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Available Nutrient Status and Fertility Capability Grouping of Soils of Bobbili Mandal, Vizianagaram District, Andhra Pradesh

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The soils of Bobbili mandal, Vizianagaram district were assessed for available nutrient status and grouped into fertility capability units by collecting surface (0-25cm) and subsurface (25-50 cm) soil samples from 50 representative locations. Based on elevation and drainage, the study area was divided into three physiographic units viz., uplands, midlands and lowlands. The soils were strongly acidic to moderately alkaline in reaction, non-saline to critical for germination, low to high in organic carbon, low to medium in available nitrogen, low to high in available phosphorus and potassium and sufficient in available sulphur. Among the micronutrients, the soils were deficient to sufficient in zinc, sufficient in manganese and copper while, sufficient at surface and deficient to sufficient at subsurface in iron. The soils under different physiographic units were grouped into a total of 20 fertility capability units based on fertility related constraints and variations in management requirements.

(***Key words:*** *Surface and sub-surface nutrient status, Micronutrients, Fertility capability modifiers*)

Soil is the most vital and precious natural resource that sustains life on the earth. A productive soil builds the foundation for any successful crop. The native ability of soils to supply sufficient nutrients has declined due to intensive and exhaustive crop production practices involving indiscriminate use of fertilizers, which not only increases the cost of production but also results in deleterious effects on soil fertility. Therefore, one of the great challenges today is to develop and implement soil, crop and nutrient management technologies that enhance the productivity and quality of soil, water and air. The concept of balanced nutrition of crops guides the use of plant nutrients in a definite proportion as required by the crops which is possible only if one knows the available nutrient status of his soils. Soil nutrient status indicates the quantity of nutrients available in the soil for adjustment of fertilizer additions. Systematic and periodical identification of current nutrient status is a prerequisite for sustaining the productivity and fertility of soils. Soil characterization, evaluation of fertility status through problem identification and suggesting suitable management are important aspects in sustainable agricultural production. Further interpretation of soil data into fertility capability classes through grouping them according to the kinds of problems they present for agronomic management of their chemical and physical properties would help in identifying fertility related soil constraints for suitable management. The present study was carried out in Bobbili mandal, Vizianagaram district to evaluate the fertility status of soils and suggest suitable management based on their fertility capability grouping.

MATERIALS AND METHODS

The study area is located between 18°34' and 18°56' North latitude and 83°22'and 83°36' East longitude with elevation varying from 107 to 178 m above the mean sea level with a mean annual rainfall of 1037 mm and annual maximum and minimum temperatures of 39.02°C and 29.04°C, respectively. Considering the physiographic location the study area was broadly divided into uplands, midlands and lowlands. Surface (0-25 cm) and sub-surface (25-50 cm) soil samples were collected from 50 representative locations. The samples were processed and analysed for macro and micronutrient status.

The texture of the soils was determined by Bouyoucos Hydrometer method (Piper, 1966), pH was determined in 1:2.5 (Jackson, 1973). & 1:1 (Sanchez, 2003) soil : water suspension using pH meter, electrical conductivity were determined in 1:2.5 soil : water suspension using conductivity meter, organic carbon content was estimated by Walkley and Black method (Jackson, 1973). The gravel content was estimated on volume basis and expressed as percent. Available nitrogen was determined by alkaline permanganate method (Subbiah and Asija, 1956), available phosphorus in the soil samples was extracted using Olsen's extractant (0.5 M $NaHCO_3$ of pH 8.5) as described by Olsen *et al.* (1954) and the phosphorus in the extract was determined

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by Murphy and Riley (1962) method using ascorbic acid as the reducing agent using spectrophotometer. Available potassium was determined flame photometrically after extraction with neutral normal ammonium acetate (Muhr *et al.,* 1965). Available sulphur (SO_4^{2-}) in the soils was extracted with 0.15 per cent $CaCl_2$. $2H_2O$ solution (Williams and Steinbergs, 1959) and estimated by turbidimetric method (Cottinie *et al.*, 1979). The available micronutrients viz*.,* Fe, Mn, Cu and Zn of the soils were extracted with DTPA extracting solution of pH 7.3 (Lindsay and Norvell, 1978) and their concentration in the extract was determined using atomic absorption spectrophotometer. The soils were grouped into fertility capability units based on the classifications given by Buol *et al.* (1975) and Sanchez *et al.* (1982).

