Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 03, Issue: 02 (MAR-APR, 2023)
Available online at http://www.agriarticles.com

Assessment of Soil Physico-chemical Quality Indicators in Rice Soils of Thiruvarur District of Tamil Nadu, India

([*]L. Seevagan, R.K. Kaleeswari, M.R. Backiyavathy, K. Balachandar and D. Amirtham)
Tamil Nadu Agricultural University, Coimbatore - 625104 (Tamil Nadu), India
[*]Corresponding Author's email: seevaganplantdoctor@gmail.com

Abstract

An assessment soil quality indicators study was conducted in rice growing block of Thiruvarur district Kottur. The present investigation entitled "Assessment of soil quality Indicators under nutrient management systems in different rice growing districts of Tamil Nadu "was carried out during 2018 with the objectives: To assess the soil physico- chemical and biological quality parameters in rice soils of Tamil Nadu and To compare soil quality indexing methods viz., Principal component analysis, Minimum data set and Indicator scoring method and To develop soil quality indices for formulating soil and crop management strategies. To fulfil these objectives a total of (40) soil samples were collected from Thiruvarur district Kottur block and TNAU research stations.

Keywords: Physico-chemical quality indicator, soil quality, principal component analysis

Introduction

Soil is one of the most valuable natural resources and to maintain its health is a moral responsibility. However, the urgency to produce more food and fuels is causing an irreparable damage on soil. Excessive mineral fertilization and irrational cultural practices contribute to reduce fertility and the organic matter contents. These circumstances have led many researchers to search new and better management strategies. The concept of soil quality evokes various responses, depending on our scientific and social backgrounds. Soil quality is an integration of soil processes and provides a measure of change in soil condition as related to factors such as land use, climate patterns, cropping sequences, and farming systems. Parnes et al.,(1990). Presently, soil quality has been defined by some scientist as capacity of a soil to function . Soil quality can be assessed by selecting different indicators upon which the functions of soil depend. A wide range of agricultural soils represents diversely managed arable lands while the main goal is to improve soil quality, rice crop yield, and reduce the ecological footprint Gugan et al .(2001).

Thiruvarur district

The district is situated between 10.7668° N, 79.6348° E of the Northern latitude. The district is bounded on the East and North by Nagapattinam district on the South by Palk Strait and on the west by Thanjavur district. Though Thanjavur, Thiruvarur and Nagapattinam districts are collectively called the Delta districts, Thiruvarur district is in the heart of the delta districts

The study was conducted in kottur block of Thiruvarur district, Tamil Nadu. The geological formations found in the district are lateritic soil occur at places over the crystalline rocks viz. migmatite, genisses and also sedimentary formations comprising fossil ferrous sandy calcareous clay and limestone of upper age and cretaceous age and grits, ferruginous sandstone gravel .

Fig 1. Location of study area in Thiruvarur district

Physicochemical indicators included pH, EC was determined in 1:2 soil water suspensions using a combined pH meter (Jackson, 1973) and cation exchange capacity of soil was determined by using Neutral Normal Ammonium Acetate (Bower *et al*., 1952). Biological properties measured in terms of organic carbon by chromic acid wet digestion method (Walkely and Black, 1934). Soil available nitrogen was determined by Alkalaine potassium permanganate method (Subbaiah and Asija 1956), soil available phosphorus by 0.5M $NaHCO_3$(pH-8.5) extractable (Olsen *et al*, 1954), Soil available potassium was determined by Flame photometric method (1NNH_4OAC extractable) (Standford and English, 1949), soil available micronutrients, zinc, Fe was determined by DTPA Extraction, (Lindsey and Norvell, 1978) Soil available boron extracted by Hot water (Bremmer, 1965)

Statistical analysis

All the Statistical Analysis described in this chapter were performed using the softwares STATISTICA 10.0 and SPSS 20.0.

Results and Discussion

Soil physico-chemical quality indicators of Thiruvarur district: The pH of the rice soils of Kottur block varied from 6.54 to 8.69. Less pH value of 6.54 could be the ascribed to the well drained and non calcareousness of the soil. These findings were in corroboration with the conclusion of Shanmuganathan and Rajendran (2016) . High pH value of 8.69 in Viruthachalam block could be due to the high base saturation , restricted leaching and high $CaCO_3$ content. This high pH would affect the availability of secondary nutrients such as Ca and Mg as well as micronutrients .

