Soil quality assessment of sesame-growing soils with different productivity in the Northern Telangana Zone, India

ABSTRACT

Present study was carried out in major sesame growing areas of Northern Telanganazone in districts namely; Nizamabad, Jagtial, Nirmal and Kamareddy. The main objective ofthisstudyistoassessthesoilqualityandtofindouttherelationbetweensesameyieldandsoilquality index. Based on the seed yield data of sesame, the above-mentioned districts weredividedintohigh,mediumandlowproductivityzones.50samplesfromeachproductivityzonewith a total of 150 surface soil samples (0-15 cm) were collected and analysed for variousphysical, physico-chemical, chemical and biological properties. Physical properties includedtexture,bulkdensityandwaterholdingcapacity.Physico-chemical propertieslikepH,EC andorganiccarbonwereanalysed.Chemicalpropertiesofsoilnamelyavailablenitrogen,availablephosphorus, available potassium, available sulphur, exchangeable bases like exchangeablecalcium and magnesium, potassium and sodium, available micronutrients like iron, copper,manganeseandzincwereanalysed.Biologicalpropertieslikeurease,acidandalkalinephosphatase and labile carbon were analysed. Principal component analysis, minimumdataset wasderived which containedavailablenitrogen,sand, pH, available phosphorus,exchangeable calcium and magnesium and urease with 70.81% variance. These are identifiedasthekeyindicatorsofsoilquality.Meansoilqualityindexvalueswere0.669,0.549and0.443for high, medium and low sesame productivity zones respectively and is in the order ofhigh>medium>low sesame productivity zones. Percent contribution of MDS to SQI are in theorderof,availablenitrogen(44.44%)>pH(16.85%)>exchangeablecalcium(9.87%)>exchangeable magnesium (8.89%)> urease (7.86%)> available phosphorus (7.38%) > sand(4.89%). This study concluded that the SQI was more significantly positively correlated withsesame yield, which revealed that soil variables from the minimum data set had biologicalsignificance and effectively evaluated the status of the sesame growing soils of NorthernTelangana Zone.

Keywords:minimumdataset,quality,sesame,Telangana,urease

INTRODUCTION

Soil is a fundamental, basic, natural and an important resource of the earth whosequalityisbeingdegradedinthepresentdays.Soilqualityisdefinedas"thesoil'sabilitytokeeppl ant and animal productivity, maintain or improve water and air quality and also providehuman health and habitation in both natural and managed ecosystems" (Cao and Zhou, 2008;Doranand Parkin, 1994).

The development of the idea of soil quality may be traced back to two distinct theoriesthat either placed a greater focus on the natural characteristics of the soil or on the results ofhuman management. Mausel (1971), who defined soil quality as "the ability of soils to yieldcorn, soybean and wheat under conditions of high-level management," made the first mentionofit in thescientificliterature.

Sesame is an important oilseed crop of India since past. The yield of sesame wassignificantly getting lowered for the past few years. The decrease in yield of sesame might bedue to the decreasing soil quality and the main reason for low productivity of sesame is use oflowyieldingvarieties,poorsoilfertilityandimbalancednutrition(Ranganatha,2013).In addition to improving the physical conditions of the soil, the application of chemical andorganic fertilisers in sesame helps increase in yield of the crop (Verma *et al.*, 2014). However,useoffertilisersalongwithFYMimprovestheyield ofsesame(Parmar*et al.*, 2020).

Soilqualitydegradationisbecomingamajorissuefordecliningsesameproductivityinlow sesame productivity areas of Northern Telangana Zone. Soil quality and crop productivityare governed by nutrients in the soil, as well as other physical properties, chemical processesand biological activities. Assessing soil quality and identifying differences between sesamegrowingsoilswithvaryingproductivityarecriticalfordevelopingsustainablelandusemanag ement and increasing sesame productivity. With this background in mind, the presentinvestigationtitled–SoilqualityassessmentofsesamegrowingareasinNorthernTelangana Zone‖wascarried out.

MATERIAL AND METHODSSOILSURVEYAND SAMPLING

A soil sampling survey was carried out in major sesame growing areas of NorthernTelanganaZoneindistricts;Nizamabad,Jagtial,NirmalandKamareddy (Figure 1).Basedonthepreviousyearssesameyielddata,theabovementioneddistrictsweredividedintohigh, mediumandlowsesame productivity zones. 50 surface soil (0-15 cm) samples from each productivity zone,withatotal of150 surfacesoil sampleswerecollected.

LABORATORYANALYSIS

Physical properties analysed were soil texture by using bouycous hydrometer method(Piper,1950).Bulkdensitywasanalysedbyusingthecoresamplermethod(BlakeandHartge, 1986).Water holding capacity of soilwas determined by using Keencup(KeenRhoezwoski,1921).

Soil pH and EC were analysed by using pH meter and EC meter with 1:2 and 1:2.5 soilwater suspensions respectively (Jackson,1973). Soil organic carbon was determined by usingrapidtitration method(WalkleyandBlackmethod,1934).

Availablenitrogenwasanalysedbyalkalinepermanganatemethod(SubbiahandAsija,1956). Available phosphorus was analysed by using sodium bicarbonate method (Olsen*et al.*, 1954). Available potassium was analysed by using neutral normal ammonium acetatemethod (Jackson, 1973). Available sulphur was analysed by using turbidimetric method (C.H.WilliamsandA. Steinbergs, 1962).

Exchangeable properties like exchangeable calcium and magnesium were analysed byusing the method demonstrated by Tandon,1989. Exchangeable sodium was determined byusing Chapman's sodium acetate method (1965). Exchangeable potassium was determined byFlame photometer method (Malo *et al.*, 2005). Available micronutrients namely iron, copper,manganeseandzincwereanalysedbyDTPAextractantmethod(Lindsayand Norvel,1978).

