

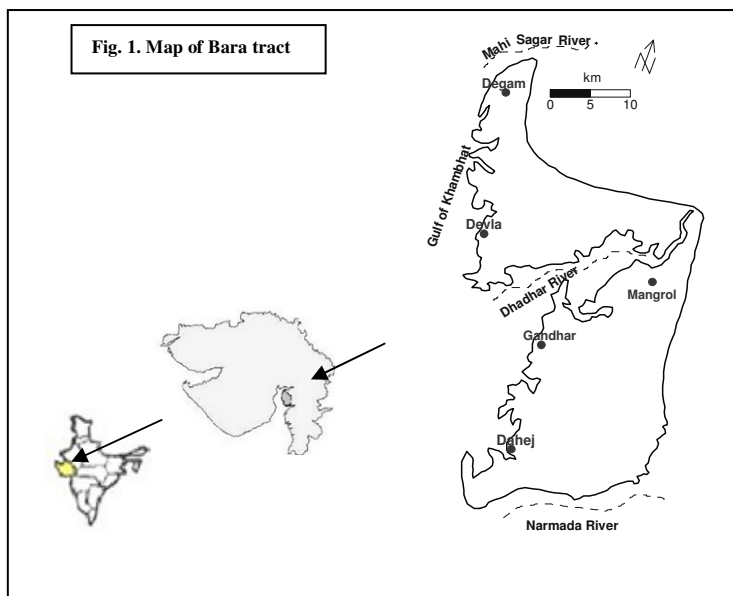
## Soil Properties and Nutrient Availability of Saline *Vertisols* of Bara Tract under Sardar Sarovar Canal Command of Gujarat State

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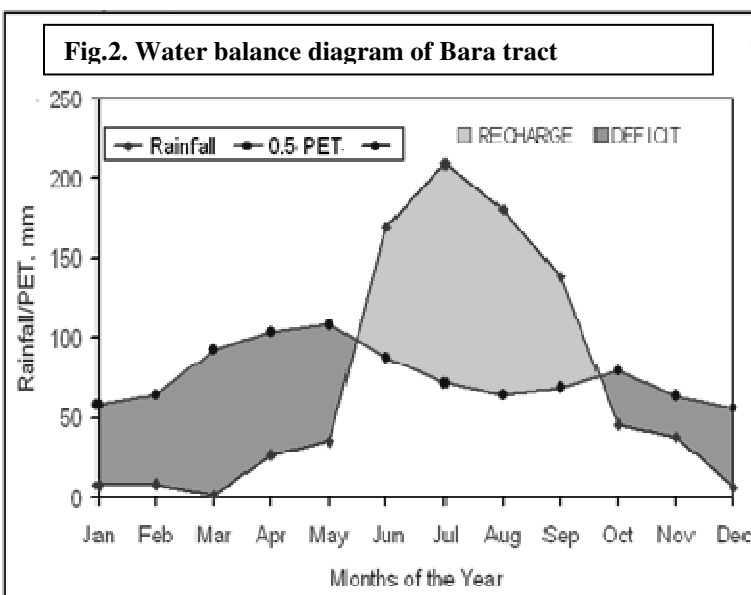
### Introduction

Bara tract (Fig. 1) is spread over 111300 hectare in Vagra, Jambusar and Amod taluka of Bharuch district. Its geographical position is situated at  $21^{\circ}40'$  from  $22^{\circ}13'$  N latitude and  $72^{\circ}32'$  to  $72^{\circ}55'$  E longitude and 5-9 m above sea level. This area is bounded by the river Narmada in the South and the river Mahi in the North. The area is situated on almost flat land. About 60 per cent of the Bara tract is under cultivation, 15-20 per cent share under non-agricultural wasteland, 8-10 per cent under agricultural wasteland and the rest are under grazing. The key part of Bara tract comes under rain-based farming and some limited areas are under irrigated agriculture. Conventional agriculture is prevalent in this area due to poor economy of farmers. In such saline tract, soil productivity is low due to lack of land use planning and its management. In view of these types of problems, a study was conducted to study soil properties and to evaluate the availability of nutrients and its attributes.