Management practices of aerobic rice farming registered the lowest pH of 7.62 . Wide variations in soil reactions could be attributed to the nature of parent material, leaching, topograpic position , presence of $CaCO_3$ concentration , base saturation per cent (BSP) and Na content in soil . A decrease in the pH of alkali or calcareous soils is a result of the accumulation of carbon dioxide in flooded soil, which neutralizes alkalinity .This is in close agreement with the findings of Ponnamperuma (1972)

In Kottur block of Thiruvarur district, electrical conductivity of the soil samples ranged from 0.05 to 0.89 dS m^{-1}. Aerobic rice farming recorded the lowest EC value of 0.11 dS m^{-1} . Highest EC value of 0.22 dS m^{-1} could be due to the foraging of nutrient ions by the vegetation in the surface soils . These observation are in the agreement with the findings of Shaikh and Gachande (2013)

The organic carbon of the rice soils of Kottur block varied from 2.00 to 5.80 g kg^{-1} . Organic carbon content of 2.00 g kg^{-1} registered to be the lowest value in this block . This could be because of erosion , leaching and rapid oxidation of organic matter . Among the nutrient management practices , SRI method registered the highest organic carbon content of 7.10 g $kg^{-1.}$ This result is in line with Jayanathi et al (2003) who reported that INM practice increases organic carbon content in rice soils .

The exchangeable properties of the soils were mostly influenced by the content and quality of clay and predominance of cations associated with colloidal complex . The cation exchange capacity varied from 17.00 to 97.00 cmol $(p)^{+}$ kg^{-1}. Wide variation in CEC was observed and it was due to the difference in mineral composition , clay content , p^{H} and organic carbon content of soils .

The low CEC value could be due to the sandy texture of the soil , poor clay content , low base saturation , low organic matter and leaching of added nutrient cations . Management practice of organic farming registered the highest CEC value of 85.00 cmol $(p)^{+}$ kg^{-1}. Of the various soil chemical properties, all results indicate that the properties of rainfed lowland ricefield under organic farming are higher than in case of conventional farming because soil organic matter is one of the soil amendments that can improve soil chemical properties. According to Supriyadi et al (2018), organic materials can improve soil chemical properties such as the CEC so that nutrient availability can also be increased and prevent the loss of nutrients from the soil due to leaching by rainwater or irrigation.

Soil Fertility and its spatial variability: Present agricultural systems exhaust soil nutrients through intensive tillage , monocropping , less recycling and burning of crop residues . The availability of macro and micronutrients to plants is influenced by several soil characteristics. The deficiency of micronutrients along with macronutrients N,P,K and S were reported in recent years due to intensive cropping, loss of top soil by erosion, losses of micronutrients through leaching, excess liming of acid soils , less application of FYM compared to chemical fertilizers , growing high nutrient demanding modern crop cultivars and use of marginal lands for crop production (Behera and Shukla, 2013).

Available N was deficient with values less than 250 kg ha^{-1} . The acute deficiency of N could be associated to low OC content , increased rate of mineralization and insufficient application of fertilizers. Nutrient management practice of organic farming registered the highest available N of 358 kg ha^{-1} . Yadav and Kumar (2009) observed that the combination of mineral fertilizers with FYM and sesbania green manure registered more increase in available N and P content of the soil in comparison to the mineral fertilizers alone.

Low to high status of olsen – P was registered in kottur block of Thiruvarur district . The deficiency of P was caused by fixation of P by iron and aluminium under acidic conditions and alkaline $CaCO_3$ in neutral and alkaline conditions . However the relatively better availability of P may be due to dissolution of precipitated forms of P. Organic farming registered the highest Olsen - P content of 40.00 kg ha^{-1}. This result corroborate with the findings of Saha et al., 2007. Higher concentration of soil organic carbon, available nitrogen (N), soluble phosphorus (P) and microbial activity were observed in the soils organic practice than from non-organic soils.