RESULTS AND DISCUSSION

Macronutrients

The data related to the soils of Bobbili mandal presented in Table 1 revealed that the available nitrogen content at surface and subsurface ranged from 138 to 304 and 82 to 254 kg ha^{-1}, with mean values of 216 and 177 kg ha^{-1}, respectively. Among the physiographic units, uplands and midlands recorded low available nitrogen both at surface and subsurface, while lowlands recorded low to medium at surface and low at subsurface. The low nitrogen status in the soils could be due to low amount of organic carbon in the soil (Srinivasan and Poongothai, 2013). The variation in available N contents in the soils could be attributed to the differences in their physiography as well as the differential cultivation and management of the soils.

The phosphorus content in surface soils varied from 18.46 to 92.97 kg ha^{-1} and in the subsurface soils it varied from 9.23 to 89.73 kg ha^{-1} (Table 1). Upland soils recorded low to high available P at both surface and subsurface. Midland and lowland soils were medium to high in available phosphorus at surface, while at subsurface varied from low to high. Low available P content of the soils could be attributed to their high fixing capacity, which prevents phosphorus to come into readily available form into the soil solution (Badrinath *et al.*, 1986).

The available potassium contents ranged from 121 to 1520 kg ha^{-1} with a mean value of 404 kg ha^{-1} at surface and 134 to 1584 kg ha^{-1} with a mean value of 386 kg ha^{-1} at subsurface (Table 1). Majority of the soils in uplands recorded medium to high potassium, while midland soils were medium and lowlands were mostly high.

The overall means of nitrogen, phosphorus and potassium in surface samples were higher compared to subsurface samples, which might possibly be due to much accumulation of crop residues, debris and root

Table 1. *Available nutrient status of soils of Bobbili mandal*

Available nutrients	Depth (cm)	UPLANDS		MIDLANDS		LOWLANDS		Overall range	Overall mean
		Range	Mean	Range	Mean	Range	Mean		
Nitrogen (kg ha^{-1})	0-25	151-270	206	138-276	212	157-304	227	138-304	216
	25-50	132-254	187	82-232	169	147-220	182	82-254	177
Phosphorus (kg ha^{-1})	0-25	18.46-62.63	43.33	26.16-92.97	46.67	29.75-87.17	53.88	18.46-92.97	48.24
	25-50	9.23-72.32	29.7	12.31-89.73	28.63	13.84-69.19	34.71	9.23-89.73	30.81
Potassium (kg ha^{-1})	0-25	161-672	328	121-1460	358	108-1520	523	121-1520	404
	25-50	134-874	307	148-1478	354	215-1584	485	134-1584	386
Sulphur (mg kg^{-1})	0-25	25.93-65.52	36.14	32.40-92.72	51.54	37.37-95.80	58.61	25.93-95.80	50.42
	25-50	25.07-64.20	31.31	29.45-69.22	45.09	29.02-97.20	58.99	25.07-97.20	46.50
Zinc (mg kg^{-1})	0-25	0.52-0.92	0.72	0.32-1.32	0.64	0.42-1.92	0.74	0.32-1.92	0.69
	25-50	0.32-0.80	0.51	0.26-0.66	0.44	0.34-0.78	0.51	0.26-0.80	0.48
Manganese (mg kg^{-1})	0-25	6.76-115.98	48.43	3.98-81.49	18.57	3.02-13.58	7.47	3.02-115.98	21.59
	25-50	3.64-64.98	23.50	2.00-32.98	7.69	1.66-7.32	4.12	1.66-64.98	10.03
Iron (mg kg^{-1})	0-25	4.84-49.22	18.99	4.02-52.20	18.95	6.94-28.34	14.49	4.02-52.20	17.53
	25-50	3.06-26.72	10.27	5.16-34.34	8.89	3.18-11.50	7.05	3.06-34.34	8.61
Copper (mg kg^{-1})	0-25	0.88-3.29	2.01	1.54-4.05	2.49	1.24-5.30	3.49	0.88-5.30	2.71
	25-50	0.59-3.10	1.50	0.72-2.62	1.53	1.24-4.24	2.42	0.59-4.24	1.81

