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INFLUENCE OF ORGANIC MANURING AND INORGANIC FERTILIZATION IN MAIZE-GROUNDNUT CROPPING SEQUENCE ON SOIL QUALITY INDEX UNDER ALFISOLS OF CHITTURE DISTRICT TIRUPATI

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ABSTRACT

ABSTRACT

Soil quality assessment study under this experiment was conducted in 2 years of research. Soil quality was assessed by identifying important Variables utilizing principal component analysis (PCA) and calculating soil quality indices (SQI) from the Minimum Data Set. Results demonstrated that the majority of soil quality metrics were strongly influenced by the integrated nutrient management treatments with application of high farm yard manure with 125% RDF. All of the observation's physical, chemical, and biological properties are considered for SQI estimation was included in PCA. Totally 36 parameters were used in PCA. The components in PCA which had more eigen value more than one is chosen for screening of Minimum Data Set (MDS). Finally, N, TC, CN, Cu, IC, pH and BD was finally screened in MDS. In maize – groundnut cropping sequence SQI values Among the main plot treatment M_1 had the highest SQI (0.80 and 0.78) while M_3 had the lowest SQI (0.75 and 0.71). The SQI of sub plot treatments varied from 0.63 to 0.86 and 0.57 to 0.82 respectively, S_1 had the lowest SQI (0.63 and 0.57) and S_2 had highest SQI (0.86 and 0.84) on average ~ sub plot treatments had higher SQI (0.777 and 0.745) over main plot treatments (0.776 and 0.743).

Key words: *Maize, Groundnut, Soil Quality Index, N, Total Carbon, Carbon nitrogen, Farm Yard Manure, Poultry manure, Urban Compost and NPK.*

INTRODUCTION

Soil management has a major impact on soil quality. A wide range of agricultural soils represents diversely managed arable lands while the main goal to improve soil quality, crop growth, crop yield, and reduce the ecological foot print. Soil quality is described as the soil's capacity to function within natural or managed ecosystem bounds, sustain plant productivity, and reduce soil deterioration [doran and karlen]. Soil quality is a complicated functional concept that cannot be assessed directly in the field or laboratory but must be inferred from soil properties. To estimate soil quality, a number of soil parameters or indicators have been developed. However, soil quality is often related to the soil management goal and practices as well to soil characteristics. Thus, a mathematical or statistical framework was put forward in early 1990s to estimate soil quality index (SQI) (doran) The SQI was assessed so that the management goals are not only focused on productivity, which may result in soil degradation, but also on environmental issues. Thus, an appropriate SQI may have three component goals: environmental quality, agronomic sustainability, and socio-economic viability. Continuous The application of fertilizers and manures has an impact on the soil's physical, chemical, and biological qualities. Changes in soil qualities caused by the ongoing application of fertilizers and manures have a significant impact on the cropping system's sustainability. Research focuses on the interplay between organic and inorganic nutrient sources.

Maize (*Zea mays* L.) – Groundnut (*Arachis hypogaea*) is one of the most significant cropping systems in Andhra Pradesh, India, and maintaining optimal soil fertility is critical for achieving higher and longer-term productivity. The responses of subsequent crops in a cropping system are heavily influenced by the preceding crops and the inputs supplied therein. Therefore, recently greater emphasis is being laid on the cropping system as whole rather than on the individual crops in a sequence. Maintaining sustained crop production, balanced manuring is essential to build up soil health. Wide use of short statured high yielding varieties and hybrids is common in maize. Organic sources will improve the nutrient

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usage efficiency of chemical fertilizers by lowering nutrient losses and increasing nutrient availability to the plant. The integration and assimilation of organic manure (FYM, poultry manure, and urban compost) into the cropping system improves soil structure, soil microbial activity, and soil moisture conservation, hence stabilizing crop yield and productivity. Integrated nutrient management is also critical for marginal farmers who cannot afford to supplement crop nutrients with expensive chemical fertilizers.

