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Available macronutrient status of soils in various cropping systems of Thotapalli irrigation project ayacut of North coastal Andhra Pradesh

K. Himabindu[1], P. Gurumurthy*[2], P.R.K. Prasad[3] and M. Martin Luther[4]

Department of Soil Science and Agricultural Chemistry,
Agricultural College, Naira-532 185, Andhra Pradesh, India.
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ABSTRACT

Assessment of macronutrient status of soils under five major cropping systems namely, rainfed mango/cashew orchards, rainfed groundnut/mesta cropping, irrigated rice followed by pulses, irrigated rice followed by maize and irrigated sugarcane in Thotapalli irrigation project ayacut area of north coastal Andhra Pradesh was carried out. A total of 125 random soil samples were collected from five different cropping systems from five villages of five Tehsils (mandals) namely, Cheeprupalli, Therlam (both tehsils from Vizianagarm district), Ranasthalam, Regidiamadalavalasa and Laveru (from Srikakulam district). The results of the study revealed that the soil organic carbon (OC), available nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) contents of the irrigated land was higher than adjacent rainfed upland, however the exchangeable calcium and magnesium were higher in rainfed uplands and relatively lower in irrigated cropping systems. Significant positive correlation was noticed between percent clay content with available N (r = 0.311**), available P_2O_5 (r = 0.232*), available K_2O (r = 0.473**), available Sulphur (r = 0.249*), likewise organic carbon content also positively correlated with available N (r = 0.456**), available P_2O_5 (r = O.578**), available K_2O (r = 0.211*) and available sulphur (r = 0.298*), while available phosphorous, was negatively correlated with soil pH, EC and $CaCO_3$ contents. The variations in soil properties and nutrient status among cropping systems indicate need for employing integrated and soil test based nutrient management in sustainable manner.

Key words: Cropping systems, Macronutrients, Physico-chemical properties.

INTRODUCTION

Soil fertility is one of the factors that controls yield of agricultural crops. It is the nutrient pool that crop plants utilizes for their growth and development. It determines the sustainable productivity of the region. Soil quality may be affected by land use type and agriculture management practices like cropping systems because these may cause alteration in land productivity (Islam and Wali, 2000). Forms and availability of nutrients in soils, their movement and their uptake by roots and the utilization of nutrients within plants are closely related (Foth and Ellis, 1997). Spatial heterogeneity in soil properties might arise as a result of the differences in cropping systems and crop management despite under the same land use type (Wen-bin *et al*., 2007). Without maintaining soil fertility, one cannot talk about increment of agricultural production in feeding the alarmingly increasing population. In the last few decades, the studies on soil nutrients has become an important topic of research. Analysis carried out in soils around Indore namely fores, garden, barren land, farm of wheat and cemented frame making industry by Gandhe (2015) observed that nutrient levels were comparatively low in cemented industrial areas and the content was comparatively more in the forest area. Similarly, available nutrients were also studied in the soils of Chiraigaon block of Varanasi district in relation to soil characteristics and found vast difference among nutrients (Singh and Mishra 2012). The information on nutrient status of soils in major croppig systems of Thotapalli irrigation project ayacut area of north coastal Andhra Pradesh are meager. Therefore, the present study was undertaken to know the macronutrient status of soils under different cropping systems of the north coastal Andhra Pradesh. The study helps in understanding the future scope of nutrient management in the study area.

MATERIALS AND METHODS

The study area (Srikakulam and Vizianagarm districts of North Coastal Andhra Pradesh) was located in in sub humid climate Eastern region of India (Fig l) in the state of Andhra Pradesh between 18° 12' 820'' to 18° 32' 876'' N latitude and 83° 29' 889'' to 83° 37' 727'' E longitudes covering 1.36 lakh acres under ayacut. It comes under north coastal agroclimatic zone with mean annual temperature and rain fall were 28.34°C, 950.8 mm and 26.48°C, 1108.7mm in Vizianagaram and Srikakulam districts, respectively.