exudates at surface than beneath, which on continuous mineralization release the nutrients. The higher nutrient contents at surface might also be due to the confinement of crop cultivation to surface and their supplementation through external sources *i.e.* fertilizers (Rajeswar *et al.*, 2009). The results were in accordance with the earlier findings of Jamuna *et al.* (2004) in soils of north coastal districts viz., Visakhapatnam, Vizianagaram and Srikakulam districts of Andhra Pradesh.

The average available sulphur content in the surface soil samples varied from 25.93 to 95.80 mg kg^{-1} with a mean value of 50.42 mg kg^{-1} and the subsurface soils varied from 25.07 to 97.20 mg kg^{-1} with a mean value of 46.50 mg kg^{-1} (Table 1). All the soils irrespective of physiography and depth were found to be sufficient in sulphur with values greater than 20 mg kg^{-1} as suggested by Hariram and Dwivedi (1994). Similar results were earlier established by Sathibabu *et al.* (2010) in soils of coastal districts of Andhra Pradesh.

Nutrient index

Nutrient index values of macronutrients for the soils of Bobbili mandal are presented in Table 2. The nutrient index values of the surface soils under study were low in available nitrogen with value 1.04, medium in available phosphorus and available potassium with values of 2.36 and 2.26, respectively.

Micro nutrients

The range and mean values of available zinc, manganese, iron and copper contents are presented in table 1. Overall, 50 per cent of the surface and 84 per cent of sub-surface soil samples were found to be deficient in available zinc content, as per the limit of 0.6 mg kg^{-1} proposed by Deb *et al.*, (2012). The low available Zn content in the soils might be due to the exhaustive uptake by rice and non replenishment through fertilizers (Venu Madhav and Prasada Rao, 2004). Data on zinc contents in different physiographic units revealed that the soils were deficient to sufficient at surface while, majorities were below the critical limit at sub-surface. The available manganese content of surface and sub-surface soil samples ranged from 3.02 to 115.98 and from 1.66 to 64.98 mg kg^{-1}, respectively. Surface soil samples have high concentration of available manganese (mean 21.59 mg kg^{-1}) than sub-surface samples (mean 10.03 mg kg^{-1}). As per the rating given by Lindsay and Norvell (1978) both surface and subsurface soils of all the three physiographic units recorded Mn contents above the critical limit of 1.0 mg kg^{-1}. The Mn bearing minerals in the parent material might be the reason for higher Mn content in the soils (Rakesh Kumar *et al.*, 2009). Considering the critical limit of 4.5 mg kg^{-1}, suggested by Lindsay and Norvell (1978), all the surface and 88 percent of sub-surface samples were sufficient in iron. The soils were sufficient in available iron at surface in both uplands and lowlands, while at subsurface the soils were sufficient to deficient. Among midland soils, all the samples were above the critical limit.

The high amount of iron content might be due to the cultivation of rice, which induced prolonged submergence coupled with reducing conditions (Rakesh Kumar *et al.*, 2009). The available copper content of the surface soils varied from 0.88 to 5.30 mg kg^{-1} with a mean value of 2.71 mg kg^{-1}, while in the sub-surface soils it

Table 2. *Nutrient index values and fertility status of soils of Bobbili mandal*

S. No.	Land form	No. of samples	Nitrogen					Phosphorus					Potassium				
			L	M	H	Nutrient index	Fertility status	L	M	H	Nutrient index	Fertility status	L	M	H	Nutrient index	Fertility status
	Surface																
1	Uplands	11	11	0	0	1.00	L	2	5	4	2.18	M	2	5	4	2.18	M
2	Midlands	23	23	0	0	1.00	L	0	16	7	2.30	M	4	13	6	2.08	M
3	Lowlands	16	14	2	0	0.78	L	0	7	9	2.00	M	2	3	11	2.56	H
	Total		48	2	0	1.04	L	2	28	20	2.36	M	8	21	21	2.26	M
	Sub-surface																
1	Uplands	11	11	0	0	1.00	L	5	5	1	1.64	L	1	7	3	3.27	H
2	Midlands	23	23	0	0	1.00	L	9	13	1	1.65	L	5	14	4	1.95	M
3	Lowlands	16	16	0	0	1.00	L	2	13	1	1.94	M	0	8	8	2.50	H
	Total		50	0	0	1.00	L	16	31	3	1.74	M	6	29	15	2.22	M