BiologicalpropertiesanalysedwereureaseactivityofsoilbymethodgivenbyTabatabai and Bremner,1972. Acid and alkaline phosphatase activity of soil were analysed bythemethodgivenbyTabatabaiandBremner,1969.Labilecarbonpoolofsoilwasanalysedbyusingthemethod given byChan*et al.* (2001) andMandal *et al.* (2008).

SOILQUALITYEVALUATION

In order to evaluate soil quality index, three basic steps were followed namely; 1.Determining the minimum data set (MDS) 2. Transformation of minimum data set indicatorsintoscores and3.Integration ofindividual scoresand weightsintosoil qualityindex.

Determiningtheminimumdataset:

Principal component analysis was used to determine the minimum data set. PCA wasperformed by using SPSS version. 20. Among all the soil parameters analysed (physical,physico-chemical, chemical and biological), those parameters whose eigen values are greaterthan 1 under each PC were considered suitable under the minimum data set (Kaiser,1960).VarimaxrotationwasperformedinordertomaximizethecorrelationbetweenPC'sandthesoilproperties by distributing the variance (Waswa *et al.,* 2013). Under each PC, highly weightedvariableswereselectedassoilqualityindicators.IftherearemorethanonevariableundereachPC,correlationwasperformedbetweenthevariables(Andrews*etal*.,2004)andifthevariableswere significantly correlated, then the one with highest factor loading and absolute factorloading within 10% of highest value were retained and the remaining were eliminated in orderto avoid redundancy. If the parameters are non-correlated then they are considered equallyimportantand wereretained in thePC.

Transformationof minimumdatasetindicatorsintoscores:

Selected parameters which are under minimum data set were transformed into scoresrangingfrom0-1usinglinearscoringscorefunctions;(1)–moreisbetter‖,(2)–lessisbetter‖ and(3)–optimumisbetter‖ basedontheirimportanceinsoil.Thisisasfollows;For–moreis better‖ indicators, score is obtained by dividing each observation with the highest value in thedataset suchthathighestvaluegetsscoreof1.For–lessisbetter‖indicators, scoreisobtained by dividing lowest value in the dataset by each observation such that the lowest value gets thescoreof1.For–optimumisbetter‖indicators,theobservationsareconsideredasmoreisbetter upto threshold value and less is better above the threshold value. (Andrews *et al.,* 2004; Vasu*etal.,* 2016; Lenka*et al.*,2022).

Integrationofindividualscoresintosoilqualityindex:

After obtaining the scores, they were multiplied by the factor loading which wasobtained by dividing variance of single PC by cumulative variance of all PC's (Kumar *et al.*,2022). Then the scores and weight factors were multiplied for each variable in the minimumdataset. These values were integrated by using weighted additive method to obtain soil qualityindex (Cherubin*et al.,* 2017).

Soilqualityindexwascalculated byusingtheformula,$\sum_{i=1}^{n}(Wi \times Si)$

where,Wi=FactorloadingderivedfromPCASi=

Scoreforsubscriptedvariable

n=numberofvariables in minimum dataset

STATISTICALANALYSIS

PearsonCorrelationtestwasusedtodothecorrelationstudyamongtheproperties.Oneway analysis of variance (ANOVA) and least significant difference (LSD) were used toseparate the mean difference between parameters at probability of 0.05. SPSS (version 20.)was used to perform principal component analysis and MS EXCEL was used to calculate thescoresandweightsofminimum datasetandsoilqualityindex.

RESULTSANDDISCUSSION

Soilphysicalproperties

Thepercentageofsand,siltandclayinhigh,mediumandlowproductivityzonesrangesfrom 10.00 to 88.00, 0.20 to 61.30 and 3.0 to 60.50 respectively. Among the three sesameproductivity zones, the mean of sand content in the medium and low zones was considerablygreater than in the high productivity zone, but silt content shown no significant differences. Inhigh sesame productivity zone, clay content was significantly higher. Variations in the soiltexturemight beduetothedifferenceinnatureandcomposition of parentmaterial.

Bulk density was found to range from 1.10 to 1.63 Mg m^{-3}. It had a significantdifferenceamongthethreesesameproductivityzones.Thelowproductivityzonehassignificantlygreaterbulkdensityoverthehighandmediumproductivityzones,whichrestrictsrootgrowth andaffectsthetransportofnutrientsinthesoil.ThisisinlinewithLiu*etal.*,2015.

Mean water holding capacities of soils were 46.02, 41.06 and 40.16 percent in high,mediumandlowproductivity sesamezones,respectively.Theresultsdemonstratedthatsignificantlyhigherwaterholdingcapacity wasfoundinhighersesame productivityzonesoilscompared to medium and low sesame growing areas of Northern Telangana zone (Table 1). This is inaccordancewith Paul*etal.,* 2014.

Soilphysico-chemicalproperties

pHofsoilsindifferentsesameproductivityzonesrangedfrom7.11to7.82,6.45to8.51and 6.81 to 7.46 respectively for high, medium and low sesame productivity zones. High soil pH valuesin high and medium sesame productivity zones compared to low sesame productivity zones, mightbe due to less base leaching, which reduces the activity of exchangeable Al^{3+} ions in soil solutionthroughchelation (Hue,1992).

EC varies in this study from 0.12 to 0.56 dSm^{-1}, which is considered safe for sesamecultivation.Theseresultsarein linewithVilakar*et al.*, 2021.

