Madras Agric. J., 2023; https://doi.org/10.29321/MAJ.10.200001

RESEARCH ARTICLE

Mapping Spatial Variability of Soil Physico-Chemical Properties and Available Nutrient Status and Assessment of Irrigation Water Quality of ICAR-KVK Farm, Pongalur

Jawahar Durairaj[1], Sivakumar K` and Renuka Devi A[2]

[1] Department of Soil Science and Agricultural Chemistry,

[2] ICAR-KVK, Pongalur, Tiruppur District

Tamil Nadu Agricultural University, Coimbatore

Received : 24 July 2023

Revised : 10 September 2023

Revised : 28 September 2023

Accepted : 30 September 2023

ABSTRACT

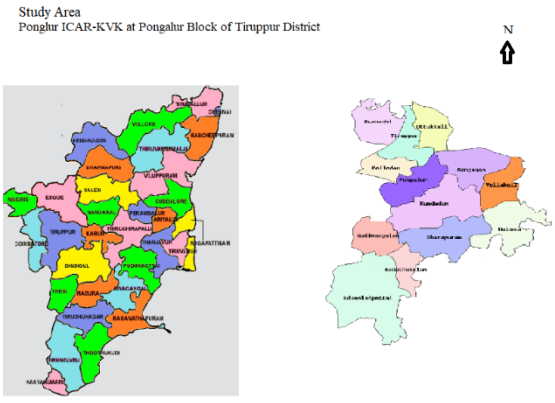
The study was conducted at the Department of Soil Science and Agricultural Chemistry to collect geo-referenced soil and water samples, analyze their soil physico-chemical properties, and quality parameters, and prepare thematic maps to suggest suitable management practices. The soils were slightly calcareous and non-saline. The available N, P and K status were low, medium and high respectively, with low to moderate OC content. The available Ca, Mg and S status of the soil were high and medium to high, respectively. The DTPA-Zn values and DTPA-Fe values were deficient DTPA Cu and DTPA-Mn values were sufficient in the farm soils. The HWS boron values were sufficient. The water samples of the farm had neutral to slightly above neutral pH, and the EC of the water sample ranges from 0.63 to 4.08 dS m^{-1}. The chloride content of the water sample ranged from 2.00 to 22.80 meq L^{-1}. There was no CO_3^{2-} and SO_4^{2-} contents observed in water. SAR value of samples lies between 1.51 and 4.19 and the adjusted SAR value varies from 2.87 to 10.48 indicating good quality of water samples.

Keywords: *ICAR-KVK; Pongalur, Soil, Physic-Chemical Properties, Nutrients, Water Quality.*

Pongalur ICAR-Krishi Vigyan Kendra is located about 50 kms East of Coimbatore and about 1.5 kms north of the Coimbatore- Tiruchirappalli highway at Pongalur Block of Palladam taluk between and 10°98'48" to10°97'76"N longitude and 77°37'88"E to77°38'48"E Latitude. The climate is semi arid and tropical monsoonic. The total area of the farm is 15.94 including 12.07 ha of garden land. The mean Annual Rainfall is 569.08 mm. May and August to November are the rainy months receiving more than 50 mm. The soil temperature regime is isohyperthermic. The soil moisture regime of the farm is Ustic. The slope is less than 1%. The aspect of slope is east. The soil is moderately-well drained to well drained. Geology of the farm is gneissic. Pongalur ICAR-KVK farm produces seeds of foundation and certified seeds of millets, pulses, oilseeds. Irrigation is done by open wells and bore wells.

Materials and Methods

The farm map available in the farm, Google map and scanned copies of village maps of Pongalur block of Tiruppur District, collected from the Department of Survey and Land Records of the scale of 1:5000 were also used for the study.



