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S Satish
Ph.D (Soil Science), Dept. of Soil Science and Agricultural Chemistry, S.V. Agricultural College, Acharya N.G. Ranga Agricultural University, Tirupati, Andhra Pradesh, India

MVS Naidu
Professor, Department of Soil Science and Agricultural Chemistry, S.V. Agricultural College, Acharya N.G. Ranga Agricultural University, Tirupati, Andhra Pradesh, India

KV Ramana
Vice – Chairman & Scientist G, Andhra Pradesh Space Applications Centre, Vijayawada, Andhra Pradesh, India

Correspondence
S Satish
Ph.D (Soil Science), Dept. of Soil Science and Agricultural Chemistry, S.V. Agricultural College, Acharya N.G. Ranga Agricultural University, Tirupati, Andhra Pradesh, India

Soil fertility status in Brahmanakotkur watershed of Andhra Pradesh for site specific recommendations

S Satish, MVS Naidu and KV Ramana

Abstract
Two hundred thirty one soil samples from Brahmanakotkur watershed in scArce rainfall zone of Andhra Pradesh were drawn at 320 m grid interval and assessed for their fertility parameters. Analytical data was interpreted and statistical parameters like range, mean, standard deviation and coefficient of variation were calculated. Soil fertility maps were prepared for each parameter under GIS environment using Arc GIS v 10.3. Soils were neutral to strongly alkaline with non-saline in nature and soil organic carbon content was low to medium. The available nitrogen (N) was low to medium, available phosphorus (P) and potassium (K) were low to high and available sulphur (S) was deficient to sufficient. Regarding available micronutrients, zinc (Zn) and iron (Fe) were deficient in about 3/4th of the sub-watershed area whereas, available copper (Cu) and manganese (Mn) was sufficient in the soils. The fertility status of nutrients in watershed revealed that, available N, S, Zn and Fe are important soil fertility constraints.

Keywords: Soil fertility status, grid method, Arc GIS, watersheds, soil fertility constraints

Introduction
Soil is the vital natural resource for the survival of life on the earth and its assessment is the prerequisite for the determination of productivity of soil and the sustainability of the ecosystem. Therefore, assessment of nutrient constraints of soils being intensively cultivated with high yielding crops need to be carried out. Soil testing is usually followed by collecting composite soil samples in the fields without geographic reference. The results of such soil testing are not useful for site specific recommendations and subsequent monitoring. Soil available nutrient constraints of an area using global positioning system (GPS) will help in formulating site specific balanced fertilizer recommendation and to understand the status of soil fertility spatially and temporally. Geographic information system (GIS) is a powerful tool which helps to integrate many types of spatial information such as agro-climatic zone, land use, soil management, *etc*. to derive useful information (Adornado and Yoshida 2008) [1]. Watershed is a holistic approach emerged for rainfed areas, which can lead to higher productivity and sustainability by conservation of soil and water resources simultaneously (Patil *et al*., 2016) [11]. Though, Brahmanakotkur watershed in Kurnool district of Andhra Pradesh is pre-dominantly under rainfed farming with erratic rainfall distribution associated with low crop productivity, needs site-specific information in terms of soil characteristics, their productivity potentials and limitations, which are not available for Kurnool district in general in and Brahmanakotkur watershed in particular for soil resource management. Hence, the present investigation was planned and executed with the objective of identifying available nutrient constraints in soils of Brahmanakotkur watershed in scArce rainfall zone of Andhra Pradesh.

Materials and Methods
The watershed lies in between15°46' and 15°50' N latitudes and 78°09' and 78°13' E longitudes (Fig 1.). It has a total geographical area of 2,931 ha and comprises of four villages namely Gargeyapuram, Diguvapadu, Paipalem and Damagatla (Fig 2.). The soils in the watershed were developed from limestone, dolomite, quartz and shale.The climate of the watershed was semi-arid monsoonic with distinct summer, winter and rainy seasons. The mean annual rainfall recorded for the last 10 years (2008 to 2017) was 543.73 mm of which 96.33 percent was received during May to November. The mean annual temperature was 28.92 °C with mean

summer temperature of 34.92 ºC and mean winter temperature of 25.62 °C. The maximum temperature recorded for the last ten years was 40.67 ºC and the minimum temperaturewas 17.47 ºC in the month of May and December, respectively. The soil moisture regime has been computed as ustic and soil temperature regime as iso hypertherrmic. The natural vegetation of the watershed comprises of *Acacia nilotica, Borassus flabellifer, Tamarindus indica, Tephrosia purpurea, Parthenium hysterophorus, Azadirachta indica, Abutilon indica, Cyperus rotundus, Sygium cumini, Cassia auriculata, Cynodon dactylon and Calotropis giganteaetc.*