Survey setup: A total of 125 random soil samples on the basis of different cropping systems were collected from five tehsils (mandals) namely, Cheeprupalli, Therlam (both tehsils

*Corresponding author's e-mail: peddintigurumurthy@gmail.com

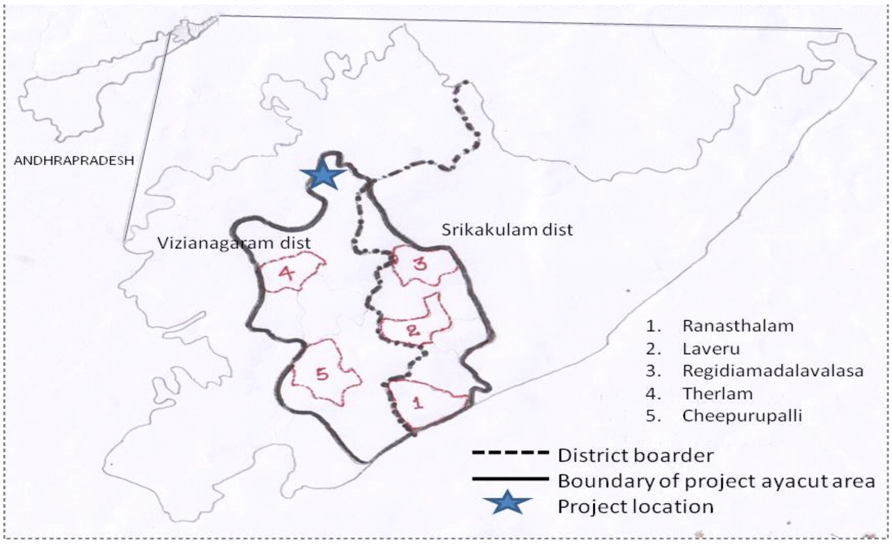

Fig 1: Location map of selected five mandals (Tahsils) for soil sampling in the Thotapalli Irrigation projecte area.

from Vizianagarm district), Ranasthalam, Regidiamadalavalasa and Laveru (from Srikakulam district). From each mandalfive villages were selected. From each village, five soil samples each from one cropping system *viz.*, Rainfed upland Mango/cashew orchards, Rainfed upland groundnut/ mesta cropping, irrigated plain land rice followed by pulses, irrigated plain land rice followed by Maize and irrigated plain land Sugarcane were collected (Table 1). Soil sampling was done during April, 2018 with the help of core sampler which comprises of volume 753.6 cm^3. Soil samples were taken at depth of 0-15 cm in all cropping systems except orchards where soil samples were taken at depth of 0-30 cm.

Laboratory analysis: Patricle size analysis was carried out by Bouyoucos hydrometer method as described by Piper (1966). The pH of soil sample was determined in 1:2.5 soil-water suspensions with the help of glass electrode pH meter as described by Jackson (1973). Electrical conductivity (EC) was determined by method as described by Jackson (1973). Organic carbon (OC) was determined by rapid titration method given Walkley and Black (1934). Estimation of $CaCO_3$ was done by rapid titration method as described by Puri (1930). Available nitrogen (N) was determined by alkaline permanganate method (Subbiah and Asija, 1956): available phosphorous (P_2O_5) was determined by Olsen and Sommers (1982); available potassium (K_2O) was analysed by extraction with l N ammonium acetate at pH 7 (Jackson, l973); available sulphur (S) was determined turbidimetrically using barium chloride (Chesnin and Yein, 1951). The exchangeable calcium and magnesium were extracted with neutral normal ammonium acetate and the contents determined by versanate method (Rechards, 1954).

RESULTS AND DISCUSSION

Size distribution soil particles: Relatively higher proportions of sand particles with mean value of 74.3% was associated with rainfed upland orchards and rainfed upland groundnut/mesta cropping system, however it was relatively lower under irrigated cropping system of rice-pulse, rice-maize and sugarcane. Higher proportions of clay were recorded in irrigated cropping system and lower proportions of clay was recorded in rainfed upland cropping systems. The soils of irrigated cropping systems situated in relatively lower elevations, hence the variation in particle size is due to movement from higher to lower elevation and/or accumulation of clay with irrigation water (Gurumurthy *et al.*, 1996). Further, presence of moisture in soil for longer period and restricted drainage in soils with high clay percentage under irrigated cropping systems caused rapid weathering which resulted in finer textures (Geethasireesha and Naidu, 2013).

Table 1: Descriptions of sampling sites under different cropping systems.