Soil and water samples collected were subjected to analysis as per standard procedures. pH in water samples was determined potentiometrically using pH meter (Jackson ML, 1973). Electrical conductivity was determined by using Conductivity Bridge (Willard, 1974). Chloride by titrating against standard silver nitrate solution, carbonates and bicarbonates (double indicator method) and calcium and magnesium (Versenate method) were determined by standard protocol given by Richards (1954). Similarly, the sodium and potassium in ground water samples were measured by using flame photometer (Richards LA, 1954). The analytical methods put forth by Walkley and Black (1934) for soil organic carbon, Subbiah and Asija (1956) for available nitrogen, Olsen *et al* (1954) for available phosphorus, Stanford and English (1949)

*Corresponding author's e-mail: arunaprabha98@gmail.com

for available potassium, Hesse (1971) for available Ca & Mg, Williams Steinbergs (1959) for available sulphur, Lindsay and Norwell (1978) for DTPA-Zn, Cu, Fe & Mn, and Gupta (1967) for hot water soluble boron were employed for the soil analyses.

Water quality indices SAR (Richards LA, 1954) and RSC (Eaton, 1950) were calculated by using following equation.

a.) SAR = $Na/\sqrt{(Ca^{2+} + Mg^{2+})/2}$ ..... (1)

b.) RSC (meq L^{-1}) = $(CO_3^{2-} + HCO^{3-})$ – $(Ca^{2+} + Mg^{2+})$..... (2)

The method of All India Coordinated Research Project (AICRP) on Management of Salt Affected Soils and Use of Saline Water in Agriculture (AICRP, 1989) was used for classification of water samples. The nutrient database was geo-coded with survey points. Geo-statistical Analysis was carried out to generate soil nutrient maps of the farm. ArcGIS 10.3 version software was used to create thematic maps of the farm.

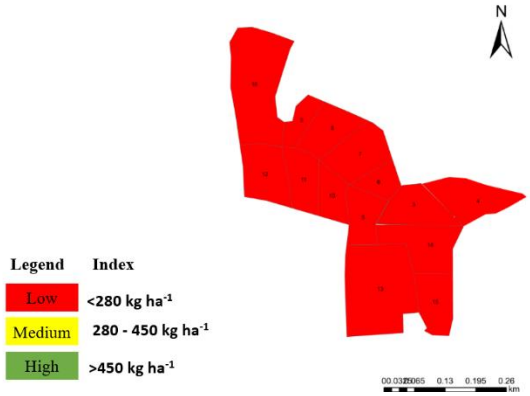
RESULTS AND DISCUSSION

The soil is slightly calcareous and non-saline. Soil texture is mostly sandy clay loam or sandy loam in most fields with root zone limitations. Soil addition of a calculated quantity of available clay or sand to adjust the texture to the nearby desirable texture is desirable and profitable for enhanced farm productivity. (Mayalagu and Jawahar, 2000).

Generally, the available nutrient status of the soils is low available nitrogen, medium available phosphorus and high available potassium. The organic carbon status is low to moderate. The deficiency level of available nutrients like N, Zn, Fe and organic carbon in fields could be ascribed to the natural losses and uptake due to cropping of the farm. Study of effect of long term fertilizer addition on soil fertility status of N,P, and K nutrients over 22 years of cropping (*i.e.,* 1988 to 2008) in pearl millet and sorghum in rotation showed significant influenced of the soil P and K over years, as reported by Jawahar *et al* (2014). Significant build-up of nutrients was observed in the soil after harvest of the crops. Similar build-up of nutrients especially P and K status is seen in the cultivated fields of the ICAR-KVK farm over years, due to fertilizer addition and favourable climatic and soil conditions at the farm.

