg\(^{-1}\) with a mean value of 15.49 mg kg\(^{-1}\). The DTPA- extractable Fe, Mn, Zn and Cu were in the range of 2.74 to 21.98; 4.22 to 25.02; 0.20 to 2.76 and 0.12 to 3.16 mg kg\(^{-1}\) with a mean value of 6.72, 10.15, 0.60 and 0.60, respectively. The overall nutrient index values were marginal for available S (1.82) and DTPA-extractable Fe (1.84) and Zn (1.74); high for DTPA-extractable Mn (2.40) and very high for Cu (2.75).

Key words: Available sulphur, Micronutrients, Nutrient index value.

INTRODUCTION

Evaluation of fertility status of the soils of an area or region is an important aspect in context of sustainable agricultural production. Sulphur is recognized as fourth important plant nutrient after N, P & K and is gaining considerable importance in quality crop production in context of Indian agriculture, particularly when there is more and more use of non-sulphur containing fertilizers as well as less use of organic manures. The data base of 1,35,000 soil analysis revealed that about 42.3 per cent soils are deficient in available S in India. Its deficiency is now estimated to be a problem in about 300 districts as compared to 70 districts in 1991 (Tardon 2010). Enhanced removal of micronutrients as a result of adoption of high yielding varieties, intensive cropping with high analysis NPK fertilizers, limited use of organic manures and less recycling of crop residues led to the depletion of secondary and micronutrients from the soil reserves. There are reports of decline in yield even with the use of recommended NPK fertilizers. The reduction in the yield is generally accounted to deficiency of secondary and micronutrients. The micronutrient deficiencies which were scarce and sporadic initially are now widespread. Under All India Coordinated Research Project (AICRP) of micro and secondary nutrients and pollutant elements in soils and plants, more than 0.25 million soil samples were analyzed from 20 states of the country and it was found that the deficiency of Zn, B, Fe and Mo were found to the tune of 49, 33, 13 and 7 per cent, respectively. The information with respect to availibility of S and micronutrients in soils of Banaskantha of North Gujarat is lacking. Therefore, an attempt was made to find out the status of available S and micronutrients cations (Fe, Mn, Zn and Cu) and correlate them with important soil characteristics.

MATERIALS AND METHODS

Geographically, Banaskantha district is situated in northern part of Gujarat state and falls in North agro climatic zone of Gujarat. The total geographical area of the district is 10,400 km\(^2\) having 14 talukas (Palanpur, Danta, Vadgam, Amirgadh, Deesa, Dhanera, Dantiwada, Kankrej, Tharad, Lakhani, Deodar, Van, Suigam and Bhabhar). The study area lies between 23º30’ to 24º45’ N latitudes and 71º03’ to 73º02’ E longitudes. The area is characterized by arid and semi arid climate with extreme cold winter and hot and dry summer. Five hundred and fifty six representative surface soil samples from 0-15 cm depth were collected from farmer’s fields during summer season using multistage stratified random sampling method covering all talukas of Banaskantha district of Gujarat. Soil samples were air-dried, ground in wooden pestle and mortar. These ground soil samples were passed through 2 mm sieve and stored in properly labeled plastic bags for analysis. The processed soil samples were analyzed for available sulphur and DTPA-extractable micronutrients (Fe, Mn, Zn and Cu). Available S was determined by extracting soil with 0.15 % CaCl\(_2\) (Williams and Steinbergs 1959) followed by turbidimetric method (Chesnin and Yien 1951). The available Fe, Mn, Zn and Cu in soil samples were extracted with 0.005 M DTPA as an extractant (Lindsay and Norvell 1978) and subsequently analyzed with the help

*Corresponding author’s e-mail: btpatel.sdau@gmail.com
of atomic absorption spectrophotometer (Model: Elico SL 194). The soil samples were categorized into low, medium and high categories based on the critical limit of available sulphur (Hariram and Dwivedi 1994) and micronutrients (Lindsay and Norvell 1978). The nutrient index values (NIV) for available sulphur and micronutrients were calculated utilizing the formula suggested by Ramamoorthy and Bajaj (1969) as follow:

\[
\text{Nutrient Index} = \frac{[N_l * 1] + [N_m * 2] + [N_h * 3]}{100}
\]