MATERIAL AND METHODS

The field experiment titled "Dynamics of soil carbon under integrated nutrient management practices in maize-groundnut cropping sequence" was carried out under field conditions during both kharif and rabi seasons of 2019-2020 and 2020-2021 at Field No. 50B of Wetland Farm, S. V. Agricultural College. Tirupati campus. which is geographically situated at 13.5°N latitude and 79.5°E longitude with an altitude of 182.9 m above mean sea level in the Southern Agro Climatic Zone of Andhra Pradesh. According to Trolls classification, it come under the Semi-Arid Tropics (SAT). The soil of experimental site was sandy clay loam with pH of 7.68, Electrical conductivity 0.85 dSm^{-1}, low in organic carbon (0.42 %), low in available nitrogen (128 kg ha^{1}) and high in phosphorus (52.8 kg ha^{-1}) and medium in potassium (318.82 kg ha^{-1}). The experiment was laid out in a split plot design for both the years with three main plots (M_1)125%, (M_2) 100%, (M_3) 75% RDF and four sub plots (S_1) control, (S_2) FYM 10 t ha^{-1}. (S_3) Poultry manure 5 t ha^{-1} and (S_4) urban compost 5 t ha^{-1} , total 12 treatments consisting of combinations of three replications. In *kharif*, maize hybrid (Kavery-55K) and in *rabi*, groundnut (K6) was sown on both (*kharif* 2019-20 and r*abi* 2020-21) adopting a spacing of 60 x 20 cm and 22.5 x 10 cm in maize and groundnut crops respectively . In general the climatic conditions were congenial during crop growth period and incidence of pest and disease attack was noticed to some extent. Based on the analysis described by Dunteman George (1989), Jolliffe (1986) and Krzanowski (1979), the principal components were determined for explaining the variability of 37 soil physical, chemical and biological parameters along with different carbon forms measured in the study. Based on the principal component (PC) model, thei^{th} PC „P_i" could be postulated as,

$$P_i = a_{i1}BD + a_{i2}PD + a_{i3}MWHC + a_{i4}PO + a_{i5}\,pH + a_{i6}EC + a_{i7}\,OC + a_{i8}\,N + a_{i9}\,P + a_{i10}\,K + a_{i11}Ca + ai12\,Mg + ai13\,S + ai14\,Zn + ai15\,Mn + ai16Fe + ai17\,Cu + ai18\,DH + ai19\,MBC + ai20\,MBN \quad \ldots\ldots\ldots\ldots\ldots(2)$$

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In equation (2), aij are the loadings of variables on „Pi", which are chosen such that they satisfy two conditions, viz., (i) the PCs are orthogonal with respect to each other; and (ii) 1st PC, say PC1 will account for maximum variance of the variables; 2nd PC, say PC2 will account for maximum of the remaining variance in variables after eliminating the variance accounted by 1st PC and so on. An eigen value „λ_k" indicates the variance extracted by the kth PC and can be expressed as percentage of total variance of all components, that is $P_k = (\lambda_k/k) \times 100$. The computational procedure of 1st PC is repeated for the 2nd PC and all the subsequent PCs. The 1st PC would always have a higher eigen value than the 2nd PC; the 2nd PC has a higher eigen value than the 3rd PC, say PC3 and so on. Based on the analysis, we could determine (i) the significant number of PCs with eigen value of more than „one" to extract maximum variance in the data; (ii) the soil parameters which have an equal or more than on the PCs; and (iii) the percent of variance explained by a PC. The leading PCs could be compared „pair-wise" along with the coefficient of variation of soil fertility parameters in order to identify the superior parameters which have a significantly higher loading of more than ± 0.50 on the PCs, apart from having a lower coefficient of variation. Through this principal components themost influenced soil parameters are categorized.