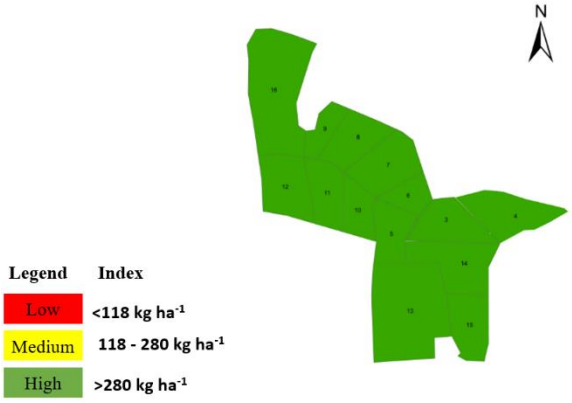
Pongalur ICAR-KVK farm

Available Nitrogen Status – KVK, Pongalur



Available Phosphorus Status – KVK, Pongalur

Available Potassium Status – KVK, Pongalur



Organic carbon Status – KVK, Pongalur

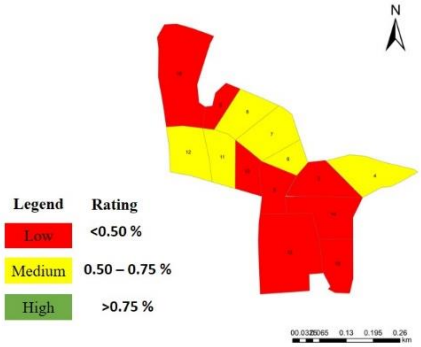


Table.1. Soil analysis of the farm

Field No	GPS coordinates		OC g kg^{-1}	pH	EC (dS/m)	Texture	Lime	Available Nutrients		
	Longitude ^{0}N	Lattitude ^{0}E						Nitrogen	Phosphorus	Potassium
								(Kg ha^{-1})		
3	10^{0}98'01"	77^{0}38'27"	0.043	7.69	0.17	scl	C	196	30	480
4	10^{0}98'02"	77^{0}38'37"	0.050	7.66	0.20	scl	C	199	16	545
5	10^{0}98'00"	77^{0}38'17"	0.042	7.65	0.28	scl	C	179	20	493
6	10^{0}98'05"	77^{0}38'19"	0.063	7.67	0.35	scl	C	232	29	794
7	10^{0}98'12"	77^{0}38'15"	0.060	7.63	0.30	scl	C	210	18	982
8	10^{0}98'17"	77^{0}38'10"	0.056	7.73	0.20	scl	C	190	16	760
9	10^{0}98'16"	77^{0}38'00"	0.039	7.78	0.16	scl	C	176	15	560
10	10^{0}98'01"	77^{0}38'08"	0.035	7.75	0.18	scl	SC	174	12	267
11	10^{0}98'01"	77^{0}38'04"	0.055	7.14	0.48	scl	SC	207	39	569
12	10^{0}98'05"	77^{0}37'97"	0.056	7.57	0.46	scl	SC	202	23	795
13	10^{0}97'86"	77^{0}38'18"	0.048	7.51	0.23	sl	SC	199	17	330
14	10^{0}97'98"	77^{0}38'26"	0.036	7.75	0.20	scl	SC	176	13	437
15	10^{0}97'86"	77^{0}38'28"	0.040	7.52	0.67	scl	C	176	24	463
16	10^{0}98'27"	77^{0}37'92"	0.042	7.81	0.24	scl	C	190	16	417

C- calcareous; SC- Slightly calcareous

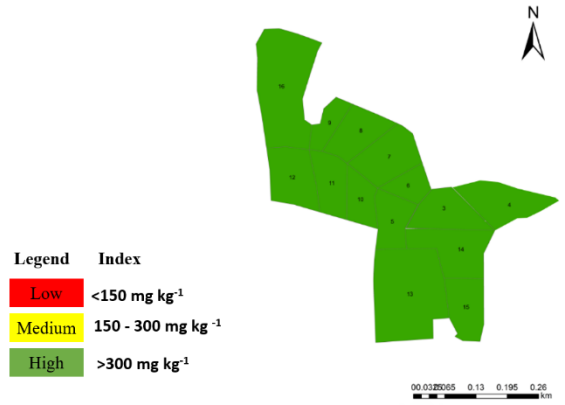
Table 2. The secondary and micronutrient analysis of the soils of the farm

