The Andhra Agric. J 69 (1): 77-85, 2022

Soil Physico-Chemical Properties, available Nutrient Status of Agricultural College Farm, Naira

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ABSTRACT

Soil Physico-chemical properties and available nutrient status of soils in different block of Agricultural college farm was investigated. Soil samples were collected at two depths viz., 3 surface samples (0- 15cm) and 3 subsurface samples (15-30cm) in each from 9 blocks, constituting a total of 54 soil samples. The results of the study revealed that the soil texture ranged from sandy loam to clay, soil reaction was slightly acidic to alkaline. The soils were non-saline. Soil organic carbon (SOC), available nitrogen (N) contents were low, available phosphorus (P_2O_5) content was low to medium, available potassium (K_2O) and sulphur (S) contents were medium to high. Available Zinc (Zn) and Iron (Fe) contents were deficient to sufficient. Exchangeable calcium and magnesium was relatively higher in E- block compared to other blocks. Cation exchange capacity (CEC) ranged from 6.35 to 16.33 Cmol/kg. Soil clay, CEC, and pH values were relatively higher in subsurface compared to surface. SOC, available nitrogen, phosphorous, potassium, sulphur, Zn and iron values were higher in surface soils than in subsurface. Nitrogen, phosphorous sulphur, zinc and iron deficiencies were more pronounced in sub-surface. Significant positive correlation was noticed between percent clay content with available N (r = 0.316**), available P_2O_5 (r = 0.234*), available K_2O (r = 0.473**), available Sulphur (r = 0.249*). The organic carbon content was 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. The variations in soil properties and nutrient status within the blocks and among the blocks indicate the need for employing integrated and soil test based site specific nutrient management particularly for sustainable productivity.

Keywords: *Available macronutrients, Available sulphur, Physico-chemical properties, Iron, Zinc.*

Soil fertility is one of the factors that controls yield of agricultural crops and sustainability of agricultural production. It is the nutrient pool that crop plants utilize for their growth and development. Soil quality may be affected by soil 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 uptake by plant 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 elevation, cropping systems and crop management despite under the same land use type (Wen-bin *et al*., 2007). Without maintaining soil fertility, it is not possible to increase of agricultural production and quality of agricultural produce. In the last few decades, the studies on soil nutrients have become an important topic of research. 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 soil physic-chemical properties, available macro nutrients and sulphur status of soils in Agriucltural College Farm, Naira has not been studied so far. Therefore, the present investigation was undertaken to determine soil physic-chemical properties and available plant nutrient status in the soils of College Farm, Agricultural College, Naira. The study helps in understanding the future scope of nutrient management in the study area.

MATERIAL AND METHODS

The Agricultural College Farm, Naira ($83^0$56.095 to $83^0$56.993 E and 18023.045 to $18^0$26.988N) comprises red, black and associate soils in moderately sloppy terrain of rainfed uplands to irrigated low lands. Major soil types of study area were red sandy loams on rainfed uplands, reddish yellow soils situated in upper elevations and medium black soils and deep black soils on irrigated low lands situated in lower elevations. The entire 250 acres land was devided to 9 blocks viz., A, A_1, B, C, D, D_1, E, F, G based on convenience. The location map of study area and block wise distribution was presented in figure 1. The climate belongs to semi-arid monsoon type with alternate wet and dry seasons as evidenced by past one decade meteorological data from 2008 to 2017. The mean annual temperature and rain fall were 26.48^{0}C, 982.7mm, respectively.

Soil sample collection

A total of 54 soil samples were collected at two depths viz., 3 surface samples (0- 15cm) and 3 subsurface samples (15-30cm) in each of 9 blocks, constituting a total of 54 soil samples. Soil sampling was done during April, 2019 with the help of core sampler which comprises of volume 753.6 cm^3.