Where, \(N_l\), \(N_m\) and \(N_h\) are the number of soil samples falling in low, medium and high categories for nutrient status and are given weightage of 1, 2 and 3, respectively. The classified this nutrient index values are rated in various categories viz., very low (<1.33), low (1.33 - 1.66), marginal (1.66 - 2.00), adequate (2.00 - 2.33), high (2.33 - 2.66) and very high (> 2.66) as suggested by Stalin et al. (2010). The correlation analysis of available S and micronutrients was computed with different physic-chemical properties of soils (viz. EC, pH and organic carbon (OC) as suggested by Panse and Sukhatme (1961).

**RESULTS AND DISCUSSION**

**Available sulphur:** The available sulphur content in soils of Banaskantha district varied from 4.98 to 66.89 mg kg\(^{-1}\) with a mean value of 15.49 mg kg\(^{-1}\). The lowest value of (4.98 mg kg\(^{-1}\)) as well as the highest value of (66.89 mg kg\(^{-1}\)) available sulphur was recorded in soils of Dhanera taluka (Table 1). Out of 556 soil samples of the district, 36.15, 45.50 and 18.35 per cent samples were found under low, medium and high categories for available sulphur, respectively (Fig. 1 and 2). The soils of Banaskantha district have an overall nutrient index value of 1.82 indicating marginal fertility status for available sulphur (Table 2). Available sulphur was positively and significantly correlated with organic carbon (\(r = 0.103^*\)) whereas, negatively and

| Name of Taluka | Available S | Available Micronutrients |
|---------------|-------------|-------------------------|
|               |             | Fe | Mn | Zn | Cu |
| Palanpur      | 6.12-26.87(15.29) | 3.68-13.56(6.94) | 4.22-15.34(9.62) | 0.36-1.52(0.70) | 0.34-1.02(0.58) |
| Danta         | 7.98-49.68(21.78) | 4.32-21.98(8.12) | 4.80-25.02(14.50) | 0.36-2.76(0.81) | 0.48-3.16(1.44) |
| Vadgam        | 6.98-34.87(14.97) | 2.98-11.98(5.85) | 4.88-20.54(10.42) | 0.36-2.08(0.79) | 0.34-0.98(0.61) |
| Amirgadh      | 6.89-32.98(15.94) | 2.96-20.02(6.78) | 4.80-18.87(10.79) | 0.38-2.76(0.65) | 0.36-2.02(0.84) |
| Deesa         | 7.12-33.89(13.42) | 4.46-12.12(6.54) | 4.87-16.76(9.78) | 0.32-1.98(0.61) | 0.22-0.76(0.45) |
| Dhanera       | 4.98-66.89(16.15) | 3.86-13.98(8.11) | 4.78-19.78(12.52) | 0.32-1.26(0.56) | 0.18-0.56(0.37) |
| Dantiwada     | 6.82-29.89(13.41) | 3.32-12.12(6.11) | 4.80-13.98(8.86) | 0.38-1.04(0.62) | 0.36-0.92(0.60) |
| Kankrej       | 5.68-58.98(17.99) | 3.32-13.00(6.44) | 4.88-16.98(9.50) | 0.32-1.34(0.59) | 0.26-1.12(0.59) |
| Tharad        | 6.78-34.76(13.77) | 3.18-11.68(6.90) | 4.98-17.86(10.16) | 0.24-1.04(0.48) | 0.18-1.98(0.51) |
| Lakhani       | 6.98-24.79(13.11) | 4.62-11.68(7.14) | 4.68-17.86(10.33) | 0.24-1.20(0.53) | 0.12-1.98(0.51) |
| Deodar        | 7.58-44.87(17.08) | 2.92-12.58(6.06) | 4.64-14.78(8.18) | 0.34-1.14(0.56) | 0.12-0.52(0.51) |
| Vav           | 6.32-41.89(13.20) | 3.18-14.88(6.73) | 4.68-17.86(10.28) | 0.24-1.12(0.51) | 0.26-1.98(0.51) |
| Suigam        | 6.45-21.87(12.43) | 2.74-12.24(6.22) | 4.68-17.32(8.83) | 0.20-1.02(0.44) | 0.24-0.84(0.38) |
| Bhabhar       | 7.50-43.82(15.01) | 3.12-12.88(6.10) | 4.42-14.78(8.13) | 0.34-1.20(0.54) | 0.16-1.02(0.32) |
| **Overall**   | **4.98-66.89(15.49)** | **2.74-21.98(6.72)** | **4.22-25.02(10.15)** | **0.20-2.76(0.60)** | **0.12-3.16(0.60)** |