Meansoilorganiccarboncontentobservedwas0.71,0.50and0.42%inthethreeproductivity zones. Among the three zones, mean soil organic carbon content was significantlyhigher in high sesame productivity zone (Table 2). This is because of application of farmyard manure andbiomass(Bhagwan *et al.*,2023).

Soilchemicalproperties

Availablenitrogencontentvariedfrom176.20to279.70,116.50to261.50and76.40to 139.80 kg ha^{-1} in HPZ, MPZ and LPZ respectively. Low content of available nitrogen in mediumand low sesame productivity areas might be due to lower amounts of organic matter. This result isinlinewith thefindingsofVerma*et al.* (2021)andPrasad *et al.* (2022).

Mean available phosphorus was found highest (41.50 kg ha^{-1}) in HPZ followed by MPZ(39.38 kg ha^{-1}) and lowest (26.88 kg ha^{-1}) in LPZ. The lower values of available phosphorus in thelow sesame productivity zone might be due to the continuous removal without matching theapplicationofphosphoruscontainingfertilizersaswellasorganicmanures.Thisisinrelevancewiththereports ofSeevagan*et al.*(2020) and Bhagwan*et al.*(2023).

Availablepotassiuminthestudiedarearangesfrom213.00to562.00,126.25to585.00and 182.50to562.50kgha^{-1} inHPZ,MPZandLPZrespectively.HigheravailablepotassiumcontentinHPZ might be due to the potassium mineralization from organic residues, which is same as theresultsofUrkurkar*et al.*,2010; Ramuluand Reddy,2018;Vilakar*et al.*,2021.

Available sulphur in the study area ranges from 15.33 to 24.84, 10.34 and 2.35 to 9.53 mgkg^{-1} in high, medium and low sesame productivity zones respectively. Less sulphur content inmediumandlowsesameproductivityzoneswasduetothelackofsulphuraddition(Pulakeshi*et* *al.*, 2012). Similar results were also reported by Ravi *et al.* (2017) in rice growing soils of NorthernTelangana Zone.

Exchangeable calcium ranged from 18.30 to 28.40 c.mol(p+) kg^{-1} in the high productivityzone, from 16.00 to 28.00 c.mol(p+) kg^{-1} in the medium productivity zone, from 11.00 to 32.50c.mol(p+) kg^{-1} in the low productivity zone. Exchangeable magnesium ranged from 5.90 to 19.00c.mol(p+) kg^{-1} in the high productivity zone, from 3.80 to 18.00 c.mol(p+) kg^{-1} in the mediumproductivityzoneandfrom7.50to17.10c.mol(p+)kg^{-1}inthelowsesameproductivityzone.Higherlevel of exchangeable calcium and magnesium under high sesame productivity zone was due to theregularadditionoffarmyardmanure,whichhasahigheradsorptioncapacityandmayhaveadsorbedcalcium and magnesium that would otherwise have leached down. Similar results were obtained byVasu*et al.* (2016).

Exchangeable potassium content ranges from 0.23 to 0.92, 0.21 to 0.57 and 0.20 to 0.65c.mol (p+) kg^{-1} and exchangeable sodium contents varies from 1.10 to 1.52, 0.59 to 1.90 and 0.56to 1.65 c.mol (p+) kg^{-1} in high, medium and low productivity zones respectively. The results are inlinewith theNarasaiah*etal.* (2018).

The DTPA Fe levels ranged from 1.35 to 26.40 mg kg^{-1}. It significantly differed in highproductivity zone from that of medium and low productivity zone, due to higher organic carboncontentwhichresultedinhigherproductionofcomplexingagentswhichpromotedbetterextractabilityofFein thesesoils (AnkithaSharma, 2022).

Copper ranges from 1.22 to 4.01 mg kg^{-1} from 1.02 to 3.05 mg kg^{-1} and from 0.12 to 1.98mgkg^{-1}inhigh,mediumandlowsesameproductivityzonesrespectively.Significantdifferencewasobservedforphosphorusinallthethreezones.CoppercontentishigherinHPZduetoitsassociationwithorganiccarbon,which isin accordancewith RajeshwarandAriffkhan, 2007.

Manganese ranges from 12.30 to 19.90 mg kg^{-1}, from 10.50 to 15.00 mg kg^{-1} and from 1.32to 9.65 mg kg^{-1} in high, medium and low sesame productivity zones respectively. High amount ofmanganese in high sesame productivity zone is due to its presence in the reduced forms, higherbiologicalactivityand organiccarbonin thesoils(Malavath andThurpu, 2019).

Zinc ranges from 0.34 to 1.95 mg kg^{-1} from 0.11 to 1.63 mg kg^{-1} and from 0.12 to 1.81 mgkg^{-1}inhigh,mediumandlowsesameproductivityzonesrespectively.Itshownsignificantdifferencein high and medium sesame productivity zones, but no significant difference was observed formedium and low sesame productivity zones. Low zinc content in low productivity zone could beassociated with the formation of insoluble products of Zn and low organic matter content (Table 3). This is inlinewith thefindings ofSanthi*et al.* (2018).

Soilbiologicalproperties

Ureaseactivitywasrecordedanditrangesfrom1.02to1.68,from1.02to1.87andfrom 1.03 to 1.32 µg NH_4^+ -N g^{-1} h^{-1} in high, medium and low sesame productivity zones respectively. Itshown significant difference in high and medium productivity zones but no significant differencewas observed for medium and low productivity zones. With increase in nitrogen content of soilurease activity also increases. Thus, urease activity is more in high productivity zone compared tomediumandlessinlowproductivityzone.Thisissimilarwiththeresultsof(Strachel*etal.*,2017).