L = low, M = medium, H = high

ranged from 0.59 to 4.24 mg kg^{-1} with a mean value of 1.81 mg kg^{-1}. All the surface and sub-surface soils, irrespective of physiography recorded Cu values, above the critical limit of 0.2 mg kg^{-1} (Lindsay and Norvell, 1978). Surface samples were found to be comparatively rich in available micronutrients than subsurface soil samples, which might be due to accumulation of comparatively more amount of organic matter in surface layers than subsurface layers (Nayak *et al.*, 2000).

Fertility capability classification

The soil fertility capability classification is a classification of soils on the basis of fertility constraints, which are quantified from condition modifiers (Rao and Jose, 2003). The concept of soil fertility capability classification was developed by Buol *et al.* (1975) and later improved by Sanchez *et al.* (1982) for grouping soils according to the kinds of problems they present for agronomic management of their chemical and physical properties.

It emphasizes quantifiable top soil parameters as well as subsoil properties directly relevant to plant growth. The classification system consists of three categorical levels viz. type (top soil texture), substrata type (sub-soil texture) and modifiers (the soil characters, which on management can modify the fertility class of the soil).

The upland soils comprised of a total 8 FCC classes (Table 4), where in the type and substrata type varied from CC (clay, clay) to LL(loam, loam). All soils were assigned the modifiers like ustic moisture regime (d) indicating dry period for > 60 consecutive days in a year and low organic carbon(o) containing < 0.5 % carbon. Within this physiographic unit, 45 per cent of soils were deficient in zinc (z), 55 per cent were basic in reaction with pH >7.3 (b), 36 per cent contained gravel between 10 to 30 per cent (r^+) (Sanchez *et al.*, 2003), 9 per cent were deficient in potassium (k) while, 36 per cent were assigned the modifier ' h' as they recorded a pH between 5.0 and 6.0 in 1: 1 soil water suspension indicating the acidity.

A total of 12 capability units were identified in midlands with type and sub strata type varying from CC to LL (Table 4). Here also the soils were under ustic moisture regime and low in organic carbon, which decides the overall health. The modifiers b, z and h were assigned to different soils to indicate basic pH, deficiency of zinc and acidity, respectively. The soils were also assigned with r^+ due to high gravel content.

However in lowlands, soils were grouped into six capability units. All the soils have uniform clay type and substrata type shown as CC (Table 4). As the soils were under rice, major part of the study area was aquic to udic in moisture regime leading to gley condition (g) designated by < 2 chroma of soil (Sanchez *et al.,* 1982). All the soils of the physiographic unit were shown with modifier 'v' which indicates the vertic property due to dominance of swell shrink clays like smectite. Overall, 94 % of villages were low in organic carbon, while 56.25 per cent of samples were deficient in zinc. All soils were basic in reaction. Soils with EC 2 to 4 dS m^{-1} assigned a modifier 's^-', which indicates the tendency to become saline.

Table 3. *Criteria used for fertility capability classification in the present study*

Parameter	Soil properties	Symbols
Type	Surface soil texture	L, C
Sub-strata type	Sub-surface soil texture	L, C
Modifiers	1. Gleying - soil color having chroma <2 within 60 cm of the soil surface	g
	2. Dry - Ustic soil moisture regime (dry >60 consecutive days per year)	d
	3. Acid - pH in 1 : 1 H_2O between 5.0 to 6.0	h
	4. Vertic property - having > 35 % clay or topsoil with shrinkage and swelling	v
	5. Low K reserve - < 168 kg ha^{-1} soil with in 50 cm depth	k
	6. Basic reaction - soils with pH > 7.3	b
	7. Low soil oragnic carbon < 0.5 per cent with in 50 cm depth	o
	8. Deficiency of zinc < 0.6 ppm with in 50 cm depth	z
	9. Gravel - denotes 10 to 15 per cent gravel or coarser particles by volume to any type or sub-strata type texture	r^+
	10. Salinity - 2 to 4 dS m^{-1} (incepient salinity)	s^-