*Values in parenthesis indicate mean value of respective nutrient

**Fig 1:** Per cent distirbution of available sulphur and DTPA-extractable micronutrients in soils of Banaskantha district
DTPA-extractable Fe: The DTPA-extractable Fe in soils of Banaskantha district ranged from 2.74 to 21.98 mg kg\(^{-1}\) with an average value of 6.72 mg kg\(^{-1}\) (Table 1). The minimum value of DTPA-extractable Fe (2.74 mg kg\(^{-1}\)) was found in Suigam taluka, whereas the maximum value (21.98 mg kg\(^{-1}\)) was found in Danta taluka. As a whole, 30.76 per cent samples were found in low category, 54.68 per cent in medium category while remaining 14.57 per cent in high category (Fig. 1). Overall, the soils of Banaskantha district had nutrient index value of 1.84 indicating marginal status for DTPA-extractable Fe (Table 2). A significant and negative correlation of DTPA-extractable Fe was observed (Table 3) with pH (r = -0.089\(^*\)). The possible reason might be due to formation of insoluble higher valent oxides of Fe at high pH. Non-significant and positive correlation of DTPA-Fe was seen with EC (r = 0.025) and OC (r = 0.071). Similar results were also reported by Bhanwaria et al. (2011). The positive correlation of Fe with soil organic carbon might be due to the formation of relatively more soluble Fe-organic chelates (Talukdar et al. 2009).

DTPA-extractable Mn: The DTPA-extractable Mn ranged from 4.22 to 25.02 mg kg\(^{-1}\) with a mean value of 10.15 mg kg\(^{-1}\) (Table 1). The lowest value of DTPA-extractable Mn (4.22 mg kg\(^{-1}\)) was found in Palanpur taluka, whereas the highest value (25.02 mg kg\(^{-1}\)) was found in Danta taluka. About 4.14, 51.98 and 43.88 per cent samples fall under low, medium and high categories, respectively (Fig. 1). The soils of Banaskantha district had nutrient index value of 2.40 indicating high fertility status for DTPA-extractable Mn (Table 2). A highly significant and positive correlation between available Mn and OC (r = 0.370**) was found. It is apparent that availability of Mn increases with increasing

---

Table 2: Nutrient Index values and fertility status of available sulphur and DTPA extractable Fe, Mn, Zn and Cu in soils of Banaskantha district