Acidphosphataseactivityrangesfrom59.30to172.00,from21.00to102.00andfrom10.00to46.00µgPNP$g^{-1}h^{-1}$inhigh,mediumandlowproductivityzonesrespectively.Alkalinephosphataseactivityrangesfrom22.00to58.00from11.00to36.00andfrom6.00to28.00µgPNP$g^{-1}h^{-1}$inhigh,mediumandlowsesameproductivityzonesrespectively.Highersignificantdifferencefor acid and alkaline phosphatase was observed in high productivity zone compared to medium andlow. It is mainly due to the higher application of FYM, as it has high level of microbial activity,similarin trend with thatof Mandal*et al.* (2008).

Labilecarbonofsoilsrangesfrom1.07to3.88Mgha^{-1},from1.14to2.65Mgha^{-1}andfrom 0.38 to 3.11 Mg ha^{-1} in high, medium and low sesame productivity zones respectively. Highersignificantdifferenceforlabilecarbonwasobservedinhighproductivityzonecomparedtomedium and low (Table 4). This might be due to application of manures which increase microbial diversity byincreasingthestorageoflabile C inthesoil(Hegalson*et al.*, 2010and Zhen *etal.*, 2014).

Principalcomponentanalysis

Theanalyseddatawassubjectedtoprincipalcomponentanalysisandthefinalminimumdataset(MDS)includedallthehighly weightedvariablesfromsevenprincipalcomponentswitheigenvalues ≥1. PC's showed a cumulative variance of 70.81% after varimax rotation. Variablesshowinganabsolutevaluewithin10%ofhighestfactorundereachPCwereconsideredunderMDS(Vasu *et al.*, 2016; Kumar *et al.*, 2022). Correlation was performed in PC1 and PC3 among thevariables with highest factor loadings as shown by Vasu *et al.* (2016). In PC1, correlation wasperformedbetweenavailablenitrogen,availablesulphur,availablemanganeseandacidphosphatase. All the parameters are well correlated (r>0.6). So, the one with the highest factor loading *i.e.*available nitrogen was considered under MDSfrom PC1. In PC3, correlation was performedbetween pH and exchangeable sodium. Both the parameters are well correlated, but as pH has thehighest factor loading, it was taken under MDS from PC3. Hence, the final minimum datasetincludedavailablenitrogen,sand,pH,availableP,exchangeablecalcium,magnesium,urease.

Calculationofsoilqualityindex

After assigning the scores by and weights to all the parameters of minimum dataset, soilquality index was calculated for three sesame productivity zones. The mean soil quality index ofhigh,medium and lowsesame productivityzoneswere0.669, 0.549and 0.443 (Fig 2).

Validationofsoilqualityindex

Correlationwasperformedbetweensoilqualityindexandsesameyield.Correlationanalysisindicated that soil quality index and sesame yield were linearly correlated (R^2=0.6835**)(Fig 3).This is inaccordance with the findings of Li *et al.* (2019); Kumar *et al.* (2022). Sesame yield increased withincreaseinsoilquality.Significantpositivecorrelationbetweensoilqualityindexandsesameyieldindicates that the established minimum data set are biologically significant and they best representthesoilqualitystatusof sesamegrowingsoils in NorthernTelanganaZone.

Contributionofretainedminimumdatasetin SQI

The percent contribution of each variable of minimum dataset towards soil quality index isintheorder,availablenitrogen(44.44%)>pH(16.85%)>exchangeablecalcium(9.87%)>exchangeable magnesium(8.89%)>urease(7.86%)>availablephosphorus(7.38%)>sand(4.89%) (Fig 4.0).This indicates that available nitrogen contributes highest towards SQI as it has highest varianceamongallothervariablesintheMDS(Liu*etal.*,2015;Sharma*etal.*,2015)andthesandcontributest heleastwhichindicatesthattheavailablenitrogenisthemostlimitingfactorinthesesamegrowingareasofN orthernTelanganaZone.

FactorslimitingsesameyieldinNorthernTelanganaZone

Due to its influence on soil quality, available nitrogen is one of the most significantpredictorsofsoilfertility(Kumar*etal.*,2021).Itaidsinenhancingthevegetativedevelopm entof crop, which raises the amount of organic matter in the soil. Additionally, it is helpful inpreservingtheagriculturaloutputinaridregions (Nabiollahi*etal.*,2020).Therefore,availablenitrogenisregardedasacrucialindicatorofsoilquality(Sharma*etal.*,2015;Jiang*etal.*,2020;Biswas*et al.*, 2023; Kumar*et al.*, 2022; Qian*etal.*, 2023).

The availability of micro and macronutrients may be impacted by the variation in soilpHthroughoutthesesameproductionzones,whichcouldhaveanimpactoncropgrowth,yield,and microbial activity, which is important for the growth of sesame (Zuza *et al.*, 2023; Kumar*et al.*,2022). Thus, soil pH is a crucial indicator of soil quality when evaluating soil quality(Andrews *et al*., 2004; Gong *et al.*,2015; Biswas *et al.*,2017; Jiang *et al.*, 2020; Zhou *et al.*,2022;Kumar*et al.*, 2022; Prasad *et al.*, 2023).

High adsorption rate and release into soil during weathering, exchangeable calcium isthemostprevalentcationinsoil(Pitty,2014).Exchangeablemagnesiumisanecessarynutrientfrom the perspective of crop production since it is a significant component in chlorophyll(Ugwa*et al.,* 2022). Consequently, exchangeable calcium and magnesium are regarded as thecrucialindicators ofsoilquality(Sharma*et al.*,2015).