In kottur block, rice soils registered medium to high status of available K . Adequate available K in these soils could be attributed to K rich minerals like illite and feldspars, more intensive weathering , release of labile K from organic residues and application of K fertilizers . This is in conformity with the findings of Pal and Murhopadhyay, 1992. SRI method registered the highest available K of 253 kg ha^{-1} . This result confirmed with the observation of Khanda et al (2005) who reported that increasing the application of K may be useful for increasing crop yields, including those of the high productivity paddy soils.

The micronutrient status of the study area was grouped in to deficient / sufficient . DTPA Zinc content ranged from 2.20 to 2.91 mg kg^{-1} . Zinc deficiency may be associated with coarse texture , high p^{H} (formation of insoluble reaction products of Zn) , less amount of organic matter and high clay contents. This is in accordance with the findings of Sood et al (2009). Among the management practices, SRI method registered the highest available Zn. This is in close agreement with Panwar et al (2010) .

DTPA - Fe varied from 12.0-22.2 to 22.2 mg kg^{-1} . Coarse texture and low organic matter content are the prominent factors that affect iron availability in varying extent and intensity . Similar trend of results was reported by Katyal and Rattan (2003). Nutrient management practice of organic farming registered the highest available iron (Fe) of 27.8 mg kg^{-1}. This is conformity with Dhaliwal et al (2013)

Hot water soluble boron content of the soil samples ranged from 0.13 to 0.88 mg kg^{-1}. INM practice registered the highest available hot water soluble boron . This is in line with the findings of Yaduvanshi (2001)

Table : 1 Physico -Chemical Quality Indicators of Thiruvarur District

Name of the Block : Kottur

Site No.	Name of the location	Available Nitrogen (kg ha^{-1})	Available Phosphorus (kg ha^{-1})	Available Potassium (kg ha^{-1})	Total Nitrogen (per cent)
1	Adichapuram	162	27	255	0.58
2	Keelakondapuram	177	17	246	0.55
3	Adichapuram vadakku	170	22	218	0.75
4	Kullikari	202	20	195	0.78
5	Kullikari kilakku	227	12	179	0.73
6	Nallur	185	17	193	0.77
7	Nemmeli	230	25	177	0.79
8	Kulamanikkam	130	20	168	0.85
9	Adichapuram	125	24	238	0.84
10	Aalathrhoor	150	28	231	0.83
11	Akkaraikottam	225	22	185	0.82
12	Irulneeki	305	17	145	0.81
13	Cheri	350	27	317	0.86
14	Devadanam	300	29	326	0.88
15	Elavanoor	275	26	216	0.89
16	Kalamanickam	262	15	246	0.90
17	Kalappal	270	12	122	0.92
18	Karupukkilar	287	14	121	0.91
19	Keluvanthur	225	12	173	0.93
20	Kottur	305	21	132	0.95
21	Kottur thottam	275	18	106	0.96
22	Kumpattithidal	262	19	102	0.98
23	Kuniyoor	219	26	160	1.70
24	Kurichi	253	18	134	1.80
25	Kurichimoolai	260	19	107	1.91
26	Melavaravanallor	180	23	187	1.1
27	Mannukumundan	315	28	281	1.11
	Range	125-350	12 -29.00	102-326	0.55-1.91
	Mean	234.0	20.0	191.0	0.95
	Standerd Deviation	59.0	5.0	62.0	0.32