Field	Available Zinc	Available Copper	Available Iron	Available Manganese	Available Calcium	Available Magnesium	Available Sulphur	HWS Boron
	(mg/kg)							
3	1.02	1.80	3.82	6.35	672	360	11.0	1.0
4	0.77	1.73	4.64	5.29	564	240	10.4	1.2
5	2.26	2.00	3.66	11.88	504	258	11.8	1.1
6	1.38	2.63	4.15	18.31	588	246	13.7	1.2
7	1.07	1.59	3.66	9.34	564	282	10.1	1.0
8	0.90	1.83	3.98	11.50	660	324	12.7	1.0
9	0.54	1.18	2.59	6.93	528	288	18.1	1.0
10	0.77	1.66	3.00	9.12	468	234	17.9	0.9
11	1.07	1.49	2.67	14.74	468	228	19.7	0.9
12	1.53	2.15	2.67	14.90	408	234	11.9	0.9
13	1.29	1.69	3.41	10.98	552	264	22.0	0.9
14	1.02	1.18	3.66	5.29	480	252	13.6	0.9
15	0.79	1.28	2.10	4.94	624	354	20.5	0.9
16	0.71	1.73	3.33	9.41	552	228	13.7	0.9

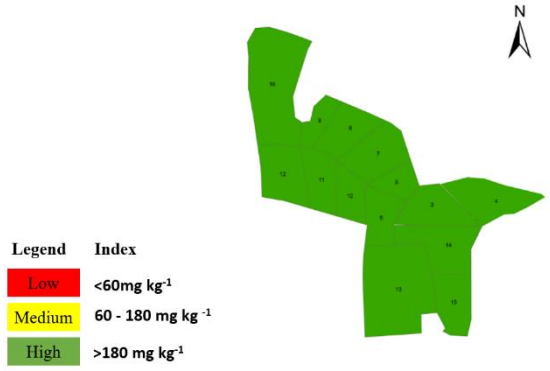
With respect to secondary nutrients, the available calcium contents ranged from 408 to 672 mg kg^{-1} falling in high category. The available magnesium values falling in higher category raged from 4.94 to 18.31 mg kg^{-1}. The available sulphur ranged from 10.1 to 22.0 mg kg^{-1} falling in medium to higher category.

The micronutrient analyses indicated that the TPA-Zn values were deficient in certain fields and sufficient in some fields. The DTPA Cu values were sufficient in the farm soils. The DTPA-Fe values found in the farm soils were deficient in most of the fields. DTPA-Mn analysis has shown the soil had sufficient available manganese. The hot water soluble boron values were sufficient in the farm.

Available Calcium Status – KVK, Pongalur



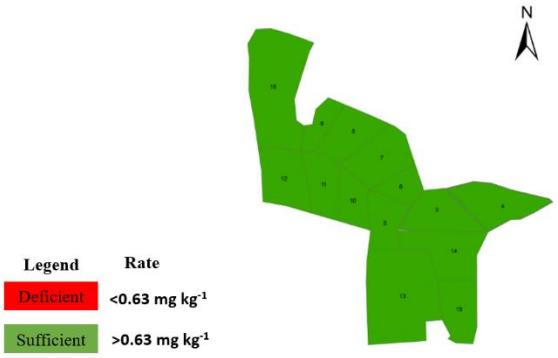
Available Magnesium Status – KVK, Pongalur



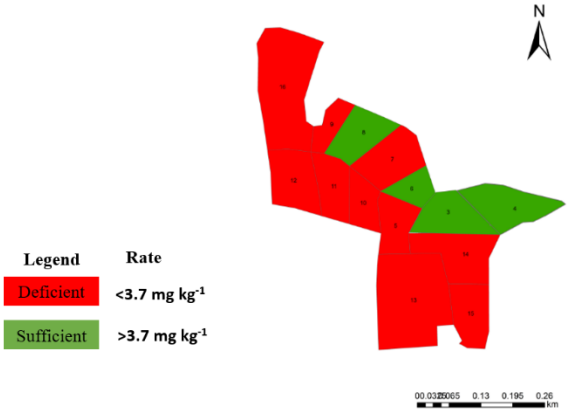
Available Sulphur Status – KVK, Pongalur