The hydrolysis of urea into carbon dioxide and ammonia by the urease enzyme isessential for the nitrogen cycle (Biswas *et al.,* 2023). Urease activity is positively impacted bythe nitrogen level of the soil (Shalini *et al.*, 2020). So, it is considered as an indicator of soilquality(Gunasekharan and Kaliappan, 2021).

One of the most restricting nutrients for crops is often the available phosphorus that ispresent in the soil (Kumar *et al.,* 2022). Available phosphorus promotes root development,which enhances nutrient intake and supports crop growth and development. Hence, it is takenas a soil quality indicator in assessing soil quality (Yu-Dong *et al.*, 2013; Liu *et al.*, 2015;Mustikaningrum *et al.*, 2015; Sharma *et al.*, 2015; Zhou *et al.*, 2021; Kumar *et al.*, 2022; Shah*etal.*, 2022; Prasad *et al.*, 2023).

Sand content of the soil has great impact on crop growth and yield. It regulates waterand nutrient intake and oxygen. So, it is regarded as an important soil quality indicator(Nabiollahi*et al.*, 2020).

CONCLUSION

In the present study, it is identified that the soil parameters namely, available nitrogen.available phosphorus, sand, pH, exchangeable calcium and magnesium and urease are theminimum dataset indicators affecting the soil quality. Among these, available nitrogen isconcluded as the most limiting factor which influences the soil quality in the three sesameproductivity zones of Northern Telangana Zone. High sesame productivity zone recordedhigher soil quality index and there is significant positive correlation between the sesame yieldand soil quality in sesame productivity zones of Northern Telangana Zone. From this study, itcan be concluded that the combined application of organic manures and fertilizers to berecommended in the sesame growing areas of Northern Telangana Zone to enhance the yieldandsoil quality.

REFERENCES

Andrews, S.S., Karlen, D.L and Cambardella, C.A. 2004. The soil management assessmentframework: a quantitative soil quality evaluation method.Soil Sci Soc Am J. 68(6):1945-1962.

AnkithaSharma,2022.SoilqualityassessmentunderprevalentcroppingsystemsinHamirpurdistrictofHimachalPradesh.(MSc.Thesis).ParmarUniversityofHorticultureandForestry, Solan,HimachalPradesh,India.

Bhagwan, V.P., Theerthala, A., Devi, U., Neelima, T.L and Chary, D.S. 2023. Delineationand evaluation of management zones for site specific nutrient management in maizetractsofNorthernTelanganausinggeostatisticalandfuzzyCmeanclusterapproach. ResSq. https://doi.org/10.21203/rs.3.rs-3039268/v1

Biswas, S., Singh, P., Rahaman, R., Patil, K.V and De, N. 2023. Soil quality and cropproductivity under 34 years old long-term rainfed rice based cropping system in anInceptisolofsub-tropicalIndia.Front. soilsci..3:1155712.

Blake, G. R and Hartge, K. H. 1986. Bulk density. In: Klute, A. (ed.). *Methods of SoilAnalysis, Part 1: Physical and Mineralogical Methods (2nd Edition).* AmericanSocietyofAgronomy. Madison: 363-375

Cao,ZandZhou,J.2008.SoilqualityofChina.SciencePress,Beijing

Chapman,H.D.1965.Cationexchangecapacity.*MethodsofSoilAnalysis:Part2. ChemicalandMicrobiologicalProperties*.9:891-901

Cherubin,M.R.,Karlen,D.L.,Franco,A.L.,Cerri,C.E.,Tormena,C.AandCerri,C.C.2017.Asoil managementassessmentframework(SMAF)evaluationofBraziliansugarcaneexpansion onsoilquality.Soil SciSocAm J.80 (1):215-226.

Doran,J.WandParkin,T.B.1994.*Definingandassessingsoilquality*.*Definingsoilqualityfora sustainableenvironment.* 35:1-21.

Gong,L.,Ran,Q.,He,G.,Tiyip,T.2015.AsoilqualityassessmentunderdifferentlandusetypesinKeriyariverbasin,southernXinjiang,China.Soiltillage res.(9):146:223.

Gunasekaran,YandKaliappan,S.B.2021.Developingsoilqualityindicesfordifferentcroprotations of deltaic Inceptisol regions of India. Commun Soil Sci Plant Anal. 52(12):1363-1376.

Hegalson,B.,Walley,FandGermida,J.2010.No-tillsoilmanagementincreasesmicrobialbiomassand alters communityaggregates. Appl. Soil Ecol. 46: 390-397.

Hue,N.V.1992.CorrectingsoilacidityofahighlyweatheredUltisolswithchickenmanureandsewagesludge. Commun SoilSciPlant Anal. 23:241-264.

Jackson,M.L.1973.SoilChemicalAnalysis.PrenticeHallofIndiaPrivateLimited,NewDelhi.Jiang, M.,Xu,L.,Chen,X.,Zhu,HandFan,H.2020.Soilqualityassessment based ona minimumdataset:a case study of acounty inthe typicalriver deltawetlands.Sustainability.12 (21): 9033.

Kaiser, H.F. 1960. *The application of electronic computers to factor analysis*. EducationalandPsychological Measurement.29: 141–151.

Keen, B. A. and Raczkowski. 1921. The relationship between clay content and certainphysicalproperties of soil.J. Agric. Sci.11: 441-449.

Kumar, U., Mishra, V.N., Kumar, N., Srivastava, L.K., Tedia, K., Bajpai, R.K., Singh, MandMohanty,M.2022.Assessingsoilqualityandtheirindicatorsforlong-termrice-based cropping systems in hot sub-humid eco-region of India. Soil Res. 60 (6):610-623.