Surface composite soil samples were collected using a handheld GPS on grid points of 320 m interval in the study area. A total of 231 samples were collected from the watershed. The soil samples were air-dried, ground (< 2 mm) and analyzed for physico-chemical and fertility parameters. The pH (1:2.5) and electrical conductivity (EC) (1:2.5) of soils were measured using standard procedures as described by Jackson (1973) [4]. Organic carbon (OC) was determined using the Walkley-Black method (Nelson and Sommers 1996) [9]. Available nitrogen (N) was estimated by alkaline permanganate method (Subbiah and Asija 1956) [19]. Available phosphorus (Olsen P) was measured using sodium bicarbonate ($NaHCO_3$) as an extractant (Olsen and Sommers 1982). Available potassium (K) was determined using the ammonium acetate method (Jackson, 1973) [4]. Available sulphur (S) was measured using 0.15 percent calcium chloride ($CaCl_2.2H_2O$) as an extractant (Williams and Steinbergs, 1959) [21]. Micronutrients (Fe, Zn, Cu and Mn) were extracted by DTPA using the procedure outlined by Lindsay and Norvell (1978) [5]. Variability of data was assessed using mean standard deviation and coefficient of variation for each set of data. Availability of N, P and K in soils are interpreted as low, medium and high and that of available sulphur (S), zinc (Zn), iron (Fe), copper (Cu) and manganese (Mn) interpreted as deficient and sufficient by following the criteria given in table 1.

A dbf file consisting of data for X and Y coordinates in respect of sampling site location was created. A shape file (Vector data) showing the outline of Brahmanakotkur watershed area was created in Arc GIS *10.3*. The dbf file was opened in the project window and in X-field, longitudes “and in Y-field, “latitudes “were selected. The Z field was used for different nutrients. The Brahmanakotkur watershed file was also opened and from the “Surface menu “of Arc GIS geostatistical Analyst, “geo statistical wizard “option was selected. On the output “grid specification dialogue”, output grid extend chosen was same as Brahmanakotkur watershed and the interpolation method employed was inverse diatance weighted (idw).

Results and Discussion

Soil reaction and electrical conductivity

Soils of the Brahmanakotkur watershed were neutral to strongly alkaline (7.01 to 8.89) in reaction with a mean pH of 8.14, standard deviation of 0.37 and coefficient of variation of 4.58 percent (Table 2). Higher soil reaction in the watershed is mainly because of calcareous nature and sodicity of soils. The CV of soil pH indicates that spatially it did not vary. The higher pH of soils could be attributed to low intensity of leaching and accumulation of bases. The results are in agreement with those reported for northern dry zone soils by Prabhavati *et al.* (2015) [13] and Patil *et al.*, (2016) [11]. The EC of soils in Brahmanakotkur watershed was in the range of 0.09 to 0.96 dSm^{-1} with a mean of 0.25 dSm^{-1} and standard deviation of 0.14.The coefficient of variation (56.18%) of EC values indicated that salt content in watershed varied spatially (Table 2). Slightly higher level of soluble salts in the study area was due to semi-arid climatic condition. Soluble salt content in the watershed revealed that, the area was non-saline. The values obtained in the present study are in agreement with those reported by Patil *et al.*, (2016) [11]