Laboratory analysis

Patricle size analysis was carried out by Bouyoucos hydrometer method as described by Piper (1966). The pH and EC 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). Organic carbon (OC) was determined by rapid titration method given Walkley and Black (1934). Cation exchange capacity (CEC), Calciun carbonate ($CaCO_3$) was analysed by adopting procedure as utlined by Jackson (1973). Available nitrogen (N) was determined by alkaline permanganate method (Subbiah and Asija, 1956) and available phosphorous (P_2O_5) was determined by Olsen and Sommers (1982). The available potassium (K_2O) was analysed by extraction with l N ammonium acetate at pH 7 (Jackson, l973) and 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 (Richards, 1954). The available Fe, Mn, Zn and Cu were extracted with DTPA-TEA buffer (0.005 *M DTPA*+ 0.01M CaC12 + *O.IM TEA pH 7.3)* as described by Lindsay and Norvell (1978). The relationship between micronutrients and physico-chemical properties was computed by simple correlation and stepwise regression analysis (Panse and Sukhatme 1967).

RESULT AND DISCUSSION

Size distribution soil particles

Relatively higher proportions of sand particles with mean value of 72.08% was associated with surface horizon of A1 block and lower mean values of 51.67 was found in sub-surface horizon of E-block.

High proportions of mean clay (33.11%) was found in sub-surface layer of E-block and lower mean clay content of 17.96% was in surface horizon of A1-block. In general the clay content was more in subsurface soils than surface soil indicating more weathering in subsurface due to presence of moisture longer periods compared to surface soil (Geethasireesha and Naidu, 2013). Further elluviation of fine clay with percolating rainwater may also contributing for the higher clay in the subsoil than surface soil.

Soil pH, EC, OC and $CaCO_3$

Perusal of the data (Table 1) represents that pH in all 9 blocks varied form slightly neutral to moderately alkaline. The mean pH values ranged from 6.88 to 8.25. In general, the soil pH was relatively higher in subsoils compared to surface soil. Presence of free calcium carbonate in subsoil caused higher pH values in subsoil. (Regmi and Zoebisch 2004). The soils of all nine blocks in study area were found non-saline in nature with lowest mean EC value of 0.51dS/m in surface of G-block and highest in subsurface of E-block. The higher EC in E-block might be due to poor drainage conditions as the block is low-lying area (Kiflu and Beyene 20l3). The mean organic carbon content of the farm ranged from low to medium in surface soil and low in subsurface soil and showed a conspicuous variation between surface and subsurface soil layers. The surface soil layers recorded higher organic carbon compared to subsurface layers. High mean SOC value of 6.13 g kg^{-1} was recorded in surface soil of E-block and lower mean value of 2.66 g kg^{-1} in subsurface of B-block. Addition of organic manures and incorporation in surface soil have contributed for higher SOM in surface soil compared to subsurface soil. The results are in agreement with the findings of Najar *et al.*, (2009).

Available Nitrogen

The mean available N content ranged between 68- 206 kg ha^{-1} (Table 2). In general, the available N content of surface soils was more than subsoil. The trends of N content among different blocks and within the blocks was variable. Among the blocks, E-block recorded relatively higher available mean N and F-block recorded lower available mean N contents. It is attributed due to high OM and overall high turnout of N during decomposition (Yihenew *et al.*, 2015).

Available Phosphorus

The mean available phosphorous in the soils is low to medium, varied from 11.3 to 42 kg ha^{-1} with trend of higher available P in surface soil and lower P in subsurface soil. The range is considerably large which might be due to variation in soil properties viz., pH, organic carbon content, texture, calcium carbonate and land use practices (Sachan and Deekasha Krishna, 2018) Application of phosphatic fertilizers to crops might have resulted in the increase of P in soils (Woldeamlak and Stroosnijder, 2003 and Gebeyaw (2007) and addition of crop residues and manures to surface soil caused the release of 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., (2009).

Available Potassium

The available K ranged between 145- 363 kg ha^{-1} with trend of relatively higher mean values in surface soil compared to subsurface soil. Himabindu and Gurumurthy (2018) found available potassium in medium range in majority of the sites of Thotapalli irrigation project ayacut of Srikakulamdistrict. However, due to differences in cropping paterns, the K content varied in soils. The results are similar with the findings of Singh *et al*. (2012).