Mandals/Tehsils	Villages covered				
	1	2	3	4	5
Ranasthalam	Kosta	Tirupathipalem	Kondamulagam	Lenkspeta	pathivadapalem
Laveru	P.lingalavalasa	Venkatapuram	patikavalasa	govindapuram	pothiavalasa
Cheepiurupalli	Patikivalas	Sankupalem	Gollapalem	Nadipilli	Metapalli
Regidiamadalavalasa	Tatipadu	Mulakavalasa	Nachanavalasa	panasavalasa	Beligivedu
Therlam	Koratam	Terlam	Amiti	Kotavalasa	appalampeta

Soil pH, EC, OC and $CaCO_3$: Perusal of the data (Table 2) represents that pH in all cropping systems varied form slightly acidic to moderately alkaline. Cropping systems involving rice and sugarcane recorded low pH value which can be attributed due to regular additions of organic manures, crop residues and frequent irrigations which caused their decomposition and leaching of slatswhile, rainfed uplands showed high pH values attributed to the accumulation of $CaCO_3$ and salts (Regmi and Zoebisch 2004). The soils of various cropping systems in study area were found non-saline in nature with lowest mean EC value of 0.59 in irrigated rice- pulse cropping system and highest in rainfed horticulture systems. The lower EC in low /plain land may be due to leaching of salts rather than accumulation in rainfed condition because there is no source of salt addition in rainfed condition. (Kiflu and Beyene 20l3). Organic carbon content showed a conspicuous variation between the cropping systems, following the trend of irrigated sugarcane > rainfed orchards > irrigated rice –pulses > irrigated rice- maize> rainfed groundnut/mesta maize with mean values of 7.14, 7.06, 6.63, 6.25 and 4.38 g kg^{-1}, respectively. Higher values of OC in irrigated sugarcane and rainfed orchard is attributed to high biomass production and lower decomposition rate due to minimum tillage and less exposure of soil to direct suns radiation (Yitbarek *et al*. 2013) and lower values of OC in Rainfed groundnut/ mesta system is due to relatively less application of organic residues and long time exposure to dryness and coarser soil texture (Mansha and Lone 2013). Presence of calcium carbonate is inherent and its value in irrigated condition is lowered due the release of acid during organic matter decomposition being added through FYM or crop residues. The results are in agreement with the findings of Najar *et al*., (2009).

Available nitrogen: The mean available N content ranged between 56- 545 kg ha^{-1} (Table 3). The trends of N content among different cropping systems were: irrigated sugarcane > rainfed orchard > irrigated rice- pulse system > irrigated rice- maize system > rainfed groundnut/ mesta) with mean values of 224, 206, 189, 183 and 160 kg ha^{-1}, respectively. It is attributed due to high OM and overall high turnout of N during decomposition of leaf litters in rainfed orchard and irrigated sugarcane as compared to other cropping systems. The results are similar with the findings of Yihenew *et al*. (2015).

Available phosphorus: The available phosphorous in the soils is low to high, varied from 15.6 to 127.4 kg ha^{-1} with trend of irrigated sugarcane> irrigated rice- maize> irrigated rice pulses> rainfed orchard> rainfed groundnut/ mesta with mean values of 26.9, 30.4, 35.5, 45.0 and 53.8 kg ha^{-1}, respectively (Table 3). The range is considerably large which might be due to variation in soil properties *viz*., pH, organic carbon content, texture, land use, various agronomic and land use practices (Sachan and Deekasha Krishna, 2018) This could be due to application of phosphatic fertilizers on the irrigated cropping systems might have resulted in the increase in P in the soil in line with the explanation made by Woldeamlak and Stroosnijder (2003) and Gebeyaw (2007)

Table 2: Important physico-chemical properties of soils in selected mandals of Thotapalli project ayacut area of North coastal Andhra Pradesh.