Lenka, N.K., Meena, B.P., Lal, R., Khandagle, A., Lenka, S and Shirale, A.O. 2022.Comparingfourindexingapproachestodefinesoilqualityinanintensivelycroppedregionof NorthernIndia.Front.Environ. Sci. 10: 865473.

Li, P., Shi, K., Wang, Y., Kong, D., Liu, T., Jiao, J., Liu, M., Li, H and Hu, F. 2019. Soilquality assessment of Wheat-Maize cropping system with different productivities inChina:Establishingaminimumdataset.Soiltillageres.190:31-40.

Malavath, R.N and Thurpu, S.R. 2019. Soil fertility status of some turmeric growing soilsofNizamabaddistrictofTelanganainrelationtoroot-knotnematodes. J.pharmacogn.phytochem.8(1):926-929.

Mausel, P.W. 1971. Soil quality in Illinois—An example of a soils geography resourceanalysis.Prof. Geogr. 23(2):127-136.

Mustikaningrum,I.A.,Herawati,A.,Purwanto,PandSumani,S.2018.Soilqualityassessment in organic and non-organic paddy fields in Susukan, Indonesia. Bulg. J.Agric.Sci.24 (5): 777-784.

Nabiollahi, K., Heshmat, E., Mosavi, A., Kerry, R., Zeraatpisheh, M and TaghizadehMehrjardi, R. 2020. Assessing the influence of soil quality on rainfed wheat yield.Agriculture.10(10):469

Olsen, S.R., Cole, C.V., Watanabe, F.S and Dean, L.A. 1954. *Estimation of availablephosphorusinsoilsbyextractionwithsodiumbicarbonate.*CircularofUnitedStatesDepartmentofAgriculture. 939.

Paul,J.,Choudhary,A.K.,Suri,V.,Sharma,A.,Kumar,VandShobhna.2014.Bioresourcenutrient recycling and its relationship with biofertility indicators of soil health andnutrient dynamics in rice–wheat cropping system. Commun Soil Sci Plant Anal.45(7):912-924.

Piper, C.S. 1950. *Soil and Plant Analysis.* Inter Science Publisher, INC, New York. 368.Pitty, A.E. 2014. Geographic and Soil Properties, MethananCompany. OxfordUniversity,Publisher. 103-105

Prasad, V., Yadav, M.B.N., Rundan, V., Geetha, G.P., Mounika, V and Vyas, R. 2023.Assessment of soil quality of selected districts of Kaleshwaram project commandareaof TelanganaState,India.Int. J. Environ.13(7):646-659.

Pulakeshi,H.B.P.,Patil,P.L.,Dasog,G.S.,Radder,B.M.,Bidari,B.IandMansur,C.P.2012.Mapping of nutrients status by geographic information system (GIS) in MantaganivillageunderNorthernTransitionZoneofKarnataka.J AgricSci.25(3):332-335.

Qian, F., Yu, Y., Dong, X., Gu, H. 2023. Soil quality evaluation based on a minimum dataset(MDS)-AcasestudyofTielingCountry,NortheastChina.Land.12: 1263.

Rajeswar, M and Aariff Khan, M.A. 2007. Physico - chemical properties and availablemacro and micro nutrients in the soils of Garikapadu research station of KrishnadistrictofAndhraPradesh,India. AnAsian Journal of SoilScience. 2(2):19-22.

Ramulu, C.H and Reddy, P.R.R. 2018. Soil fertility status of regional agricultural researchstation, Warangal (Telangana). Journal of Pharmacognosy and Phytochemistry. 7(6):1852-1856. Ranganatha, A.R.G. 2013. Improved technology for maximizingproductionofsesame.AICRPonsesameandNiger,ICAR,JNKVVCampus, Jabalpur. 1-17.

Ravi,P.,Raj,G.B.,Jayasree,GandKranthi,G.P.2017.GIS-AidedMappingofMacronutrientsintheRiceGrowingSoilsofKarimnagarDistrictinTelanganaState,India.NatureEnvironmentand PollutionTechnology.16 (2):493.

Santhi,R.,Stalin,P.,Arulmozhiselvan,K.,Radhika,K.,Sivagnanam,S.,Sekar,J.,Rao,A.S.2018. Soil fertility appraisal for Villupuram district of Tamil Nadu using GPS andGIStechniques.J.Indian Soc. Soil Sci.. 66(2):158-165

Seevagan, L., Kutralingam, Kaleeswari, Balachandar, Dananjeyan, Damodarasamy andAmirtham.2020.Assessmentofsoilphysico-chemicalqualityindicatorsinricesoilsofCuddaloredistrictofTamilNadu.J.pharmacogn.Phytochem. (4):995-1001

Sharma,K.L.,Sharma,S.C.,Bawa,S.S.,Singh,S.,Chandrika,D.S.,Grace,J.K.,Rao,C.S.,Sankar, G.M.,Ravindrachary,G., MunnalalandKumar, T.S.2015.Effectsofconjunctive nutrient management on soil fertility and overall soil quality index insubmountainousInceptisolsoilsunderrainfedmaize(ZeamaysL.)–wheat(Triticumaestivum)system.CommunSoilSci PlantAnal.46(1):47-61.

Strachel,R.,Wyszkowska,JandBaćmaga,M.2017.Theeffectofnitrogenonthemicrobiologicalandbiochemicalpropertiesofzinc-contaminatedsoil. J.Environ.Eng.Landsc. 25(1):13-22.

Subbiah, B.V and Asija, G.L. 1956. A rapid procedure for the estimation available N in thesoils. Current Science. 25: 259. Tabatabai, M.A and J.M. Bremner. 1972. Assay ofurease activityin soils.Soil Biol. Biochem.4: 479-487.