Available Sulphur

The mean available Sulphur content ranged from 6.3 to 16.9 mg kg^{-1}. The deficiency of available sulphur was recorded in subsurface soil, however the available S in surface soil is medium to high range. 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) and this might be due to facts that with increase in organic matter in soil, the clay-humus complex become more 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).

Available micronutrients

The mean available Zn varied from 0.19 to 0.89 mg kg^{-1}. In general, the available Zn content is relatively high in surface soil and low in subsurface. The higher content of available Zn in surface horizons might be due to higher organic carbon addition through crop residues and decreased with soil depth (Dhane and Shukla 1995 and Setia and Sharma 2004). Further the mean available Zn content was found high in E-block which might be due to relatively fine texture of the E-block compared to other blocks. SSingh *et al* (2012) also reported higher Zn content in fine textured soils than coarse textured soils. The subsoil available Zn was found less than critical value of 0.6 mg kg^{-1}. The available Zn was positively correlated with organic carbon (r=0.442**)) and clay content (r=0.531**) and negatively correlated with pH (r= -0.355**) and calcium carbonate (r= -0.331**).

The available Fe ranged from 4.51 to 9.14 mg kg^{-1}. In general, the available Fe content is relatively high in surface soil and low in subsurface. The surface horizons contained relatively more available iron than sub-surface horizons, which is ascribed to the presence of relatively more organic carbon in the surface horizons. The organic carbon due to its affinity to influence the solubility and availability of iron by chelation effect that might have protected the iron from oxidation and precipitation which consequently increased the availability of iron (Prasad and Sakal, 1991 and Thangasaamy et al., 2005). The subsoil mean available Fe of E and G blocks was found less than critical value of 4.5 mg kg^{-1}. The variation in the available iron content is also influenced by soil reaction, organic matter and calcium carbonate content The available Fe was positively correlated with organic carbon (r=0.411**) and clay content (r=0.355**) and negatively correlated with pH (r= -0.322**) and calcium carbonate (r= -0.383**)..

Correlation

In general, pH show significant correlation with nutrients like macro and micronutrients (Kozak et al, 2005). Perusal of the data in table 5 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 and available N (r = 0.366**), P_2O_5 (r = 0.234*), 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 macronutrients. Significant negative correlation was found between pH and available N (r = -0.372**), available P_2O_5 (r = -0.422**), available Zn (-0.355**) and available Fe (-0.322**). 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 : -0.174*), P_2O_5 (r = -387*), S (r = -0.182*), Zn (-0.331**) and Fe (-0.383**).

Table 1. Physico-chemical properties of soils in Agricultural College Farm, Naira