### Climatic resources of Bara tract

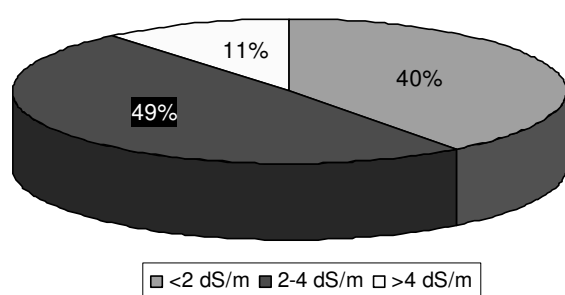
The Bara tract falls under tropical climate. The maximum temperature in the month of May goes to  $45^{\circ}\text{C}$  and average rainfall is 737 mm. According to the analysis of rainfall data for ninety-six years (1901-1998), precipitation in the region in about 23 years had been below normal rainfall and in about 6 years was a drought condition. In Bara tract, the arrival of monsoon is irregular which affects the sowing, seed germination and seedlings stand. This region usually experienced at least one critical dry spell in the months of July-September, which is of 21-28 days. Water balance graph (Fig.2) revealed that water supply was higher than water demand (potential evapotranspiration; PET) during June to September. By rain water recharging, soil available water can be used upto month of October, while rest of nine months water supply was lower than PET.



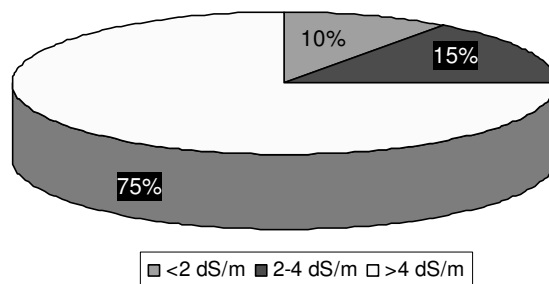
### Soil properties of Bara tract

Soils of this area have been classified in the *Vertisol* order and are also recognized as black cotton soils. The soil is deep (150 cm), fine textured (39-61% clay), having montmorillonite clay mineral, exhibited swell shrink properties and having 4-6 cm wide and 90 cm deep cracks. Black cotton soil is having the ability to hold higher amount of soil water due to high clay content but its permeability is very low and saturated hydraulic conductivity (Ks) is also very low or negligible (SSNNL, 2009; Nayak *et al.*, 2004). These soils are calcareous in nature.

In Bara tract area, it has been found that soil salinity at surface layer measuring 44,075 hectare area (40 % of Bara tract area) is having soil salinity  $< 2.0 \text{ dS m}^{-1}$  i.e. non-saline soils. In 54871 hectare area (49%) is having soil salinity in the range of  $2.0\text{-}4.0 \text{ dS m}^{-1}$  and while 12,354 hectare area (11%) is having soil salinity more than  $4.0 \text{ dS m}^{-1}$  (Fig.3).



**Fig. 3 Surface soils of Bara tract (%) affected by soil salinity**



**Fig. 4 Sub-surface soils of Bara tract (%) affected by soil salinity**

In case of sub-surface layer, sub-surface soil salinity covering 83,475 hectare (75% of Bara tract), area is having salinity more than  $4.0 \text{ dS m}^{-1}$ . About 16695 hectare (15%) area is having soil salinity in the range of  $2\text{-}4 \text{ dS m}^{-1}$ , and in about 11130 hectare (10%) area is having  $< 2 \text{ dS m}^{-1}$  soil salinity (Fig.4, Table 1).

**Table 1. Extent and area (ha) of soil salinity in three talukas**

Taluka	$< 2 \text{ dS m}^{-1}$ soil salinity (surface)	$> 4 \text{ dS m}^{-1}$ soil salinity (sub-surface)	$> 4 \text{ dS m}^{-1}$ soil salinity (costal salinity)	Total Area
Jambusar	20516 (18.7%)	57086 (51.9%)	32337 (29.4%)	109939 (100%)
Vagra	18466 (20.6%)	27000 (30.1%)	44324 (49.3%)	89808 (100%)
Amod	32919 (70.6%)	7694 (16.5%)	6038 (12.9%)	46651 (100%)

Irrigated soils showed organic carbon content ranged from 0.30 to 0.72 per cent which is in 'low to medium' category while unirrigated (rainfed) soils are low in organic carbon content i.e. 0.22 to 0.47 per cent. The reason might be due to application of higher quantum of organic manures, apart from higher litter fall and higher quantum of roots and their subsequent deposition under irrigated conditions as a result of luxurious growth of plants (Kadu *et al.*, 2009). Higher cation exchange capacity (CEC) of these soils indicated their good potential in terms of fertility. The CEC is increasing with the depth of soil profile which might be due to presence of varying proportions of clay/ silt+clay and exchangeable  $\text{Na}^{2+}$ ,  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  ions (Chinchmalatpure *et al.*, 2008).

### Major nutrient availability

In irrigated and rainfed soils, the available nitrogen was found in the range of 'low' to 'medium' ( $156.8$  to  $313.6 \text{ kg ha}^{-1}$ ) and 'low' ( $125.4$  to  $258.3 \text{ kg ha}^{-1}$ ) category, respectively. The

quantities of nitrogen were found more at surface soil layer in irrigated soils and decreased with soil depth and irregular trends was found in unirrigated soils which could be the cause of churning process in black soils. The mineralization is slow in the deep soil layers due to low microbial activity, in addition to high pH, salinity or alkalinity (Paramasivan and Jawahar, 2014). Nitrogen management through inorganic or organic sources (FYM/ green manure) may be the major option for increasing crop productivity.