SQI = ∑ WiSi (Wi ; weight of MDS parameters, Si; linear scores of MDS parameters)

SQI = 0.49 x N + 0.22 x TC + 0.07 x BD + 0.07 x pH + 0.05 x Cu + 0.05 x C:N + 0.05 x IC

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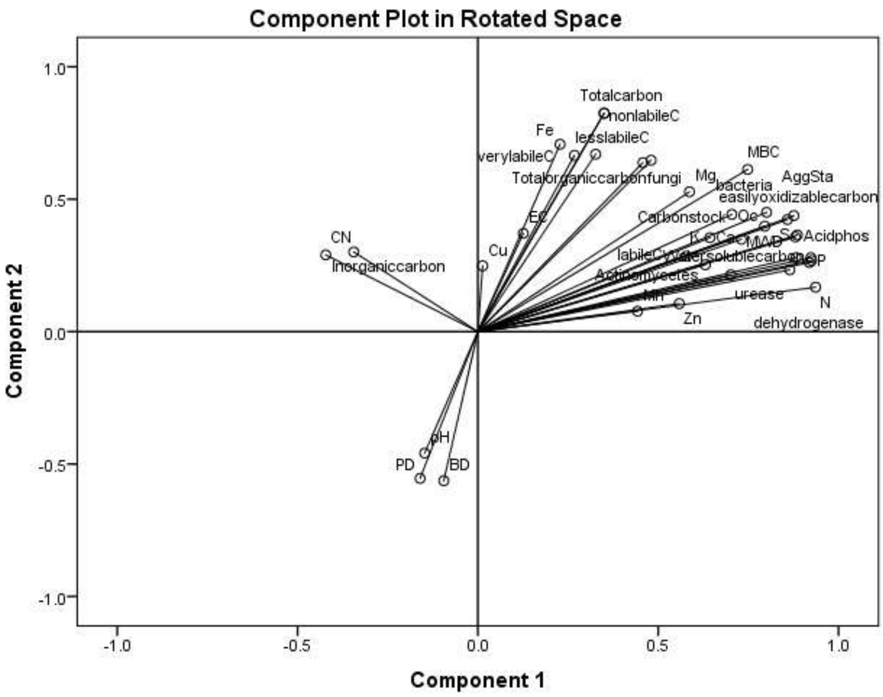
RESULTS AND DISCUSSION

Soil Quality Index After the Maize Crop

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	19.214	53.372	53.372	19.214	53.372	53.372	14.490	40.251	40.251
2	2.874	7.984	61.356	2.874	7.984	61.356	6.683	18.565	58.815
3	2.443	6.786	68.141	2.443	6.786	68.141	2.199	6.109	64.924
4	1.751	4.864	73.005	1.751	4.864	73.005	2.163	6.007	70.931
5	1.303	3.621	76.626	1.303	3.621	76.626	1.504	4.177	75.109
6	1.154	3.205	79.830	1.154	3.205	79.830	1.405	3.904	79.013
7	1.094	3.040	82.870	1.094	3.040	82.870	1.389	3.857	82.870



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Rotated Component Matrix[a]