Soil property	A block		A_1 block		B block		C block		D block		D_1 block		E block		F block		G block	
Soil depth (cm)	0 –15cm	15-30cm	0 –15cm	15-30cm	0 –15cm	15-30cm	0 –15cm	15-30cm	0 –15cm	15-30cm	0 –15cm	15-30cm	0 –15cm	15-30cm	0 –15cm	15-30cm	0 –15cm	15-30cm
Sand (%)																		
Range	57- 78	53-76	62- 82	60-80	51- 71	48-68	54- 68	51-63	55-77	52-75	58-70	55-67	44-62	40-55	55-71	51-65	57-75	54-72
Mean	71.52	70.33	72.08	69.48	63.44	60.25	61.24	58.13	63.18	60.33	64.2	61.33	54.48	51.67	62.15	58.4	64.5	61.33
Silt (%)																		
Range	06-Nov	Jun-13	Jun-15	Jul-15	Aug-16	Aug-18	Oct-15	Nov-14	Aug-14	Aug-16	Jun-18	Sep-18	Aug-15	Sep-16	Sep-16	Sep-17	Aug-15	Oct-16
Mean	8.52	9.33	8.84	9.24	11.64	12.33	9.64	12.18	11.28	12	10.21	12.25	11.5	13.05	11.72	12.54	10.21	11.33
Clay (%)																		
Range	13- 23	15-24	Dec-24	13-26	Nov-25	Dec-28	19- 23	19-24	17-26	19-28	17-26	19-28	19-39	23-47	15-25	15-27	13-25	15-26
Mean	18.08	19.3	17.96	19.48	19.52	20.33	20.12	21.5	20.94	22.33	22.15	23.1	32.48	33.11	19.2	20.58	18.82	21.18
pH (1:2)																		
Range	6.22-7.76	6.58-8.43	5.83-7.39	6.12-8.19	6.05- 7.53	6.53-8.40	5.15- 7.36	5.48-7.59	6.35- 7.22	6.69-7.92	6.81-7.55	7.04-7.88	7.35-8.23	7.48-8.55	7.05-8.26	7.22-8.82	6.45-8.53	6.71-8.93
Mean	7.07	7.48	7.1	7.58	7.14	7.66	6.88	7.18	7.02	7.38	7.23	7.37	7.81	7.96	7.48	7.65	8.05	8.25
EC (dSm^{-1})																		
Range	0.23-1.84	0.25-1.38	0.16- 1.33	0.21-1.49	0.23- 1.48	0.19-1.05	0.26- 1.30	0.28-1.51	0.18- 1.25	0.24-1.40	0.16-1.48	0.19-1.33	0.25-1.28	0.27-1.41	0.18-1.26	0.21-1.26	0.14-1.22	0.21-1.38
Mean	0.81	0.87	0.71	0.68	0.59	0.55	0.62	0.71	0.68	0.66	0.64	0.68	0.91	0.98	0.6	0.68	0.51	0.65
O.C ($g\ kg^{-1}$)																		
Range	3.21-8.05	2.10-4.50	2.91- 7.60	2.10-3.65	3.20- 7.39	2.70-3.65	3.20- 10.33	3.20-4.80	3.68- 7.17	270-4.80	3.20-8.50	2.10-3.65	4.65-10.50	3.20-4.50	3.20-8.80	2.10-3.65	3.34-5.11	2.50-4.20
Mean	5.08	3.08	4.38	2.82	4.23	2.66	5.25	2.95	4.82	3.1	4.71	2.82	6.13	3.38	4.65	2.82	4.28	3.2
CEC (mol/kg)																		
Range	5.18-9.60	6.22-11.31	6.55-12.35	7.15-9.60	4.65-9.60	5.33-9.60	6.55-9.60	6.55-11.31	5.18-9.60	6.22-9.60	6.95-9.60	6.22-10.40	10.46-21.45	14.25-26.33	6.55-12.35	8.75-12.35	7.15-14.30	8.75-15.50
Mean	8.46	9.33	9.11	8.14	6.35	6.78	7.82	8.14	8.25	8.81	7.54	7.92	16.33	19.41	8.05	9.21	11.82	12.5
$CaCO_3$ (%)																		
Range	-	0.0- 3.4	0.0-1.30	2.60-4.81	0-1.30	0.0-3.4	-	1.30-2.9	-	0-1.30	-	0-1.30	0-1.30	1.30-3.4	-	0-1.30	0-4.81	1.30-6.30
Mean	-	0.82	0.33	3.15	-	0.67	-	1.77	-	-	-	-	-	1.77	-	-	2.33	3.87