Organic carbon

Soil organic carbon content (OC) of Brahmanakotkur watershed varied from 0.06 to 0.75 percent with a mean and standard deviation value of 0.43 percent and 0.15, respectively. The CV of 35.28 percent for organic carbon content indicated that, in the watershed organic carbon varied spatially. (Table 2). The values obtained in the present study are in agreement with those reported by Ravikumar *et al.* (2007) [14] for black soils of Malaprabha command area of Karnataka. The reason for low organic carbon content in these soils may be attributed to the prevalence of semi-arid condition, where the degradation of organic matter occurs at a faster rate coupled with little or no addition of organic manures and low vegetation cover on the fields, there by leaving less chances of accumulation of organic carbon in the soils. Intensive cropping is also one of the reasons for low organic carbon content. Similar results were also reported by Prabhavati *et al.* (2015) [13] and Nalina *et al.*, (2016) [7] for the soils of northern dry zone of Karnataka and soils of eastern dry zone of Karnataka.

Available macronutrients

The available nitrogen in surface soils of the Brahmanalotkur watershed varied from 100.35 to 439.04 kg ha^{-1} with a mean of 231.76 and SD of 67.87. The CV value of 29.28 percent indicates that, available N in soils varied spatially. The study revealed that, 91.00 percent watershed was low in the available N (Table 2). The low available N could be attributed to soil management, varied application of FYM and fertilizers to previous crops. Another possible reason may also be due to low organic matter content in these areas due to low rainfall and high temperature which facilitate faster degradation and removal of organic matter leading to N deficiency. Similar N status was reported by Basavaraju *et al.* (2005) [3], Shankaraiah *et al.* (2006) [16] and Patil *et al.*, (2016) [11].

The available phosphorus content in soils of Brahmanalotkur watershed ranged from 15.39 to 180.91 kg P_2O_5 ha^{-1} with an average and SD value of 104.97 and 49.69, respectively. The CV of 47.33 percent for available P_2O_5 distribution in the watershed indicates that, it varied spatially (Table 2). Semi-arid environment with low rainfall, the continuous use of high analysis fertilizers especially DAP in the study area resulting in the phosphorus build up and contributing towards high available phosphorus status of the soils. Anilkumar *et al.*, (2010) [2] and Nalina *et al.*, (2016) [7] also found similar observations. The available potassium content in soils of Brahmanalotkur watershed ranged from 43.78 to 819.88 kg K_2O ha^{-1} with mean and SD value of 397 and 117.23, respectively. The CV of 29.53 for available potassium indicates that, it varied spatially in the watershed (Table 2). Soils are able to maintain a sufficient or even high level of exchangeable K and provide a good supply of K to plants for many years. The medium to higher content of available K_2O in soils of Brahmanalotkur watershed may be due to the predominance of K-rich micaceous and feldspar minerals in parent material. Similar results were observed by Srikant *et al.* (2008) [18] and Patil *et al.*, (2016) [11].

The available S content of soils of the watershed varied from 0.62 to 43.75 mg kg^{-1} soil with mean and SD values of 14.49 and 8.64, respectively. The CV of 59.53 percent for available S indicates that, in the watershed available S varied spatially (Table 2). It was observed that the area is divided almost equally between the high and medium status in sub-watershed highlighting the importance of mapping the area rather than the statistics derived from soil analysis. The low S is partly due to gypsiferous nature of S which is non-available in black soils. Low and medium level of available S was due to lack of sulphur addition and continuous removal of S by crops (Venkatesh and Satynarayana 1999) [20].

Available micronutrients

The available Zinc in the watershed ranged from 0.03 to 3.97 mg kg^{-1} with a mean and SD values of 0.53 and 0.37, respectively. The CV of 70.08 percent for available zinc indicates that, it varied spatially in the watershed (Table 3). The available Zn increased with decrease in pH and increase in organic carbon content. Similarly, Satyavathi and Reddy (2004) [15] also reported that available Zn in soils decreased with increase in pH. Since, most of the soils are alkaline, low in OC and dominated by $CaCO_3$, Zn might have been precipitated
as hydroxides and carbonates, as a result their decreased solubility and mobility might have reduced the availability (Patil *et al.* 2006) [12]. Similar results were observed by Patil *et al.* (2016) [11] in soils of Dindur sub-watershed of Karnataka.