__Table 4.__ Type, sub-strata type, modifiers and fertility capability units of soils of Bobbili mandal

S. No.	Village	Type	Substrata type	Modifiers										FCC unit
				g	d	b	h	k	r^+	S^-	v	o	z	
UPLANDS														
1	A. Velavalasa	C	C	-	d	b	-	-	-	-	-	o	z	CCdboz
2	Bankuruvalasa	C	C	-	d	b	-	-	r^+	-	-	o	z	CCdbr$^+$oz
3	Ch. Boddavalasa	C	C	-	d	b	-	-	-	-	-	o	-	CCdbo
4	Dongirivalasa	L	L	-	d	-	h	-	-	-	-	o	-	LLdho
5	Gopalarayudupeta	L	L	-	d	b	-	-	-	-	-	o	-	LLdbo
6	Mallampeta	C	L	-	d	b	-	-	-	-	-	o	z	CLdboz
7	Narasimhunipeta	L	L	-	d	-	h	-	-	-	-	o	-	LLdho
8	Nimmalapadu	L	L	-	d	-	h	-	-	-	-	o	-	LLdho
9	Rajupeta	C	C	-	d	b	-	-	r^+	-	-	o	z	CCdbr$^+$oz
10	Ramandhoravalasa	L	L	-	d	-	h	k	r^+	-	-	o	-	LLdhr$^+$ko
11	Venkatarayudupeta	L	L	-	d	-	-	-	r^+	-	-	o	z	LLdr$^+$oz
MIDLANDS														
12	Chinthada	C	C	-	d	b	-	-	-	-	-	o	-	CCdbo
13	Dibbagudivalasa	C	C	-	d	b	-	-	-	-	-	o	z	CCdboz
14	Gunnathotavalasa	C	L	-	d	b	-	-	-	-	-	o	-	CLdbo
15	Gunnathotavalasa	L	L	-	d	b	-	-	-	-	-	o	z	LLdboz
16	Kalavarai	L	C	-	d	b	-	-	-	-	-	o	z	LCdboz
17	Kammavalasa	C	C	-	d	b	-	-	-	-	-	o	z	CCdboz
18	Kasindhoravalasa	L	L	-	d	b	-	-	-	-	-	o	z	LLdboz
19	Kinthalipeta	C	C	-	d	b	-	-	-	-	-	o	-	CCdbo
20	Komatipalli	C	C	-	d	b	-	-	-	-	-	o	z	CCdboz
21	Konda Devupalli	L	L	-	d	-	h	-	-	-	-	o	z	LLdhoz
22	Krishnapuram	L	L	-	d	b	-	-	-	-	-	o	z	LLdboz
23	Kumandanpeta	C	L	-	d	b	-	-	-	-	-	o	z	CLdboz
24	M.Burjavalasa	L	L	-	d	b	-	-	-	-	-	o	z	LLdboz
25	Mettavalasa	L	L	-	d	b	-	-	-	-	-	o	z	LLdboz
26	Mettavalasa	C	L	-	d	b	-	-	-	-	-	o	_	CLdbo
27	Narayanappavalasa	C	C	-	d	b	-	-	-	-	-	o	z	CCdboz
28	Pakki	C	C	-	d	b	-	-	r^+	-	-	o	z	CCdr$^+$boz
29	Patha Bobbili	L	L	-	d	_	-	k	-	-	-	o	_	LLdko
30	Piridi	L	L	-	d	b	-	-	-	-	-	o	z	LLdboz
31	Ramuduvalasa	C	C	-	d	b	-	-	-	-	-	o	z	CCdboz
32	Seethayyapeta	C	C	-	d	b	-	-	-	-	-	o	z	CCdboz
33	Sivadavalasa	L	L	-	d	b	-	-	-	-	-	o	_	LLdbo
34	Vakadavalasa	C	L	-	d	-	h	k	-	-	-	o	z	CLdhkoz
LOWLANDS														
35	Alajangi	C	C	g	-	b	-	-	-	-	v	o	z	CCgvboz
36	Bobbili	C	C	g	-	b	-	-	-	-	v	o	-	CCgvbo
37	Bojarajupuram	C	C	-	-	b	-	-	-	-	v	o	z	CCvboz
38	Gollapalli	C	C	g	-	b	-	-	-	s^-	v	o	z	CCgs$^-$vboz
39	Gorli seetharamapuram	C	C	g	-	b	-	-	-	-	v	o	-	CCgvbo
40	J. Rangarayapuram	C	C	g	-	b	-	-	-	-	v	o	z	CCgvboz