DTPA-Zn Status – KVK, Pongalur

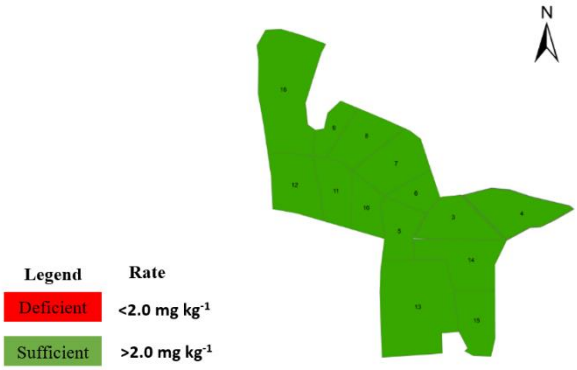
DTPA-Cu Status – KVK, Pongalur



DTPA- Fe Status – KVK, Pongalur



DTPA- Mn Status – KVK, Pongalur



After a modelling study with long term experiment of 13 years, reported Maruthi Sankar *et al* (2012) that conjunctive use of organic and inorganic source of fertilizers enhanced favourable effect on soil organic carbon, water holding capacity and fertility status of farms. This practice can be recommended in this Pongalur ICAR-KVK farm also for better nutrient status and sustainability of farm.

Quality of water

The characteristics of well water collected from the ICAR-KVK, TNAU farm, Pongalur are presented in Table 3. The water samples of bench mark wells recorded neutral to slightly above neutral pH ranges from 7.14 to 7.94 and the EC of the water sample ranges from 0.63 to 4.08 dS m^{-1}. Borewell 2 has recorded high EC of 4.08 dS m^{-1} and the Borewell 1 registered the less EC of 0.63 dS m^{-1}. There was no CO_3^{2-} content in all the wells. HCO_3^- content ranged from 2.80 to 3.60 meq L^{-1} and the solar pump site water sample recorded highest HCO_3^- of 3.60 meq L^{-1}.

The calcium content of water samples ranges from 2.00 to 17.36 meq L^{-1}. The highest Ca content of 17.36 meq L^{-1} was recorded in borewell 2 which was followed by solar pump site (12.40 meq L^{-1}). The magnesium content of the water sample ranges from 1.97 to 9.07 meq L^{-1}. The highest Mg content was recorded in borewell 2 (9.07 meq L^{-1}). The borewell 2 recorded highest sodium content of 13.66 meq L^{-1}. The potassium content of the water sample ranges from 0.18 to 0.66 meq L^{-1}, the chloride content of the water sample ranges from 2.00 to 22.80 meq L^{-1}. The highest chloride content was observed in Borewell 2 (22.80 meq L^{-1}).The bore well 2 recorded the highest chloride content of 22.80 meq L^{-1}. There is no sulphate content observed in all the wells. SAR value of water lied between 1.51 and 4.19 and Adjusted SAR value varied from 2.87 to 10.48. The SAR value indicating the quality of water is good.

The concentration of anions viz., carbonate, bicarbonates, chloride and sulphate were of the range from 0, 2.8 to 3.6, 2.0 to 22.8 and 0 meq L^{-1} with average values of 0, 3.1, 12.3 and 0 meq L^{-1} , respectively (Table 3.). The anionic concentration followed the order of chloride > bicarbonate > sulphate > carbonate. Absence of active processes such as weathering, salt dissolving, and irrigation drainage return flow may be responsible for the no chloride level in the groundwater (Kumar SK *et al* 2009). Besides, as the source of chloride could be non-lithological, indicating that the soil is free from salinity conditions, irrigation-return-flows, excessive addition of chemical fertilisers etc. The reasons for carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) concentrations in groundwater can be ascribed to carbonate weathering as well as from the dissolution of carbonic acid in the aquifers (Kumar *et al* 2013). The absence of sulphide-bearing minerals and gypsum in aquifer materials, as well as the non-application of sulphate-rich fertilisers or industrial wastes to soil, could all contribute to absence of sulphate ions in groundwater (Sridharan *et al* 2017). Furthermore, absence of SO_4^{2-} content in groundwater is expected as a result of restricted or no use of soil amendments such as gypsum (Bhat *et al* 2018).