The available Copper in the watershed was sufficient and ranged from 0.11 to 1.7 mg kg^{-1} with a mean and SD value of 0.60 and 0.30, respectively. The CV value of 50.19 percent for available copper indicates that, it varied spatially in the watershed (Table 3). Manojkumar (2011) [6] and Patil *et al.* (2016) [11] also observed sufficient status of available copper in soils of north Karnataka.

The available Fe in the watershed varied from 0.19 to 12.54 mg kg^{-1} with a mean and SD value of 3.9 and 1.7, respectively. The CV of 43.52 percent for available iron indicates that, it varied spatially in the watershed (Table 3). The low Fe content may be due to precipitation of Fe by CaCO3 which decreased its availability. Similar results were also observed by Patil *et al.* (2006) [12] and Ravikumar *et al.* (2007) [14]. The available iron in surface soils has no regular pattern of distribution as also reported by Nayak *et al.* (2002) [8]. This type of variation may be due to the soil management practices and cropping pattern adopted by different farmers.

The available manganese in surface soil samples of Brahmanalotkur watershed ranged from 0.72 to 15.46 mg kg^{-1} with a mean and SD of 6.03 and 3.13, respectively. The CV value of 51.88 percent for available manganese indicates that, it varied spatially in the watershed (Table 3). Similar results were also reported by Sireesha and Naidu (2013) [17] who reported that available Mn was sufficient in the soils of Banaganapalle mandal of Kurnool district in Andhra Pradesh. Sufficient content of Mn was also observed by Ravikumar *et al.* (2007) [14] in Vertisols of Malaprabha command area and Manojkumar (2011) [6] in the soils of northern transition zone of Karnataka derived from basalt.

Table 1: Soil fertility ratings for available nutrients

Nutrients	Fertility rating major nutrients		
	Low	**Medium**	**High**
Organic carbon (%)	< 0.5	0.5 – 0.75	> 0.75
Macronutrients (kg ha^{-1})			
Available N	< 280	280 – 560	> 560
Available P_2O_5	< 22.9	22.9 – 56.33	> 56.33
Available K_2O	< 129.6	129.6 – 336	> 336
	Deficient	**Sufficient**	
Available Sulphur (S) (mg kg-1)	< 10	> 10	
Micronutrients (mg kg^{-1} soil)	**Deficient**	**Sufficient**	
Zinc (Zn)	< 0.6	>0.6	
Copper (Cu)	< 0.2	>0.2	
Iron (Fe)	< 4.5	>4.5	
Manganese (Mn)	< 1.0	>1.0	

Table 2: Physico-chemical properties and available major nutrients status in Brahmanakotkur watershed

	Physico-chemical properties			Available major nutrients (kg ha^{-1})			
Statistics	**pH**	**EC (dS m^{-1})**	**OC (%)**	**N**	**P**	**K**	**S (mg kg^{-1})**
Minimum	7.01	0.09	0.06	100.35	15.39	43.78	0.62
Maximum	8.89	0.96	0.75	439.04	180.91	819.88	43.75
Mean	8.14	0.25	0.43	231.76	104.97	397.00	14.49
SD	0.37	0.14	0.15	67.87	49.69	117.23	8.64
CV (%)	4.58	56.18	35.28	29.28	47.33	29.53	59.53

Table 3: Available micronutrients status in Brahmanakotkur watershed

	Available micronutrients (mg kg^{-1} soil)			
Statistics	**Zn**	**Cu**	**Fe**	**Mn**
Minimum	0.03	0.11	0.19	0.72
Maximum	3.97	1.70	12.54	15.46
Mean	0.53	0.60	3.90	6.03
SD	0.37	0.30	1.70	3.13
CV (%)	70.08	50.19	43.52	51.88