Contd.

Contd. Table 4

S. No.	Village	Type	Sub-strata type	Modifiers										
				g	d	b	h	k	r^+	S^-	v	o	z	FCC unit
41	Jagannadhapuram	C	C	-	-	b	-	-	-	-	v	o	-	CCvbo
42	Karada	C	C	g	-	b	-	-	-	-	v	o	-	CCgvbo
43	Karada	C	C	g	-	b	-	-	-	-	v	o	z	CCgvboz
44	Kollivalasa	C	C	g	-	b	-	-	-	-	v	o	z	CCgvboz
45	Kotha Penta	C	C	g	-	b	-	-	-	-	v	o	-	CCgvbo
46	Muttavalasa	C	C	-	-	b	-	-	-	-	v	o	z	CCvboz
47	Panukuvalasa	C	C	g	-	b	-	-	-	-	v	o	z	CCgvboz
48	Paradhi	C	C	g	-	b	-	-	-	-	v	o	-	CCgvbo
49	Penta	C	C	g	-	b	-	-	-	-	v	-	-	Ccgvbo
50	Rangarayapuram	C	C	g	-	b	-	-	-	-	v	o	z	CCgvbz

g = gleying h = acidic b = basic reaction r^+ = gravel C = clayey k = low potassium L = loamy d = ustic moisture regime v = vertic property z = zinc deficiency o = organic carbon deficienc

Among the physiographic units both similarities and differences were noticed. The similarities might be due to fact that many of the condition modifiers were measured only in the surface soil and similarities in these properties cluster the soils into one group, though inherently there could be differences in several other features. The differences might be due to variation in slope, parent material or any other feature, which could influence the composition of surface soils (Rao and Jose, 2003).

The soils with clay- clay (CC) type and sub-strata type usually have low infiltration rate with limited drainage so that tillage operations may be restricted and some crops may be adversely affected by poor aeration (Sanchez *et al.*, 1982)). The soils with loamy texture throughout have medium infiltration rate and good water holding capacity while, soils with loamy surface and clayey sub-surface may lead to perched water table and poor aeration.

Dry soil moisture regime results in moisture stress during dry season. Soils with modifier 'h' have acidic pH, affects nutrient solubility and influences the sorption or precipitation of nutrient with Al and Fe (Whalen *et al.*, 2000). Acidity also affects the plant growth by influencing the availability and uptake of plant nutrients especially P and Mg, and biological processes like nitrification (Swarnam *et al.*, 2009). Soils with modifiers 'k' and 'z' have low ability to supply potassium and zinc, respectively. Soils with modifier r^+ have gravel which reduces the available water capacity of soils and makes tillage difficult, often damaging the equipment (Sanchez *et al.*, 2003). All most all soils were deficient in organic carbon. Reduced soil conditions (gley-g) due to high moisture pose a threat of poor aeration for crops other than rice. Vertic properties (v) due to high swell shrink minerals like smectite create problems during tillage (Table 5).