	Component						
	1	**2**	**3**	**4**	**5**	**6**	**7**
pH	-.172	-.153	-.011	**-.881**	.047	-.102	.096
EC	.261	.047	.682	-.068	.041	.229	-.049
Oc	.772	.319	.012	.071	.121	.314	-.012
N	**.946**	.148	.034	.078	-.026	-.166	-.024
P	**.928**	.206	.075	.189	-.001	-.105	.065
K	.663	.091	.181	.325	-.159	-.078	-.017
CN	-.275	-.021	.168	.085	.010	**.803**	-.068
BD	-.236	-.156	**-.763**	-.220	-.048	-.057	.300
PD	-.322	-.314	-.361	.009	.459	-.335	.002
AggSta	.848	.443	.042	.023	.022	.050	.119
MWD	.808	.402	.040	-.052	.062	.154	.103
Ca	.614	.242	-.005	.598	-.091	-.215	-.011
Mg	.557	.712	.006	-.210	.046	-.117	-.144
S	**.914**	.284	.145	.009	.062	.093	.087
Zn	.556	.178	-.247	-.177	.551	.134	-.038
Cu	.072	.055	.299	-.003	**.860**	.026	-.149
Fe	.274	.413	.341	.502	.103	.291	.108
Mn	.386	.323	-.653	.001	-.129	.142	-.119
Total carbon	**.304**	**.909**	.072	.161	.000	-.031	-.080
Total organic carbon	.363	**.833**	.005	.103	-.071	-.069	.303
Inorganic carbon	-.174	.054	.145	.111	.162	.090	**-.868**
Water soluble carbon	**.939**	.253	.028	.052	.007	-.001	.035
Easily oxidizable carbon	**.888**	.376	.131	.156	.003	-.041	.022
Very labile C	.220	.725	.020	.139	.102	.106	.079
Labile C	.506	.301	-.047	.226	.059	.125	.446
Less labile C	.289	.806	-.135	.047	-.030	.119	-.103
Non labile C	.304	**.909**	.072	.161	.000	-.031	-.080
MBC	.707	.644	.078	.168	.020	-.025	.131
Carbonstock	.766	.301	-.104	.035	.122	.316	.036
Fungi	.437	.503	.302	.347	.255	-.009	.187
Bacteria	**.810**	.420	.096	.120	-.038	-.024	-.010
Actinomycetes	.650	.288	.002	.040	.142	-.195	.124
Urease	.850	.183	-.026	.279	-.012	-.088	.084
Dehydrogenase	**.910**	.215	.070	.183	.006	-.109	.113
Acidphos	**.903**	.278	.120	.182	.076	-.058	.010
AlkalineP	.897	.225	.166	.032	.050	-.043	.102

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	N	**P**	**S**	**Water soluble carbon**	**TC**	**dehydrogenase**
N	1	.933**	.904**	.931**	.923**	.934**
P	.933**	1	.910**	.935**	.964**	.959**
S	.904**	.910**	1	.928**	.901**	.900**
Water soluble carbon	.931**	.935**	.928**	1	.923**	.926**
TC	.923**	.964**	.901**	.923**	1	.941**
dehydrogenase	.934**	.959**	.900**	.926**	.941**	1

MDS	**Factor loading**	**Weightage**
N	0.95	0.49
TC	0.91	0.22
BD	-0.76	0.07
pH	-0.88	0.07
Cu	0.86	0.05
CN	0.80	0.05
IC	-0.87	0.05

SQI_{maize} = ∑ WiSi (Wi ; weight of MDS parameters, Si; linear scores of MDS parameters)

SQI_{maize} = 0.49 x N + 0.22 x TC + 0.07 x BD + 0.07 x pH + 0.05 x Cu + 0.05 x C:N + 0.05 x IC

Treatments		SQI
Main Plot	M_1	0.80
	M_2	0.78
	M_3	0.75
Sub plot	S_1	0.63
	S_2	0.86
	S_3	0.84
	S_4	0.78

The Statistics-based model was used to estimate SQI using principal component analysis (PCA). The PCA-model is used to create a minimum data set (MDS) to reduce the indicator load in the model and avoid data redundancy. All the observation (untransformed) physical, chemical and biological parameters considered for SQI estimation was included in PCA. Totally 36 parameters were used in PCA. The components in PCA which had more eigen value more than 1 is chosen for screening of Minimum Data Set (MDS). First 7 components of PCA were considered which explains 82.87 % variability in the dataset (table 1). Under each principal component variables having highly weighted factor loading in rotated component matrix is retained for MDS. The 'highly weighted' variables were defined as the highest weighted variable under a certain PC and absolute factor loading value within 10 % of the highest values under the same PC. The bold faces in rotated component matrix table, within each component viz., N, P, K, oxidisable carbon, dehydrogenase, S, *Ac-P* for PC1, TC, TOC, NLC for PC2, BD for PC3, pH for PC4, Cu for PC5, CN for PC6 and IC for PC7 (table 2) are retained for screening MDS. Since, more than one variable got retained in PC1 multivariate correlation is done between the retained variable, and only N and TC is retained since it had significant correlation with all other variables and highest eigen vector value (0.95) followed by TC (0.91) was retained. Finally, N, TC, CN, Cu, IC, pH and BD was finally screened in MDS. After selection of parameters for the MDS, all selected observations were transformed using