Tabatabai, M.A and Bremner, J.M. 1969. Use of p-nitrophenyl phosphate for assay of soilphosphataseactivity. Soil Biol. Biochem.1(4):301-307

Tandon, H.L.S. 1989. *Secondary and Micronutrient Recommendation for Soils and Crops.A Guide book.* Fertilizer Development and Consultation Organization, New Delhi.22.

Ugwa,I.,Ekpenkhio,EandOrobator,P.2022.Distributionofexchangeablecationsinsoilsunder different agricultural land uses of similar lithology in Edo state, Nigeria. IfeJournalofAgriculture. 34 (3):93-109.

Urkurkar, J., Alok, T., Shrikant, C and Bajpai, R. 2010. Influence of long-term use ofinorganic and organic manures on soil fertility and sustainable productivity of rice(Oryza sativa) and wheat (Triticum aestivum) in Inceptisols. Indian J. Agric. Sci.80(3):208-212.

Vasu, D., Singh, S.K., Ray, S.K., Duraisami, V.P., Tiwary, P., Chandran, P., Nimkar, A.Mand Anantwar, S.G. 2016. Soil quality index (SQI) as a tool to evaluate cropproductivityin semi-aridDeccan plateau,India. Geoderma. 282:70-79.

Verma, R. R., Srivastava, T.K., Singh, P., Manjunath, B.L and Kumar, A. 2021. Spatialmapping of soil properties in Konkan region of India experiencing anthropogeniconslaught.Plos One.16 (2): e0247177.

Verma,R.K.,Yadav,S.S.,Puniya,M.M.,Yadav,L.R.,Yadav,B.LandShivran,A.C.2014.Effect ofphosphorusandsulphurfertilizationongrowthandyieldofsesame(*Sesamum indicum* L.) under loamy sand soils of Rajasthan. Ann. Agric. Sci.35(1).

Vilakar, K., Harish Sharma, K., Ravi, P., Revathi, P and Madhukar, R. 2021. Soil fertilitystatusofsesamegrowingsoilsofNorthernTelanganaZone.ThePharmaInnovationJournal.10 (9): 267-271.

Walkley, A and Black, C.A. 1934. Estimation of organic carbon by chromic acid titrationmethod.Soil Science.37:29-34.

Waswa, B.S., Vlek, P.L., Tamene, L.D., Okoth, P., Mbakaya, D and Zingore, S. 2013.Evaluatingindicatorsoflanddegradationinsmallholderfarmingsystemsofwestern Kenya.Geoderma, 195:192-200.

Williams,C.HandSteinbergs,A.1962.Theevaluationofplant-availablesulphurinsoils.

Yu-Dong,Ch.,Huo-Yan,W.,Jian-Min,Z.,Lu,X.,Bai-Shu,Z.,Yong-Cun,ZandXiaoQin,Ch. 2013. Minimum data set for assessing soil quality in farmland of NortheastChina.Pedosphere. 23 (5):564-576.

Zhen,Z.,Liu,H.,Wang,N.,Guo,L.,Mang,J.,Ding,N.,Wu,GandJiang,G.2014.Effectsof manure compost application on soil microbial community diversity and soilmicroenvironmentsin atemperatecroplandinChina.PlosOne.9(10):3108555.

Zhou, Y, Fan, Y., Lu, G., Zhang, A., Zhao, T and Sun, G. 2022. Assessment of soil qualityfor guided fertilization in 7 barley agro-ecological areas of China. Plos one. 17 (1):e0261638.

Zuza, E.J., Maseyk, K., Bhagwat, S.A., Chemura, A., Brandenburg, R.L., Emmott, A.,Rawes, W., Hancock, W., Mnthambala, F and Araya, Y.N. 2023. Factors affectingsoil quality among smallholder macadamia farms in Malawi. Agric. Food Secur. 12(1):1-14

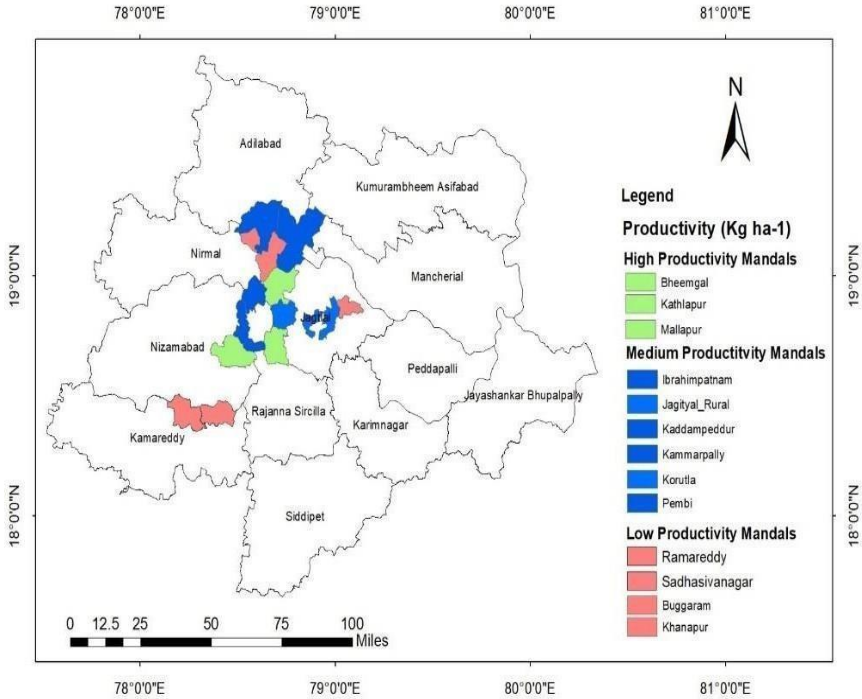

Fig 1. Geographical representation of sesame sampling areas in Northern Telangana Zo