Suitable management practices have to be followed to overcome the above constraints and maximize the agriculture production of the soils (Table 5). The upland and midlands with dry moisture regime can be made more productive by coinciding planting date to the onset of monsoon for maximum utilization of rains. If possible, provision of irrigation following the dry period during peak growth stages would save the crop. The soils under lowlands with aquic or udic moisture regime can provide ideal conditions for rice, but for other crops to be used efficiently, the field drains have be constructed to remove the standing water. Acidic condition could be brought under control by the application of lime and minimizing the use of acid forming fertilizers. Soils having low amounts of potassium bearing minerals could be improved by the addition of potassium fertilizers. Zinc was found to be deficient in several soils, which warrants the inclusion of zinc containing chemical fertilizers in regular fertilizer schedule. Soils with a threat of being saline could be addressed by using good quality irrigation water. Management of soil organic matter involves minimum or zero tillage farming, green manuring, incorporation of crop residues, animal manure, composted municipal waste, sewage sludge and locally available organic wastes obtained from off-site systems (Moody *et al.*, 2008). Further, addition of organics to soils would help in overcoming the problems associated with basic reaction (<8.5), low water holding capacity (due to gravelly nature), high plasticity in swell-

Table 5. Interpretation and management suggestions for different modifiers

S. No	Modifier	Interpretation	Management suggestions
1	d	Dry soil moisture regime	Dry moisture regime can be made more productive by coinciding planting date to the onset of monsoon for maximum utilization of rains
2	h	Acidic pH	Application of lime and minimizing the use of acid forming fertilizers
3	k	Low potassium	Addition of potassium fertilizers and organic amendments with a significant content of K need to be applied.
4	z	Deficient in zinc	Inclusion of zinc containing chemical fertilizers in regular fertilizer schedule.
5	r^+	Gravelly nature	Addition of organics to soils
6	o	Deficient in organic carbon	Involves mulching and incorporation of green manure crops, crop residues, minimum or zero tillage farming systems, application of organic materials
7	g	Reduced soil conditions, due to high moisture	Provision of drainage and reducing plasticity through organic manures.
8	v	Vertic properties (v) due to high swell shrink minerals like smectite	Addition of organics to soils
9	s^-	Indicating the tendency to become saline	Using good quality irrigation water

shrink soils and improve overall fertility of the soils by improving aggregation, nutrient supply, nutrient transformations and reducing P fixation.

CONCLUSION

The soils of Bobbili mandal, Vijayanagarm district were low to medium in available nitrogen, low to high in available phosphorus and available potassium. All the soils were found to be sufficient in available sulphur. Among the micronutrients, the soils were deficient to sufficient in zinc, sufficient in manganese, in case of iron sufficient at surface and deficient to sufficient at subsurface while, all soils were sufficient in copper. The study revealed that general fertility constraints of the soils were ustic moisture regime (d), low organic carbon (o), deficiency of zinc (z), basic reaction (b), gravel content (r^+), deficiency of potassium (k), acidity (h) , gley condition (g), vertic property (v) and salinity (s^-). Efficient soil management through lime, NPK fertilizers and organic manure application, will support sustainable arable crop production.

REFERENCES

Badrinath, A., Krishnappa, M., Patil, B. N., Kenchaiah, K and Rao, K. B. (1986). Fertility status of some typical soils of coastal Karnataka. *Journal of the Indian Society of Soil Science* **34**(2): 436-438.

Boul, S. W., Sanchez, P.A., Cate, R. B and Granger, M. A. (1975). Soil fertility capability classification. In: *Soil Management in Tropical America*, E. Bornemisza and A. Alvarado (eds.), North Carolina State University, Raleigh. pp 126-141.

Cottenie, A., Virloo, M., Velghe, G and Kiekins, L. (1979). *Analytical methods for plants and soils,* State University, Ghent, Belgium.

Deb, D. L., Sakal, R and Datta, S. P. (2012). Micronutrients. In: *Fundamentals of Soil Science*, N. N. Goswami, R.K. Rattan, G. Dev, G. Narayanaswamy, D.K. Das, S.K. Sanyal, D.K. Pal, and D.L.N. Rao (eds). Indian Society of Soil Science, New Delhi. pp 414-415.

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

Jackson, M. L. (1973). *Soil Chemical Analysis,* Prentice Hall of India Private Ltd., New Delhi. pp 134-182.