Naseem *et.al*. (2010) reported that the pH, EC and SAR of the irrigation water were significantly influenced by RSC. Based on RSC, water could be grouped into three categories such as safe (2.5 meq L^{-1}), marginally suitable (1.25-2.5 meq L^{-1}) and unsuitable (>2.5 meq L^{-1}) indicating that all the water samples were found to be under safe category.

Table 4. Ground water quality classification (AICRP, 1989)

Water quality	Class	Number of samples	Percent
Good	A	1	25
Saline	B	nil	nil
Marginally saline	B1	2	50
Saline	B2	1	25
High SAR saline	B3	nil	nil
Alkali water	C	nil	nil
Marginally alkali	C1	nil	nil
Alkali	C2	nil	nil
Highly alkali	C3	nil	nil

According to All India Coordinated Research Project (AICRP) on Management of Salt Affected Soils and Use of Saline Water in Agriculture classification, out of 4 groundwater samples, 1 was of good quality, 2 marginally saline, 1 saline, as represented in Table 4. All the water samples had desirable values of SAR and RSC, but with slightly increased EC values. This implies that careful and regular monitoring of groundwater is imperative to avoid major environmental threat.

Table.3. Characteristics of water samples of ICAR-KVK, TNAU farm, Pongalur

Parameter	Borewell 1 (F.No:14)	Borewell 2 (F.No:16)	Solar pump (F.No:16)	Windmill open well (F.No:16)
GPS coordinates	10°97'97"N 77°38'24"E	10°98'32"N 77°37'91"E	10°98'97"N 77°37'91"E	10°98'29"N 77°37'90"E
pH	7.85	7.14	7.37	7.94
EC (dS m^{-1})	0.63	4.08	2.87	2.69
Ca^{2+} (mg L^{-1})	2.00	17.36	12.40	9.76
Mg^{2+} (mg L^{-1})	1.97	9.07	6.47	5.21
Na^{+} (mg L^{-1})	2.13	13.66	9.28	11.47
K^{+} (mg L^{-1})	0.18	0.66	0.53	0.41
CO_3^{2-} (mg L^{-1})	0.00	0.00	0.00	0.00
HCO_3^{-} (mg L^{-1})	2.80	2.80	3.60	3.20
Cl^{-} (mg L^{-1})	2.00	22.80	12.40	12.00
SO_4^{2-} (mg L^{-1})	0.00	0.00	0.00	0.00
SAR	1.51	3.76	3.02	4.19
Adj. SAR	2.87	9.78	7.85	10.48
RSC (meq L^{-1})	-1.17	-23.63	-15.27	-11.77

CONCLUSION

The soils are slightly calcareous and non-saline. Generally, the available nutrient status of the soils is low available nitrogen, medium available phosphorus and high available potassium. The organic carbon status is low to moderate. With respect to secondary nutrients, the available calcium and magnesium contents were high. The available sulphur ranged from medium to higher category. The available Mn, Cu and Bo values were sufficient. The characteristics of well water collected from the ICAR-KVK, TNAU farm, Pongalur recorded neutral to slightly above neutral pH ranges from 7.14 to 7.94 and the EC of the water sample ranges from 0.63 to 4.08 dS m^{-1}. The chloride content of the water sample ranged from 2.00 to 22.80 meq L^{-1}. There is no sulphate content observed in all the wells of TNAU farm, Pongalur. SAR value of water lies between 1.51 and 4.19 and Adjusted SAR value varies from 2.87 to 10.48. The SAR value indicates the quality of water is good.

REFERENCES

AICRP (1989) Progress Report (1988-1991). All India Coordinated Research Project on Management of Salt Affected Soils and Use of Saline Water in Agriculture. Central Soil Salinity Research Institute, Karnal.

Naseem S, Hamza, S Bashir E. 2010. Groundwater geochemistry of winder agricultural farms, Balochistan, Pakistan and assessment of irrigation water quality. European Water. 31:21-32.