| Taluka   | S  | Fe  | Mn  | Zn  | Cu  | S  | Fe  | Mn  | Zn  | Cu  |
|----------|----|-----|-----|-----|-----|----|-----|-----|-----|-----|
| Palanpur | 1.90 | 1.85 | 2.35 | 1.80 | 2.88 | Marginal | Marginal | High | Marginal | Very High |
| Danta    | 2.32 | 2.03 | 2.78 | 1.93 | 3.00 | Adequate | Adequate | Very High | Marginal | Very High |
| Vadgam   | 1.80 | 1.75 | 2.43 | 1.80 | 2.95 | Marginal | Marginal | High | Marginal | Very High |
| Amirdadh | 1.98 | 1.95 | 2.60 | 1.78 | 2.93 | Marginal | Marginal | High | Marginal | Very High |
| Deesa    | 1.65 | 1.88 | 2.43 | 1.75 | 2.58 | Low | Marginal | High | Marginal | High |
| Dhnera   | 1.78 | 1.95 | 2.55 | 1.70 | 2.35 | Marginal | Marginal | High | Marginal | High |
| Daniwada | 2.03 | 1.83 | 2.35 | 1.83 | 2.95 | Adequate | Marginal | High | Marginal | Very High |
| Kankrej  | 1.95 | 1.83 | 2.30 | 1.68 | 2.80 | Marginal | Adequate | Marginal | Very High |
| Tharad   | 1.65 | 1.83 | 2.40 | 1.63 | 2.68 | Low | Marginal | High | Low | Very High |
| Lkhani   | 1.63 | 1.85 | 2.40 | 1.75 | 2.60 | Low | Marginal | High | Marginal | High |
| Deodar   | 1.98 | 1.78 | 2.23 | 1.78 | 2.80 | Marginal | Adequate | Marginal | Very High |
| Vav      | 1.53 | 1.68 | 2.38 | 1.70 | 2.68 | Low | Marginal | High | Marginal | Very High |
| Suigam   | 1.44 | 1.69 | 2.11 | 1.61 | 2.36 | Low | Marginal | Adequate | Low | Very High |
| Bhbbhar  | 1.83 | 1.85 | 2.25 | 1.63 | 2.83 | Marginal | Adequate | Low | Marginal | Very High |

**District**: 1.82 1.84 2.40 1.74 2.74 Marginal Marginal High Marginal Very High

---

Table 3: Correlation co-efficient (r) of soil properties (EC, pH and OC) with available sulphur and DTPA-extractable micronutrients

| Soil Properties | Available nutrients | S  | Fe  | Mn  | Zn  | Cu  |
|-----------------|---------------------|----|-----|-----|-----|-----|
| EC              | -0.059              | 0.025 | 0.045 | -0.063 | -0.075 |
| pH              | -0.057              | -0.089** | -0.182** | -0.124*** | -0.337*** |
| OC              | 0.103***            | 0.071 | 0.370** | 0.346** | 0.464*** |

* Significant at 5 % level of significance
** Significant at 1 % level of significance
organic matter content in the soils. This may be due to either its addition to the soil through plant residues or decomposing organic matter promotes chelation or both. This findings support from similar observation reported by Patel et al. (2016). The DTPA-Mn was negative and significantly correlated with pH \((r = -0.182**)\), whereas non-significantly correlated with EC \((r = 0.045)\). The results are also in close conforming to the finding of Singh et al. (2014).

**DTPA-extractable Zn:** The DTPA-extractable Zn in soils of Banaskantha district varied from 0.20 to 2.76 mg kg\(^{-1}\) with a mean value of 0.60 mg kg\(^{-1}\) (Table 1). Considering the soil test rating for DTPA-extractable Zn, 37.59 per cent samples were low, 50.90 per cent medium and 11.51 per cent samples were found in high categorizes (Fig. 1). As whole, the soils of Banaskantha district had nutrient index value of 1.74 indicating marginal fertility status for DTPA-extractable Zn (Table 2). The DTPA-extractable Zn showed highly significant and positive correlation with organic carbon \((r = 0.346^*)\). This clearly indicates that higher OC content increased the availability of Zn in soil. Talukdar et al. (2009) also reported significant and positive correlation between available Zn and OC content of soil. In the present investigation, the available Zn showed highly significant and negative correlation with pH \((r = -0.124**)\). It may be due to increased solubility of oxides and hydroxides of Zn at lower pH condition (Talukdar et al. 2009).

**DTPA-extractable Cu:** The DTPA-extractable Cu in soils of Banaskantha district varied from 0.12 to 3.16 mg kg\(^{-1}\) with a mean value of 0.60 mg kg\(^{-1}\) (Table 1). Out of 556 soil samples, 75.72, 22.84 and 1.44 per cent samples were found in high, medium and low categories of DTPA-extractable Cu, respectively (Fig 1). Overall, the soils of Banaskantha district had nutrient index value of 2.74 indicating very high fertility status for DTPA-extractable Cu (Table 2). In the present investigation, DTPA-extractable Cu showed highly significant and positive correlation with pH \((r = 0.464^*)\). This may be attributed to increased stability of Cu complexes implicating presence of greater amount of DTPA-Cu bound with organic matter. These observations are in agreement with those made by Singh et al. (2014). The DTPA-Cu was negatively and significantly correlated with pH \((r = -0.337^*)\), whereas non-significantly negatively correlated with EC \((r = -0.075)\). This indicates the increased availability of Cu at lower pH. Similar results were also reported by Patel et al. 2017.