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linear scoring functions (less is better, more is better and optimum). The weightage for each parameter was calculated by the ratio between amount of variation explained by a particular PC and the maximum total variation in all PCs (table 3). SQI was calculated using the equation.

$$SQI_{maize} = \sum WiSi \text{ (Wi ; weight of MDS parameters, Si; linear scores of MDS parameters)}$$

There after the weighted SQI is computed as follows

$$SQI_{maize} = 0.49 \times N + 0.22 \times TC + 0.07 \times BD + 0.07 \times pH + 0.05 \times Cu + 0.05 \times C{:}N + 0.05 \times IC$$

The SQI values for both main plots and sub plots are represented in table.4. Among the main plot treatment M_1 had the highest SQI (0.80) while M_3 had the lowest SQI (0.75). The SQI of sub plot treatments varied from 0.63 to 0.86, S_1 had the lowest SQI (0.63) and S_2 had highest SQI (0.86) on average ~ sub plot treatments had higher SQI (0.777) over main plot treatments (0.776).

Soil Quality Index of Post Harvest Groundout Crop

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	21.251	59.031	59.031	21.251	59.031	59.031	16.258	45.160	45.160
2	2.757	7.657	66.688	2.757	7.657	66.688	4.133	11.480	56.639
3	1.868	5.190	71.878	1.868	5.190	71.878	3.430	9.528	66.168
4	1.749	4.858	76.736	1.749	4.858	76.736	2.926	8.129	74.297
5	1.487	4.131	80.866	1.487	4.131	80.866	1.643	4.563	78.860
6	1.187	3.297	84.163	1.187	3.297	84.163	1.496	4.154	83.015
7	1.060	2.945	87.108	1.060	2.945	87.108	1.474	4.094	87.108

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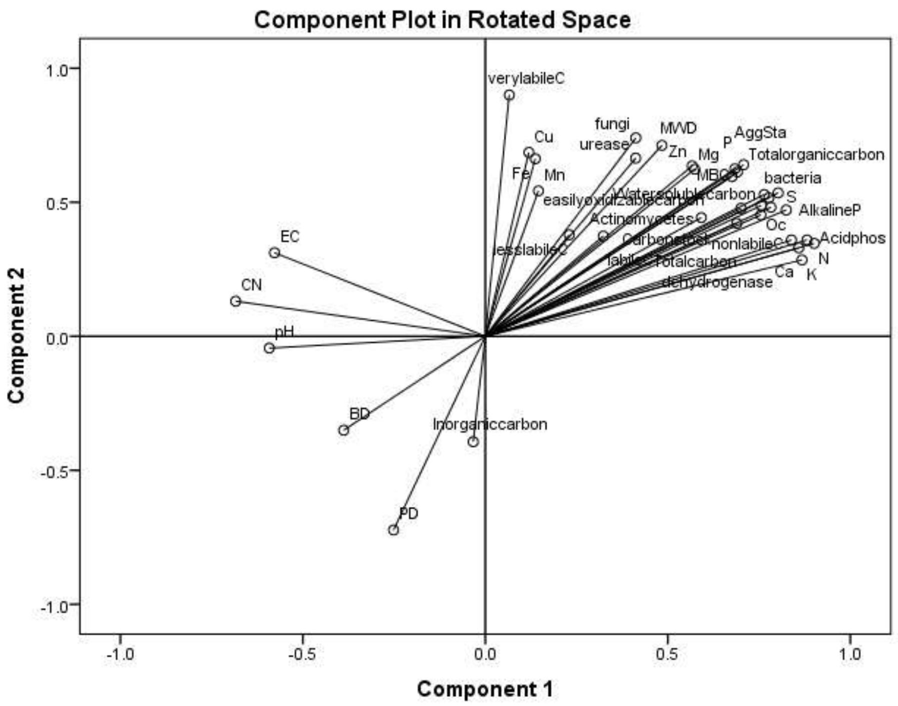