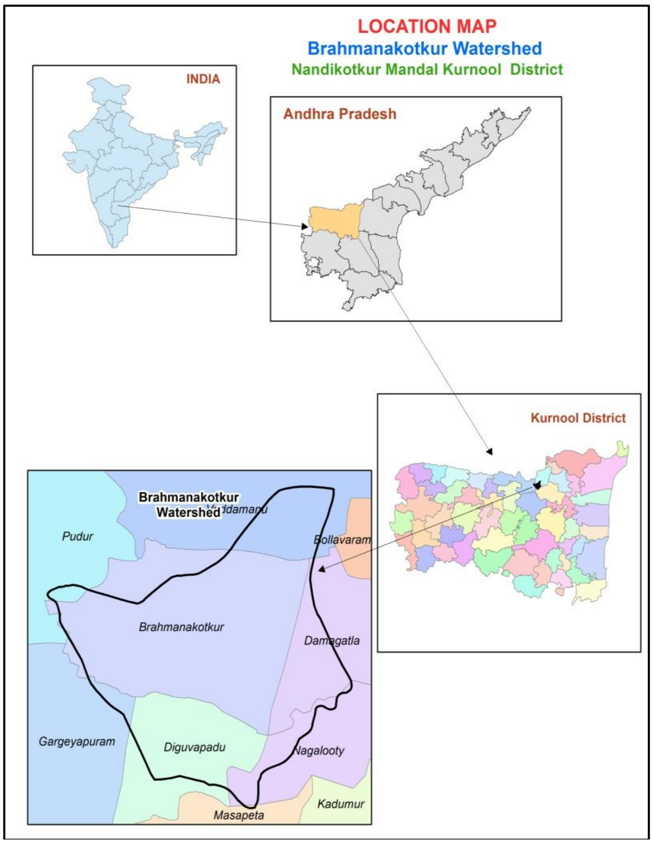

Fig 1: Location map of Brahmanakotkur watershed

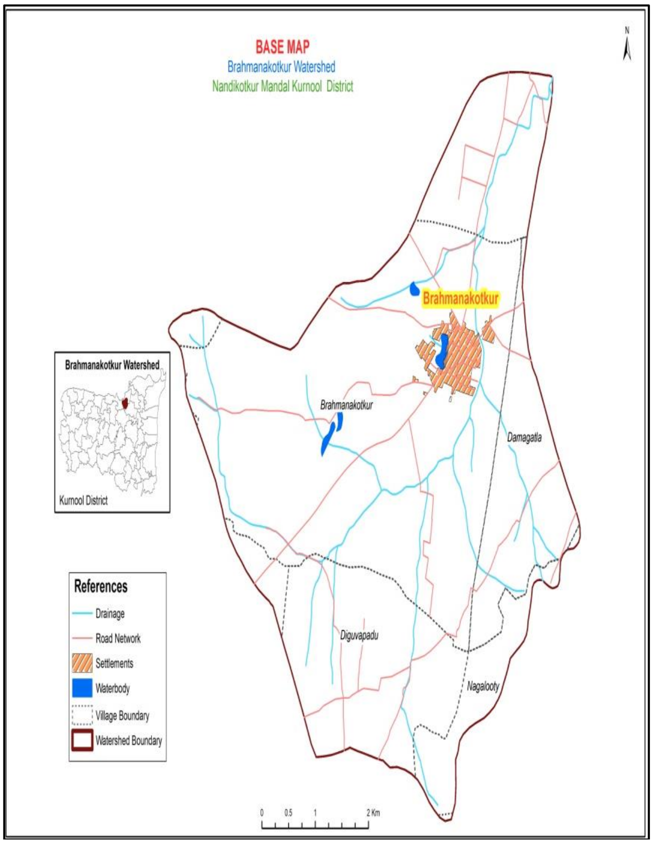

Fig 2: Base map of Brahmanakotkur watershed

Conclusions

From the study, it can be concluded that, soils of Brahmanakotkur watershed in scArce rainfall zone of Andhra Pradesh are neutral to strongly alkaline with non-saline to slight salinity. Alkaline soils in the study area need immediate attention for their management to arrest further degradation. Soil organic carbon content was low to medium. Available N was low to medium, available P_2O_5 and K_2O was low to high, and available S was deficient to sufficient. Regarding available micronutrients, zinc (Zn) and iron (Fe) were deficient in about $3/4^{th}$ of the sub-watershed area whereas Cu and Mn were sufficient in the soils. The fertility status of nutrients in watershed revealed that, available N, S, Zn and Fe are important soil fertility constraints indicating their immediate attention for sustained crop production. The deficient micronutrients need to be replenished to avoid the crops suffering from their deficiency and for optimum utilization of other nutrients.

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