In irrigated and rainfed area, the respective available phosphorus was found in the range of 'high' and 'low' to 'medium', category. The variation of available phosphorus in these soils is due to soil pH, texture and organic matter. 'Low' to 'medium' status of available phosphorus in rainfed soils was possibly due to less vegetation, warm dry weather and soil constraints like calcareousness, alkalinity (Paramasivan and Jawahar, 2014) or precipitation of calcium phosphate or fixation of P by clay/ clay+silt particles (Rao *et al.*, 2008). Available potassium status in both irrigated and rainfed soils was 'high', which is due to presence of high quantity of micaceous (biotite and muscovite) clay minerals. The available sulphur were found in the range of 'medium' to 'high' and 'low' to 'medium' category, respectively in irrigated and rainfed soils. Higher amount of sulphur in *Vertisol* might be attributed to high SOC with heavy texture of these soils.

### Available micronutrients

The status of available Fe in irrigated soils ranged from 1.9 to 6.7 mg kg<sup>-1</sup> and in rainfed soils ranged from 3.3 to 3.8 mg kg<sup>-1</sup> which is in the range of 'low' to 'medium' and 'low', respectively and its higher value in the surface layer, which may be in close relationship with the higher organic matter. In irrigated and rainfed soils, available Mn were found in the range of 'low' to 'high'. Available Cu was found in the high range in irrigated as well as in rainfed soils. The available Zn in the irrigated soils was in the range of 0.22 to 0.61 mg kg<sup>-1</sup> and in rainfed soils ranged from 0.19 to 0.29 mg kg<sup>-1</sup> which is in the range of 'low' to 'medium'. In rainfed soils, available Zn exhibited an irregular trend with soil depth, while the available Zn value was more at surface layer in irrigated soils. It has been observed that the available Fe, Mn, Cu and Zn values increased with increasing organic matter. The values of all micro-nutrients are higher in irrigated soils than in rainfed soils, which might be due to high organic sources, plant debris or root and crop management practices. However, the magnitude of available micronutrients in both the cases generally decreased with depth.

### Dynamics of nutrients

In irrigated soils, NH<sub>4</sub><sup>+</sup>, NO<sub>3</sub><sup>-</sup>, TN, water soluble K (WSK) and exchangeable K (Exch. K) varied from 24.5 to 70.0 ppm, 35.2 to 93.8 ppm, 0.021 to 0.075 percent, 4.2 to 68.5 ppm and 162.8 to 415.6 ppm, respectively and the corresponding values for rainfed soils were 21.0 to 56.3 ppm, 7.0 to 77.0 ppm, 0.018 to 0.35 percent, 8.9 to 18.8 ppm and 266.1 to 375.4 ppm, respectively. The content of ammonical and nitrate was high in surface soils and the magnitude slightly decreased with depth showing somewhat irregular trend which might be due to churning processes of vertic clay soils and swell-shrink characteristics.

### Crop productivity

Soil properties of black cotton soils of Bara tract such as soil texture, depth, cation exchange capacity, organic carbon, pH *etc.* do not vary too much, but due to wide variation in soil salinity and availability of soil moisture content, soil site suitability for cotton and wheat crop is affected. Availability of water through canal irrigation can boost productivity of existing crops in Bara tract and productivity of cotton, pearl millet and sorghum, wheat and castor might be enhanced provided scientific utilization of canal water is followed.

## Conclusion:

Based on the overall results and soil-crop related constraints, following suggestions have been made for improvement/ sustaining yield of crop and soil health.

- Low status of available N and Zn in these soils necessitates use of more organic manures like farm waste / compost/ bio-compost/ vermicompost *etc.* for enhancing the fertility of soils. In specific cases, to overcome Zn deficiency, application of Zn in soil or through foliar spray and in case of N-deficiency, adoption of INM / RDF with inorganic-N in splits and incorporation of leguminous crop in crop rotation and *in-situ* incorporation of decomposable crop residue would improve soil OC and available N status.
- Adoption of sodicity / salinity tolerant crop varieties of arable crops would be highly remunerative in soils having high soil pH, ESP above threshold limit (9.0) and moderately to highly saline soils.
- As the study area is having semiarid climate, rainwater harvesting and recycling, making field bunds for maximum rain water storage in profiles would be highly beneficial. As the ground water is saline and unsafe for irrigation in the entire tract, ground water must be used judiciously (as life-saving/ supplementary) only by mixing with rain water/ canal water or alternately with canal/ rain water to sustain crop yield and to avoid further deterioration in soil health.

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