Rotated Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
pH	-.454	-.020	-.058	.000	-.088	**-.788**	-.079
EC	-.426	.014	-.129	.716	-.142	.369	-.173
Oc	.772	.118	.473	.094	.071	.257	.116
N	**.901**	.242	.191	-.088	.023	.105	.115
P	**.865**	.244	.158	.253	-.169	-.029	.034
K	**.868**	.251	.012	-.079	.086	-.014	.292
CN	-.436	-.585	.209	.422	-.217	-.318	.113
BD	-.342	-.240	-.123	-.074	-.037	-.053	**-.756**
PD	-.339	-.398	-.405	-.407	-.071	.005	-.215
AggSta	.823	.181	.376	.227	-.093	.089	.198
MWD	.677	.028	.518	.334	-.231	.014	.140
Ca	**.899**	.222	-.046	.027	.021	.068	.253
Mg	.666	.301	.427	.213	-.130	.203	-.180
S	**.894**	.065	.276	.196	-.004	.089	.125
Zn	.739	.158	.148	.434	.072	-.038	.247
Cu	.352	.237	-.021	**.720**	.098	-.093	.157
Fe	.204	**.791**	-.051	.357	-.141	-.046	.190
Mn	.194	.287	.593	-.016	-.242	-.292	.331

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Total carbon	.709	.327	.178	.263	.392	.184	.065
Total organic carbon	.770	.386	.188	.278	-.015	.167	.066
Inorganic carbon	-.217	-.171	-.043	-.062	**.911**	.019	-.009
Water soluble carbon	.890	.177	.214	.069	-.081	-.060	.132
Easily oxidizable carbon	.879	.340	.240	.089	-.039	.045	-.028
Very labile C	.292	.370	.502	.623	-.065	-.098	-.166
Labile C	.566	-.010	.047	.346	.127	-.310	-.395
Less labile C	.188	.029	**.838**	-.034	.106	.079	-.001
Non labile C	.666	.247	.263	.220	.506	.171	.112
MBC	.706	.550	.304	.042	-.011	-.082	.103
Carbon stock	.772	.080	.488	.076	.076	.279	.009
Fungi	.500	.611	.220	.328	-.083	.006	.139
Bacteria	.805	.405	.236	.080	.072	-.008	.095
Actinomycetes	.685	.020	.240	.210	-.143	.281	.087
Urease	.376	.776	.377	.066	-.097	.036	.149
Dehydrogenase	.923	.260	.106	-.054	-.091	.104	-.006
Acidphos	**.909**	.236	.038	-.004	-.104	.060	-.002
Alkaline P	.854	.457	.105	.041	.000	.094	-.013

	N	**P**	**K**	**Ca**	**S**	**Acid phos**	**urease**
N	1	.876**	.912**	.876**	.920**	.879**	.590**
P	.876**	1	.780**	.809**	.899**	.873**	.584**
K	.912**	.780**	1	.925**	.833**	.829**	.563**
Ca	.876**	.809**	.925**	1	.827**	.885**	.539**
S	.920**	.899**	.833**	.827**	1	.825**	.510**
Acid phos	.879**	.873**	.829**	.885**	.825**	1	.542**
urease	.590**	.584**	.563**	.539**	.510**	.542**	1

MDS	Factor loadings	Weightage
N	0.90	0.52
Fe	0.79	0.13
less labile C	0.84	0.11
Cu	0.72	0.09
IC	0.91	0.05
pH	-0.79	0.05
BD	-0.76	0.05

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$SQI_{groundnut} = \sum$ WiSi (Wi ; weight of MDS parameters, Si; linear scores of MDS parameters)

$SQI_{groundnut}$ = 0.52 x N + 0.13 x Fe + 0.11 x Less labile C + 0.09 x Cu + 0.05 x IC + 0.05 x pH + 0.05 x BD

Treatments		SQI
Main Plot	M_1	0.78
	M_2	0.74
	M_3	0.71
Sub plot	S_1	0.57
	S_2	0.84
	S_3	0.81
	S_4	0.76