Bhat MA, Wani, SA, Singh, VJ Sahoo, J Tomar, D and Sanswal, R. 2018. An overview of the assessment of groundwater quality for irrigation. Journal of Agricultural Science and Food Research. 9(1):1-9.

Eaton, F.M. 1950. Significance of carbonate in irrigation waters. Soil Science. 69(2): 123–133.

Gupta, U. C. 1967. A Simplified Method for Determining Hot Water-soluble Boron in Podzol Soils. Soil Sci. 103: 424-428.

Hessey, P. 1971. A text book of soil chemical analysis. John Murrey, London.

Jackson ML. 1973. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd. New Delhi.134-182.

Jawahar.D., G.R.Maruthi Sankar, A.Renuka Devi, M.Rajeswari, V.Subramanian, K.L.Sharma, P.K.Mishra, G.Ravindra Chary and K.Bhaskar 2014 Modeling effects of soil fertility of nutrients and precipitation of 22 years on sustainable productivity and profitability of pearlmillet and sorghum rotation in semiarid vertisols. Communications in Soil Science and Plant Analysis 45:251-270.

Kumar SK, Rammohan V, Sahayam, JD and Jeevanandam, M. 2009. Assessment of groundwater quality and hydro-geochemistry of Manimuktha River basin, Tamil Nadu, India. Environmental Monitoring and Assessment.159: 341-351.

Kumar S, Sharma SK, Rajpaul, Ramprakash, Satyavan. 2013. Mapping groundwater quality for Lakhan Majra block of Rohtak district (Haryana). Annals of Agri Bio Research.;18(2):186-190.

Lindsay, W.L. and Norwell, W.A. (1978) Development of DTPA of Soil Test for Zn, Fe, Mn and Cu. Journal of American Soil Science, 42: 421-428.

Maruthi Sankar, G.R., V.Subramanian, K.L.Sharma, P.K.Mishra, S.Jyothimani, K.Bhaskar, D.Jawahar, M.Rajeswari, T.Taghavan, G.Ravindra Chary, A.Renuka Devi, K.A.Gopinath, B.Venkateswarlu, and J.Kusuma Grace. 2012 Modelling of interactive effects of rainfall evaporation, soil temperature, and soil fertility and sustainability productivity of sorghum + cowpea and cotton +black gram intercrops under rotation trials in a rain-fed semi-arid Vetisol. 2012. Communications in Soil Science and Plant Analysis, 43:756-787. DOI: 10.1080/00103624.2013.861905

Mayalagu. K and Jawahar, D. 2000. Effect of mixing black clay soil and organic amendment on properties of coarse-textured soil and rice yield. *International Rice Research Notes*, 25.03.2000, p:30-31.

Olsen, S.R., Cole, C.V. and Watanabe, F.S. (1954) Estimation of Available Phosphorus in Soils by Extraction with Sodium Bicarbonate. USDA Circular No. 939, US Government Printing Office, Washington DC.

Richards LA. 1954. Diagnosis and improvement of Saline and Alkali Soils. Agricultural Hand Book No.60, USDA, Washington DC.160.

Sridharan M and Nathan DS. 2017. Groundwater quality assessment for domestic and agriculture purposes in Puducherry region. Applied Water Science. 7:4037-4053.

Stanford, S., and L. English, 1949. A use of flame photometer in rapid soil tests of potassium and calcium. Agron. J., 41:446-447.

Subbiah, B.V. and Asija, G.L. (1956) A Rapid Procedure for the Estimation of Available Nitrogen in Soils. Current Science, 25: 259-260.

Walkley, A. and Black, I.A. (1934) An Examination of the Degtjareff Method for Determining Soil Organic Matter and a Proposed Modification of the Chromic Acid Titration Method. Soil Science, 37: 29-38.

Williams, C.H., Steinberg, A., 1959. Soil sulphur fractions as chemical indices of available sulphur in some Australian soils. Australian Journal of Agriculture Research 10: 340–352.

Willard HH, Meritt LL and Dean JA. 1974. Instrument Methods of Analysis.5th edition, D Van Nastrand Company, New York.