Jamuna, P., Ramalingaswamy, K., Naidu, N. V and Subrahmanyam, K. (2004). Soil fertility status and integrated plant nutrient supply for increasing sugarcane productivity in north coastal Andhra Pradesh. *The Andhra Agricultural Journal*. 50 - *Golden Jubilee Special Issue.* pp 125-132.

Lindsay, W. L and Norvell, W. A. (1978). Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of American Journal* **45**: 378-385.

Moody, P. W., Legrandyl, P. T. J and Chon, N. Q. (2008). A decision support constraints to upland soils. *Soil Use and Management* **24**: 148-155.

Muhr, G. R., Datta, N. P., Sankarasubramani, H., Leley, V. K and Dunabha, R. L. (1965). *Soil testing in India,* Second edition, USAID – Mission to India, New Delhi.

Murphy, J and Riley, J. P. (1962). A modified single solution method for determination of phosphate in natural waters. *Analytical Chemistry Acta* **27**: 31-36.

Nayak, D. C., Mukhopadhyay, S and Sarkar, D. (2000). Distribution of some available mironutrients in alluvium soils of Arunachal Pradesh in relation to some characteristics. *Journal of the Indian Society of Soil Science* **48**: 612-614.

Olsen, S. R., Cole, C. V, Frank, S. W and Dean, L. A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. United States Department of Agriculture Circular. 939p.

Piper, C. S. (1966). *Soil and Plant Analysis*. Interscience Publishers, New York, USA, pp. 368.

Rajeswar, M., Sujini Rao, Ch., Balaguravaiah, D and Aariff Khan, M. A. (2009). Distribution of available macro and micronutrients in soils of Garikapadu of Krishna District of Andhra Pradesh. *Journal of the Indian Society of Soil Science* **57**(2): 210-213.

Rakesh Kumar, Sarkar, A. K., Singh, K. P., Agarwal, B. K and Karmakar, S. (2009). Appraisal of Available nutrients status in santhal paraganas region of Jharkhand. *Journal of the Indian Society of Soil Science* **57**(3): 366-369.

Rao, D. V. K. N. and Jose, A. I. (2003). Fertility capability classification of some soils under rubber in Kerala. *Journal of the Indian Society of Soil Science* **51**: 183-188.

Sanchez, P. A., Couto, W and Boul, S. W. (1982). The fertility capability soil classification system : interpretation applicability and modification. *Geoderma* **27**: 283-309.

Sanchez, P. A., Palm, C. A and Buol, S. W. (2003). Fertility capability soil classification : a tool to help assess soil quality in the tropics. *Geoderma* **114**: 157-185.

Sathibabu, N., Hariprasad, P and Venkateswara Rao, B. (2010). Survey on fertility status of cashew gardens in coastal districts of Andhra Pradesh. *The Andhra Agricultural Journal* **57**(4): 360-363.

Srinivasan, K and Poongothai, S. (2013). Macronutrients and micronutrients relation to soil characteristics of Wellington Reservoir, Tamilnadu, India. *Journal of Chemistry and Chemical Sciences* **3**(3): 107-116.

Subbiah, B. V and Asija, C. L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Science* **25**: 259-260.

Swarnam, T. P., Velmurugal, A, Ravisankar, N., Raja, R., Chudari, S. G and Meena, B. L. (2009). Soil fertility classification (FCC) as a tool for sustainable management of soils of island ecosystem. *Journal of the Indian Society of Coastal Agricultural Research* **27**(2): 1-4.

Venu Madhav, M and Prasada Rao, B. R. C. (2004). Major and micro nutrient status of rice- fallow blackgram grown in soils of Krishna western delta region of Andhra Pradesh. *The Andhra Agriculture Journal* **50**: 151-153.

Whalen, J .K., Chang, C., Clayton, G and Wand carefoot. (2000). Cattle manure amendment can increase pH of acid soils. *Soil Science Society of American Journal* **64**: 962-966.

Williams, C. H and Steinberg, A. (1959). Soil sulphur fractions as chemical indices of available sulphur in soils. *Australian Journal of Agriculture Research* **10**: 340-352.