Soil property	Rainfed uplands Mango/cashew	Rainfed uplands Groundnut/mesta	Irrigated plainlands Rice- pulses	Irrigated plainlands Rice-Maize	Irrigated Sugarcane
Sand					
Range	57- 81	62- 82	51- 71	54- 68	55-77
Mean	74.52	72.08	63.44	61.24	63.18
Silt					
Range	6- 11	6- 15	08- 16	10- 15	8- 14
Mean	8.52	8.84	11.64	12.64	11.28
Clay					
Range	13- 20	12- 27	22 -37	19- 35	17-32
Mean	18.96	21.08	27.92	27.12	25.52
pH (1:2)					
Range	6.22-8.76	5.83-8.39	6.05- 8.53	5.15- 8.36	6.35- 8.22
Mean	7.37	7.40	7.14	6.88	7.20
EC (dSm^{-1})					
Range	0.23-1.84	0.16- 1.53	0.23- 1.48	0.26- 3.80	0.18- 1.55
Mean	0.81	0.71	0.59	0.62	0.68
O.C (g kg^{-1})					
Range	3.21-11.03	2.91- 13.82	3.11- 13.39	3.34- 12.33	3.68- 15.17
Mean	7.06	4.38	6.63	6.25	7.14
$CaCO_3$ (%)					
Range	0.0-2.5	0.0- 3.0	0.0-2.50	0.0- 1.80	0.0- 5.3
Mean	1.93	1.34	0.83	1.02	0.213

and addition of crop residues and manures in case of irrigated cropping systems which releases organic anions on decomposition and form chelates with Fe and Al and make restricted P fixation and increase P availability. The results are in conformity with the studies of Najar *et al*., (2002).

Available potassium: The available K ranged between 88-439 kg ha^{-1} with trend rainfed orchard > irrigated rice- pulse > irrigated rice- maize > rainfed groundnut/ mesta > irrigated sugarcane with mean values of 263, 256, 245, 230 and 188 kg ha^{-1} (Table 3). Geetasireesha and Naidu (2013) found Potassium in medium range in majority of the sites of Banaganapalli mandal of Kurnool district. However, due to intensive cultivation of irrigated sugarcane, it leads to removal of high K from soil and makes it low in status. The results are similar with the findings of Singh *et al*. (2012).

Available sulphur: About half of the soil samples in all the cropping systems showed low status of available soil sulphur. The cropping systems under study do not showed wide variation of available sulphur content. Relatively high available sulphur under horticultural cropping and rice-maize and sugarcane cropping was due to more organic matter accumulation, however relatively less sulphur content under rice- pulses system is due to more sulphur removal by pulse crops for protein synthesis. The results were in conformity with findings of Farida *et al.* (2008). Available sulphur was positively and significantly correlated with organic carbon (r = 0.298*) whereas, negatively and non-significantly correlated with EC (r = -0.169) and pH (r = -0.093). This might be due to facts that with increase in organic matter in soil, the clay-humus complex become more

Table 3: Available Macronutrient status of soils in selected mandals of Thotapalli project ayacut area of North Coastal Andhra Pradesh.

	Rainfed uplands Mango/cashew	Rainfed uplands Groundnut/ mesta	Irrigated plainlands Rice- pulses	Irrigated plainlands Rice-Maize	Irrigated Sugarcane
Available N status (kg ha^{-1})					
Range	96.8- 353	64- 383	56- 545	83- 520	76- 420
Mean	206	160	189	183	224
No of samples recorded low status	16 (64)	24 (96)	21 (84)	19 (76)	17 (68)
No of samples recorded medium status	09 (36)	01 (4)	04 (16)	06 (24)	08 (32)
No of samples recorded high status	0	0	0	0	0
Available P_2O_5 status (kg ha^{-1})					
Range	17.5- 47.4	15.6- 55.2	15.6- 58.4	16.16- 77.8	19.3- 127.4
Mean	30.4	26.86	35.5	45.04	53.8
No of samples recorded low status	9 (36)	12 (48)	04 (16)	3 (12)	04 (16)
No of samples recorded medium status	16 (64)	12 (48)	20 (80)	10 (40)	12 (48)
No of samples recorded high status	0	01 (4)	01 (4)	12 (48)	09 (36)
Available K_2O status (kg ha^{-1})					
Range	102- 439	101- 366	126-375	164- 360	88- 326
Mean	263	230	245	256	148
No of samples recorded low status	02 (8)	4 (16)	0 (0)	0 (0)	09 (36)
No of samples recorded medium status	13 (52)	12 (48)	12 (48)	14 (56)	11 (44)
No of samples recorded high status	10 (40)	9 (36)	13 (52)	11 (44)	05 (20)
Available Sulphur status (mg kg^{-1})					
Range	3.8- 16.5	4.0- 14.0	3.9- 14	3.8- 12.5	2.9-9.68
Mean	6.09	6.86	5.5	6.9	3.97
No of samples recorded low status	11 (44)	17 (68)	13 (52)	10 (40)	16 (64)
No of samples recorded medium status	14 (56)	8 (32)	12(48)	15 (60)	9 (36)
No of samples recorded high status	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Exchangeable Calcium status (mg kg^{-1})					
Range	933- 2086	880- 1895	624 - 1194	453 - 935	582 - 864
Mean	1456	1232	879	755	709
No of samples recorded low status	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
No of samples recorded medium status	3 (12)	5 (20)	7 (28)	10 (40)	9 (56)
No of samples recorded high status	22 (88)	20 (80)	18 (72)	15 (60)	16 (44)
Exchangeable Magnesium status (mg kg^{-1})					
Range	221 - 398	143- 325	85- 155	68- 127	71- 140
Mean	244	251	121	97	94
No of samples recorded low status	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
No of samples recorded medium status	2 (8)	3 (12)	5 (20)	7 (28)	3 (12)
No of samples recorded high status	23 (92)	22 (88)	20 (80)	18 (72)	22 (88)