Table: 2 Physico-Chemical Quality Indicators Of Icar –Kvk, Needamangalam

Management strategies	P^H (1:2.5 soil : water)	Electrical Conductivity (dSm^{-1})	Organic carbon ($g\ kg^{-1}$)	CEC $cmol(p^+)\ kg^{-1}$	N ($kg\ ha^{-1}$)	P ($kg\ ha^{-1}$)	K ($kg\ ha^{-1}$)	TN (per cent)	ZN ($mg\ kg^{-1}$)	FE ($mg\ kg^{-1}$)	B ($mg\ kg^{-1}$)
SRI Method	7.69	0.15	7.1	81.0	320	34	253	1.08	2.91	25.6	0.84
Organic Farming	8.51	0.22	6.8	85.0	358	40	240	1.09	2.51	27.8	0.83
INM practice	8.58	0.14	6.2	80.0	310	35	238	1.05	2.65	26.9	0.95
Aerobic Rice	7.62	0.11	6.0	82.0	290	33	220	0.99	2.20	27.3	0.93
Conventional Farming	7.74	0.13	6.3	79.0	318	32	235	1.04	2.63	23.0	0.92
Mechanical Farming	7.73	0.21	6.4	78.0	322	34	234	1.07	2.6	24.6	0.91
Range	7.62-8.58	0.11-0.22	6.0-7.1	78.0-85.0	290-358	32-40	220-253	0.99-1.09	2.20-2.91	23.0-27.8	0.84-0.95
Mean	7.97	0.16	6.46	80.0	319	34	236	1.00	2.58	26.2	0.89
Standard Deviation	0.44	0.04	0.40	2.48	22.0	2 .0	10.0	0.03	0.23	1.97	0.049

EC-Electrical Conductivity ,OC-Organic carbon, CEC-Cation Exchange capacity,N-Available nitrogen, P-Available phosphorus,K-Available potassium,TN-Total Nitrogen, Zn-Zinc, Fe-Iron, B-Boron

Table : 3 Principal components ,eigen values and component matrix variables of Thiruvarur district

Principal components	PC 1	PC 2	PC 3	PC 4	PC 5
Eigen values	11.078	44.312	44.312	3.697	14.788
%Variance	59.1	2.559	10.234	69.335	1.658
%Cumulative variance	75.966	1.41	5.638	81.604	1.205
Weightage factor	4.82	86.424	0.784	3.134	89.558
Bulk Density	0.139	0.191	-0.28	-0.125	0.382
Particle Density	-0.078	0.029	**0.524**	-0.231	0.034
Porosity	0.154	0.097	**-0.472**	0.041	0.188
Sand	-0.069	**-0.435**	0.078	0.123	0.122
Silt	0.098	0.055	-0.01	0.117	0.53
Clay	0.011	**0.407**	-0.072	-0.184	**-0.408**
AWC	-0.142	0.336	0.187	-0.068	0.207
MWD	-0.285	-0.085	-0.116	-0.03	0.019
Aggregate stability	-0.276	0.022	-0.109	-0.078	0.037
P^H	0.045	0.254	-0.221	0.197	**-0.434**
EC	0.032	-0.272	-0.03	-0.358	-0.08
OC	-0.207	0.046	0.243	0.221	-0.005
CEC	0.068	-0.091	0.156	**0.607**	-0.029
AN	-0.201	-0.016	-0.07	**0.444**	-0.078
AP	-0.197	0.27	0.047	-0.072	0.077
AK	-0.037	0.364	0.122	0.127	0.304
TN	-0.211	-0.188	-0.195	-0.105	0.092

Zn	-0.242	0.219	0.026	0.072	-0.007
Fe	-0.272	0.121	0.062	0.019	0.024
Boron	-0.232	0.015	-0.266	0.115	0.014
MBC	**-0.287**	-0.068	-0.093	-0.088	0.015
MBN	**-0.284**	-0.091	-0.136	0.019	0.002
PMN	**-0.285**	-0.088	-0.132	-0.017	0.006
SRR	-0.26	-0.034	0.161	-0.113	-0.007
DHA	-0.29	0.01	-0.113	-0.044	0.026

Table: 4 Thiruvarur District highly weighed parameters under Principal component Analysis

Highy weighed parameters	PC 1	PC 2	PC 3	PC 4	PC 5
	MBC	Sand	Particle Density	CEC	P^H
	PMN	Clay	Porosity	Available Nitrogen	Clay