**CONCLUSION**

The soils of Banaskantha district of Gujarat were marginal in the status of available sulphur and DTPA-extractable Fe and Zn, whereas high and very high status in the of DTPA-extractable Mn and Cu, respectively. Deficiency of Fe, Mn, Zn and Cu increased with an increase in pH whereas it decreased with an increase in organic carbon content.

**REFERENCES**

Bhanwaria, R., Kamera, P.R. and Yadav, B.L. (2011). Available micronutrient status and their relationship with soil properties of Mokola soil series of Rajasthan. *Journal of the Indian Society of Soil Science*. 59: 392-396.

Cheslin, L. and Yien, C.H. (1951). Turbidimetric determination of available sulphates. *Proceedings of Soil Science Society of America*. 15: 149-151.

Hariram and Dwivedi, K.N. (1994). Delineation of sulphur deficient soil groups in the central alluvial tract of Uttar Pradesh. *Journal of the Indian Society of Soil Science*. 42 (3): 284-286.

Jat, J.R. and Yadav, B.L. (2006). Different forms of sulphur and their relationship with properties of Entisols of Jaipur district under mustard cultivation. *Journal of the Indian Society of Soil Science*. 54: 208-212.

Lindsay, W.L. and Norvell, W.A. (1978). Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal*. 42: 421-428.

Panse, V.G. and Sukhatme, P.V. (1961). Statistical Methods for Agricultural Workers. ICAR, New Delhi.

Patel, B.T., Patel I.M. and Patel J.M. (2017). Fertility status of cultivated soils in Gandhinagar district of Gujarat. *Gujarat Agricultural Universities Research Journal*. 42(1): 8-12.

Patel, J.M., Patel, B.T. and Patel I.M. (2016). Fertility status of cultivated soils in Patan district of North Gujarat. *Gujarat Agricultural Universities Research Journal*. 41(1): 23-27.

Rajput, B., Trivedi, S.K., Gupta, N. and Tomar, A.S. (2015). Status of available sulphur and micronutrients in mustard growing areas of Northern Madhya Pradesh. *Journal of the Indian Society of Soil Science*. 63(3): 358-361.

Ramamoorthy, B. and Bajaj, J.C. (1969). Available N, P and K status of Indian soils. *Fertilizer News*. 14: 24-26.

Singh, Y.P., Raghubanshi, B.P.S., Tomar, R.S., Verma and Dubey, S.K. (2014). Soil fertility status and correlation of available macro and micronutrients in chambal region of Madhya Pradesh. *Journal of the Indian Society of Soil Science*. 62(4): 369-375.

Stalin, P., Singh, M.V., Muthumanickam, D., Chitedeshwari, T., Velu, V., Appavu, K. (2010). Four Decades of Research on Management of Micro- and Secondary-Nutrients and Pollutant Elements in Crops and Soils of Tamil Nadu. Publication No. 8. AICRP micro- and secondary-nutrients and pollutant elements in soils and plants. IISS, Bhopal. 8: 22.

Talukdar, M.C., Basumatary, A. and Dutta, S.K. (2009). Status of DTPA extractable cationic micronutrients in soils under rice and sugarcane ecosystems of Golaghat district in Assam. *Journal of the Indian Society of Soil Science*. 57(3): 313-316.

Tandon, H.L.S. (2010). Soil sulphur deficiencies: towards integration of diverse data bases. *Indian Journal of Fertilisers*. 6: 14-24.

Williams, C.H. and Steinbergs, H. (1959). Soil sulphur fractions as chemical indices of available sulphur in some Australian soils. *Australian Journal of Agriculture Research*. 21: 50-62.