Table 2. Available Macronutrient status of Agricultural College Farm, Naira

Nutrient elements	A block		A_1 block		B block		C block		D block		D_1 block		E block		F block		G block	
Soil depth	0-15cm	15-30cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Available N status (kg ha^{-1})																		
Range	97-253	45-80	64-283	45-105	75-245	45-160	83-250	56-80	76-250	56-150	120-230	56-120	105-310	83-150	97-210	56-120	115-210	73-125
Mean	136	68	160	75	139	105	183	75	134	87	172	92	206	108	132	68	140	88
Available P_2O_5 status (kg ha^{-1})																		
Range	17.5-47.4	10.5-22.5	15.6-54.2	10.5-25	15.6-58.2	8.8-22.5	16.2-37.5	10.5-25.0	19.3-47.4	7.5-15.0	17.5-40.5	15.6-25.0	14.5- 32.0	7.5-18.0	17.5-40.5	8.8-22.5	15.6-42.8	10.5-22.5
Mean	24.4	14.6	26.86	15.8	31.5	12.7	42	15.2	38.8	11.3	24.7	18.1	25.3	15.2	22.4	14.8	23.7	15.1
Available K_2O status (kg ha^{-1})																		
Range	202-439	140-320	225-360	126-295	180-375	110-310	164-360	130-310	145-326	95-280	135-380	110-255	160-415	145-310	126-360	126-310	225-360	175-410
Mean	363	242	295	218	265	235	256	208	248	145	251	164	288	248	242	215	228	230
Available Sulphur status (mg kg^{-1})																		
Range	9.8-26.5	3.8-10.5	10.4-28.0	5.5-13.0	12.5-32.0	3.8-15.0	10.4-22.5	6.8-12.5	9.8-19.7	4.5-15.4	12.5-26.0	3.8-14.0	10.2-34.0	4.5-18.0	12.5-28.3	5.5-14.0	10.2-24.0	3.8-12.5
Mean	16	7.1	18.7	6.3	20.5	8.8	16.9	8.1	13.9	8.5	14.2	7.1	19.8	8.6	15.2	7.7	14.6	7.2
Available Zn status (mg kg^{-1})																		
Range	0.32-0.93	0.13-0.54	0.14-0.75	0.13-0.32	0.38-1.18	0.13-0.56	0.30-1.33	0.13-0.64	0.40-1.20	0.23-0.68	0.44-1.58	0.18-0.54	0.38-1.76	0.13-0.51	0.28-1.18	0.11-0.33	0.22-0.81	0.11-0.86
Mean	0.66	0.27	0.42	0.19	0.52	0.21	0.72	0.39	0.56	0.41	0.82	0.39	0.89	0.36	0.54	0.22	0.48	0.34
Available Fe status (mg kg^{-1})																		
Range	3.5-9.4	3.5-8.8	4.6-11.8	3.3-8.4	5.2-11.8	4.8-14.3	6.3-14.3	4.8-12.4	4.5-12.5	3.0-7.4	3.8-11.4	2.5-8.8	3.3-7.0	2.3-8.1	3.8-8.2	3.5-8.8	2.5-7.5	3.0-7.4
Mean	6.91	6.14	8.13	5.84	7.49	8.12	9.14	8.34	8.21	4.84	7.61	6.53	5.81	3.18	5.93	5.84	5.18	4.31

Table 3. Relationship between available macro nutrients and soil physico-chemical properties of 'r' in Agricultural College Farm, Naira.

Available nutrient	Sand (%)	Clay (%)	pH	EC	OC	$CaCO_3$
Nitrogen	-0.237*	0.361**	-0.372**	-0.156	0.456**	-0.136
Phosphorous	-0.264*	0.234*	-0.422**	-0.194	0.578**	-0.387
Potassium	-0.361**	0.473**	-0.102	-0.138	0.211*	-0.177
Sulphur	-0.186	0.249*	-0.093	-0.169	0.298*	-0.108
Calcium	-0.415**	0.531**	-0.355**	0.188**	0.242*	-0.331
Magnesium	-0.398**	0.411**	-0.322**	0.136**	0.055	-0.383