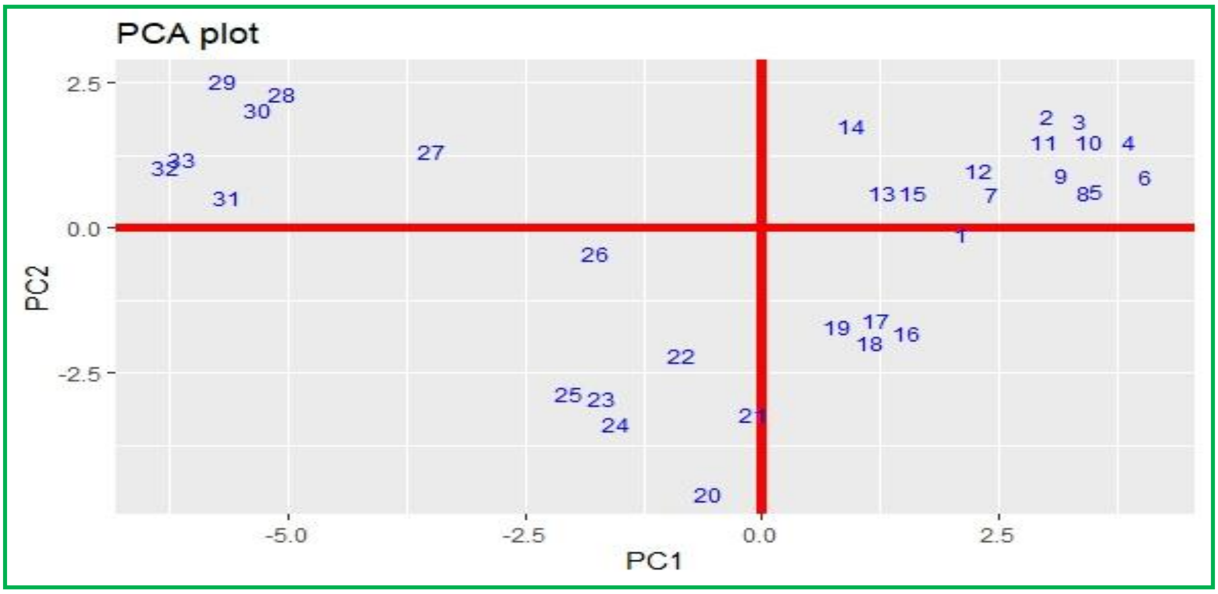

Fig:2 Thiruvarur District soil physico-chemical indicators in PCA plot variables

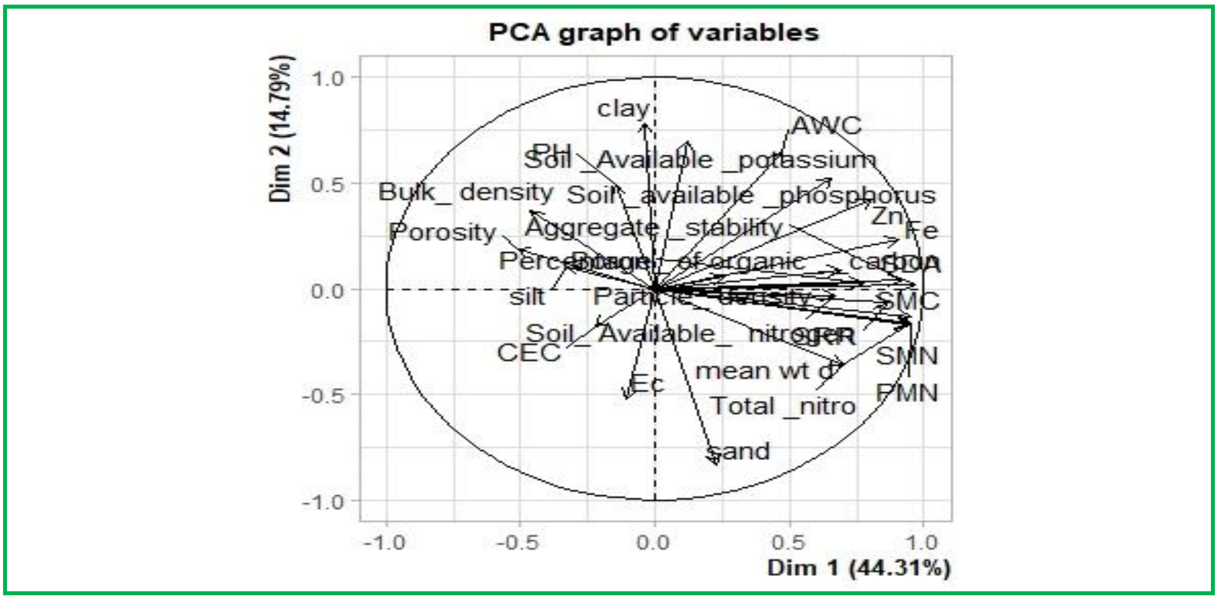

Fig:3 Thiruvarur District soil physico-chemical indicators in PCA graph variables