The A statistics-based model was utilized to estimate SQI using principal component analysis (PCA). The PCA-model is used to generate a minimum data set (MDS) in order to reduce indicator load in the model and eliminate data redundancy. All of the observed (untransformed) physical, chemical, and biological parameters considered for SQI estimation was included in PCA. Totally 36 parameters were used in PCA. The components in PCA which had more eigen value more than 1 is chosen for screening of Minimum Data Set (MDS). First 7 components of PCA were considered which explains 87 % variability in the dataset (table 1). Under each principal component variables having highly weighted factor loading in rotated component matrix is retained for MDS. The 'highly weighted' variables were defined as the highest weighted variable under a specific PC with an absolute factor loading value within 10% of the maximum values under the same PC. The bold faces in rotated component matrix table, within each component viz., N, P, K, Ca, S, *Ac-P* for PC1, Fe for PC2, LLC for PC3, Cu for PC4, IC for PC5, pH for PC6 and BD for PC7 (table 2) are retained for screening MDS. Since, more than one variable got retained in PC1 multi variate correlation is done between the retained variable, and only N is

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retained since it had significant correlation with all other variables and highest eigen vector value (0.90) was retained. Finally, N, Fe, LLC, Cu, IC, pH and BD was finally screened in MDS. After choosing parameters for the MDS, all selected observations were transformed using linear scoring functions (less is better, more is better, and optimum). The weightage for each parameter was derived as the ratio between the amount of variance explained by a specific PC. and the maximum total variation in all PCs (table 3). SQI was calculated using the equation.

$SQI_{groundnut} = \sum WiSi$ (Wi ; weight of MDS parameters, Si; linear scores of MDS parameters)

There after the weighted SQI is computed as follows

$$\mathbf{SQI_{groundnut} = 0.52 \times N + 0.13 \times Fe + 0.11 \times Less\ labile\ C + 0.09 \times Cu + 0.05 \times IC + 0.05 \times pH + 0.05 \times BD}$$

The SQI values for both main plots and sub plots are represented in table.4. Among the main plot treatment M_1 had the highest SQI (0.78) while M_3 had the lowest SQI (0.71). Main plot treatments had fairly high SQI values over sub plot treatments. The SQI of sub plot treatments varied from 0.57 to 0.82, S_1 had the lowest SQI (0.57) and S_2 had highest SQI (0.84). on average ~ sub plot treatments had higher SQI (0.745) over main plot treatments (0.743) Jogarao *et al.*, 2017 reported that the status of nutrients - their depletion and build up in soil and crop productivity after twenty two years (1991-2012) of cotton mono-cropping were studied under continuous use of various inorganic fertilizers and organic manure in a Vertisol and results showed that application of 100% RD of NPK (90:45:45 kg ha^{-1}) +FYM @ 10 t ha^{-1} recorded the soil pH and EC did not change significantly but markedly changed the organic carbon and available nutrient contents of the soil. Thus, the balanced use of fertilizers continuously either alone or in combination with organic manure is necessary for sustaining soil fertility and productivity of cotton under rainfed conditions.

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CONCLUSION

Finally experimental results concluded that the majority of soil quality metrics were strongly influenced by the integrated nutrient management treatments with application of high farm yard manure with 125% RDF. All of the observation's physical, chemical, and biological properties are considered for SQI estimation was included in PCA. Totally 36 parameters were used in PCA. The components in PCA which had more eigen value more than one is chosen for screening of Minimum Data Set (MDS). Finally, N, TC, CN, Cu, IC, pH and BD was finally screened in MDS. In maize – groundnut cropping sequence SQI values Among the main plot treatment M_1 had the highest SQI (0.80 and 0.78) while M_3 had the lowest SQI (0.75 and 0.71). The SQI of sub plot treatments varied from 0.63 to 0.86 and 0.57 to 0.82 respectively, S_1 had the lowest SQI (0.63 and 0.57) and S_2 had highest SQI (0.86 and 0.84) on average ~ sub plot treatments had higher SQI (0.777 and 0.745) over main plot treatments (0.776 and 0.743).

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