(Note: figures in parenthesis are percentage).

Table 4: Relationship between available macronutrientsand soil physico-chemical properties of r under different cropping systems of North Coastal Andhra Pradesh.

Available nutrient	Sand (%)	Clay (%)	pH	EC	OC	$CaCO_3$
Nitrogen	-0.237*	0.361**	-0.372**	-0.156	0.456**	-0.274**
Phosphorous	-0.264*	0.234*	-0.422**	-0.194	0.578**	-0.214*
Potassium	-0.361**	0.473**	-0.102	-0.138	0.211*	-0.159
Sulphur	-0.186	0.249*	-0.093	-0.169	0.298*	-0.255**
Calcium	-0.415**	0.531**	0.355**	0.588**	0.242*	0.728**
Magnesium	-0.398**	0.411**	0.322**	0.436**	0.055	0.515**

*correlation is significant at P=0.05 level; **correlation is significant at P= 0.01 level.

active thereby providing more exchangeable sites and access to sulphur. These results are in same lines to those of Dipali Desai *et al.*, (2018) and Rajput *et al.* (2015).

Exchangeable calcium and magnesium: Exchangeable forms of calcium and magnesium contents in the soils of study area showed a range between 453 to 2086 mg kg^{-1} and 68 to 398 mg kg^{-1}, respectively (Table 3) having order of rainfed uplands with orchards> rainfed uplands with groundnut/mesta> irrigated rice-pulses> irrigated rice- maize > irrigated sugarcane in Ca with a mean of 1456, 1232, 879, 755 and 709, respectively and exchangeable Mg also followed the similar trend. Relatively low levels of exchangeable calcium and magnesium in irrigated cropping systems may be due to crop removal, leaching through irrigation water and use of acid forming fertilizers like urea. The results are similar with the studies of Gebrelibanos and Assen (2013) in Northern Ethiopia on soil exchangeable ions under various cropping systems.

Correlation: In general, pH shows significant correlation with nutrients like macro and micronutrients (Kozak *et al*, 2005). Perusal of the data in Table 4 showed significant negative correlation between percent sand and N (r = -0.237*), P_2O_5 (r = -0.264*), K_2O (r = -0.361**). Further significant positive correlation was noticed between percent clay content and, available N (r = 0.311**), P_2O_5 (r = 0.232*), K_2O (r = 0.473**), S (r = 0.249*). The findings are in support of Sharma *et al.*, (2013) who reported as significant positive correlations between clay percent and macronutrient content.

Significant negative correlation was found between pH and available N (r = -0.372**) and available P_2O_5 (r = -0.422**). The organic carbon showed positive significant correlation with available N (r = 0.456**), P_2O_5 (r = O.578**), K_2O (r = 0.211*) and S (r = 0.298*). Negative significant correlation of $CaCO_3$, with N (r: -0.274*), P_2O_5 (r = -241*), S (r = -0.255*) and positive significant of $CaCO_3$ with exchangeable Ca (r = 0.728**) and Mg (r = 0.515**) was also found.

CONCLUSION

It could be concluded that phosphorus and potassium needs more attention in rainfed uplands because most of the samples are in low to medium categories. Majority of soil samples for nitrogen and about half soil samples falls in low category which suggest that there is a need of intervention for integrated nutrient management based on soil test crop response value.

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