Principal Component Analysis: The results obtained from PCA indicated five Principal Components (PCs) with eigen values greater than 1 (Table 5) and soil variables from each PC were considered for minimum soil data set MDS) The soil parameters selected from PC 1, PC2, PC3, PC4,PC5 were MBC, PMN, sand, clay, particle density, Porosity, CEC,and available nitrogen

However , PCA Pt , PCA graph varibles showed higher variables between these parameters indicated soil available nitrogen only which has the highest factor loading and was retained in the MDS

Conclusion

Soil quality index is a useful tool to assess soil health and well being. Few methods are available to estimate it. Among those PCA based scoring, ranking and weightage method gaining popularity. However, SQI assessment primarily depends on objectives of study or soil functions need to be addressed. Selection of MDS and its ranking play important role for determining SQI. However , PCA Pt , PCA graph variables showed higher variables between these parameters indicated soil available nitrogen only which has the highest factor loading and was retained in the MDS.Thiruvarur district soil Physico-Chemical quality indicators Soil Available Nitrogen high under based on the Principal Component Analysis .

References

1. Behera, S. K., and Shukla, A. K (2013) .: Depth-wise distribution of zinc, copper, manganese and iron in acid soils of India and their relationship with some soil properties, J. Indian Soc. Soil Sci., 61(3), ,
2. Bower, C. A., Reitemeier, R. F. and Fireman, M., 1952. Exchangeable cation analysis of saline and alkali soils. Soil Sci., 73: 251-261.
3. Bremner J M (1965) Nitrogen availability indices. In: Black C A (ed.) Methods of Soil Analysis, Part 2, Agron 9: 134-45. Am Soc Agron Madison, Wisconsin.
4. Dhaliwal, SS, JS Manchanda, SS Walia, and MK Dhaliwal. "Differential Response of Manures in Transformation of Dtpa and Total Zinc and Iron in Rice Transplanted on Light Textured Soils of Punjab." *International Journal of Science Environment and Technology* 2 (2013): 300-12.
5. Glanz, J.T. 1995. Saving Our Soil: Solutions for Sustaining Earth's Vital Resource. Johnson Books, Boulder, CO.
6. Gugan S, Ramesh Kumar C, Rajendran A, Princy Merlin J, Jeyakarchellaraj J. Formulation of a new heber soil quality index for rice and sugarcane cultivation. Pollut Res. 2001;19(3):485-489.
7. Jackson ML. Soil chemical analysis. Prentice hall of India Pvt Ltd., New Delhi, 1973.
8. Jayanthi, C, M Balusamy, C Chinnusamy, and S Mythili. "Integrated Nutrient Supply System of Linked Components in Lowland Integrated Farming System." *Indian journal of Agronomy* 48, no. 4 (2003): 41-46.
9. Katyal JC, Rattan RK. 2003. Secondary and micronutrients – research gaps and future needs. Fert News 48(4):9 – 20. Kausar MA, Chaudhary FM, Rashid A, Latif A, Alam SM. 1976. Micronutrient availability to cereals from calcareous soils. I. Comparative Zn and Cu deficiency and their mutual interaction in rice and wheat. Pl Soil 45:397 – 410.
10. Katyal JC, Rattan RK. 2003. Secondary and micronutrients – research gaps and future needs. Fert News 48(4):9 – 20. Kausar MA, Chaudhary FM, Rashid A, Latif A, Alam SM. 1976. Micronutrient availability to cereals from calcareous soils. I. Comparative Zn and Cu deficiency and their mutual interaction in rice and wheat. Pl Soil 45:397 – 410.
11. Khanda, C.M., Mandal, B.K. and Garayak, L.M. (2005). Productivity and economics of different rice based cropping sequences as influenced by Integrated Nutrient Management. Oryza, 42 (1):48-51.