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

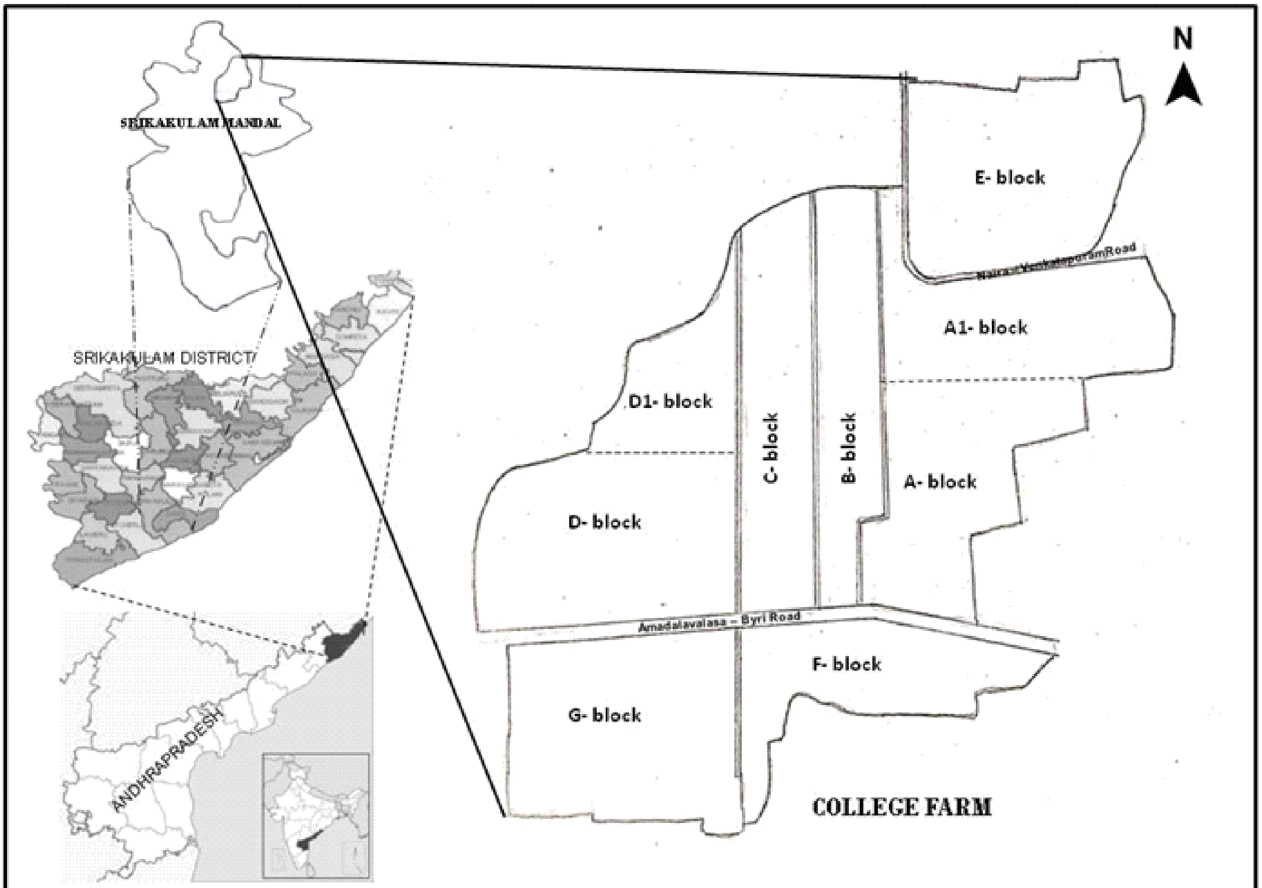

Fig 1. MAP SHOWING VARIOUS BLOCKS IN AGRICULTURAL COLLEGE FARM, NAIRA

CONCLUSION

It can be concluded that the soils of Agricultural College, Naira had covariation in soil physic-chemical properties and nutrient contents among the nine blocks and within the blocks. Nitrogen, phosphorus, zinc and iron management needs more attention. The results of the investigation suggest that there is a need of intervention for integrated nutrient management based on soil test crop response value and site specific nutrient management for sustainable soil productivity.

ACKNOWLEDGEMENT

Authors are highly grateful to Acharya N.G.Ranga Agricultural University for providing necessary facility to cary oout this research work. Thanks are due to the Associate Dean, Agricultural college, Naira for providing laboratory facilities to analyze soil samples.

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Received on 19.01.2022 and Accepted on 23.03.2022