12. Khanda, C.M., Mandal, B.K. and Garayak, L.M. (2005). Productivity and economics of different rice based cropping sequences as influenced by Integrated Nutrient Management. Oryza, 42 (1):48-51.
13. Lindsay W L and Norvell W A (1978) Development of DTPA soil test for Zn, Fe, Mn and Cu. Soil Sci Soc Am J 42: 421-28.
14. Olsen R, Cole C V, Watenabale F S and Dean L A (1954) Estimation of available phosphorus by extraction with sodium bicarbonate. USDA Circ 939: 1-19.
15. Pal, SK, and AK Mukhopadhyay. "Distribution of Different Forms of Potassium in Profiles of Some Entisols." *Journal of the Indian Society of Soil Science* 40, no. 2 (1992): 371-73.
16. Panwar, N.R., Ramesh, P., Singh, A.B. and Ramana, S. (2010). Influence of organic, chemical and integrated management practices on soil organic carbon and soil nutrient status under semi-arid tropical conditions in central India. Communications in Soil Science and Plant Analysis, 41: 1073-1083.
17. Parnes R. Fertile soil, a growers guide to organic and inorganic fertilizers. AgAcces, Davis, CA. 1990;190.
18. Ponnamperuma, Felix N. "The Chemistry of Submerged Soils." In *Advances in Agronomy*, 29-96: Elsevier, 1972
19. Saha, PK, M Ishaque, MA Saleque, MAM Miah, GM Panaullah, and NI Bhuiyan. "Long-Term Integrated Nutrient Management for Rice-Based Cropping Pattern: Effect on Growth, Yield, Nutrient Uptake, Nutrient Balance Sheet, and Soil Fertility." *Communications in Soil Science and Plant Analysis* 38, no. 5-6 (2007): 579-610.
20. Shaikh N.F.1 , Gachande B.D.2 (20`13): Effect of Organic Bio-Booster and Inorganic Inputs on Rhizosphere Mycoflora Population and Species Diversity of Wheat . International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064
21. Shanmuganathan M and Rajendran A "Assessment of Soil Quality of Some Lands in Thanjavur and Tiruvarur Districts for Improved Cultivation of Rice and Sugarcane." International Journal of Plant & Soil Science 10(5): 1-19, (2016);
22. Sood, Anil, PK Sharma, NS Tur, and VK Nayyar. "Micronutrient Status and Their Spatial Variability in Soils of Muktsar District of Punjab–a Gis Approach." *Journal of the Indian Society of Soil Science* 57, no. 3 (2009): 300-06.
23. Stanford, S. and English, L. (1949) Use of flame photometer in rapid soil tests of potassium and calcium. Agronomy Journal 41, 446-447.
24. Subbiah B V and Asija G L (1956) A rapid procedure for the estimation of available nitrogen in soils. Current Sci 25: 259-60.
25. Supriyadi, Supriyadi, Septiana Rachmawati, Aktavia Herawati, and Purwanto Purwanto. "Soil Quality Assessment of the Rainfed Lowland Ricefields under Organic and Conventional Farming Systems in Kaliwungu (Central Java)." *Polish Journal of Soil Science* 51, no. 2 (2018).
26. Walkley A and Black C A (1934) An examination of the Degtjareff method for determining soil organic matter and proposed modification of chromic acid titration method. Soil Sci 37: 27-38.
27. Yadav, DS, and Alok Kumar. "Long-Term Effect of Nutrient Management on Soil Health and Productivity of Rice (Oryza Sativa)-Wheat (Triticum Aestivum) System." *Indian Journal of Agronomy* 54, no. 1 (2009): 15-23.
28. Yaduvanshi, NPS. "Effect of Five Years of Rice-Wheat Cropping and Npk Fertilizer Use with and without Organic and Green Manures on Soil Properties and Crop Yields in a Reclaimed Sodic Soil." *Journal of the Indian Society of Soil Science* 49, no. 4 (2001): 714-19.