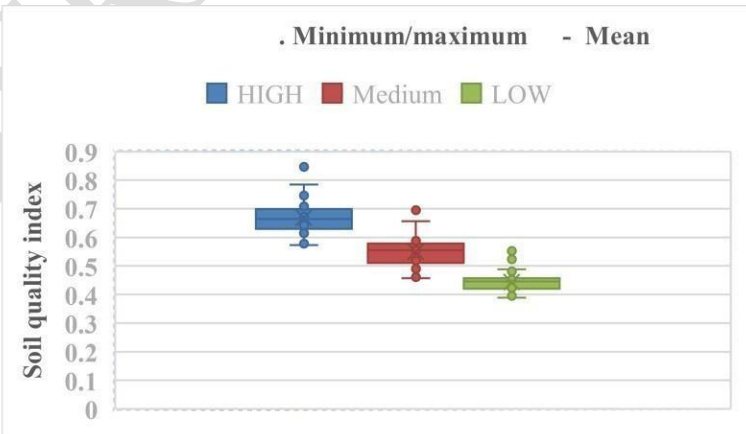

Fig 2. Graph showing the soil quality index of three sesame productivity zones of Northern Telangana Zone, India

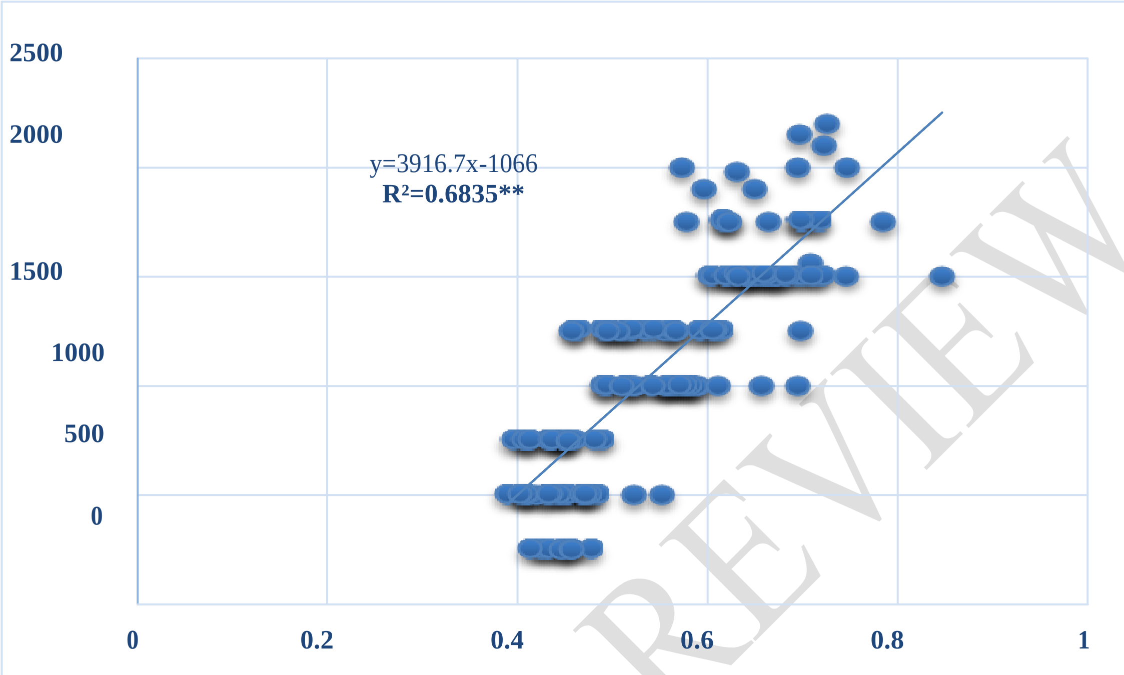

Fig 3. Graph showing the Correlation of soil quality index (SQI) with yield of sesame in Northern Telangana Zone [X axis = SQI; Y axis = yield (kg ha $^{-1}$)]

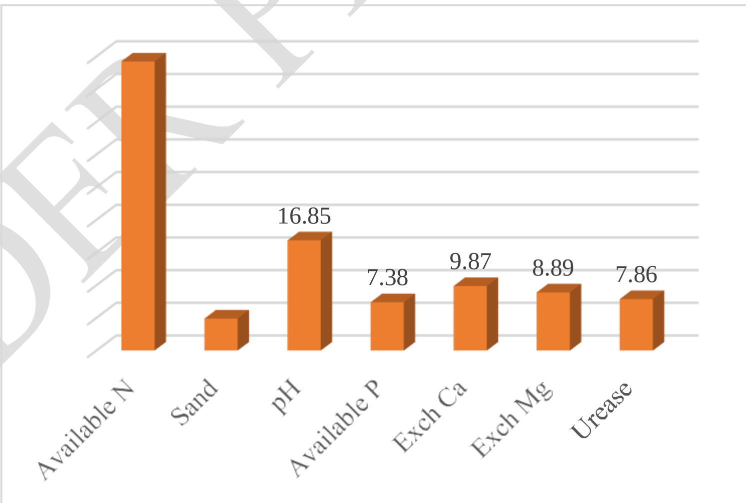

Fig 4. Contribution of each indicator of minimum dataset to soil quality index

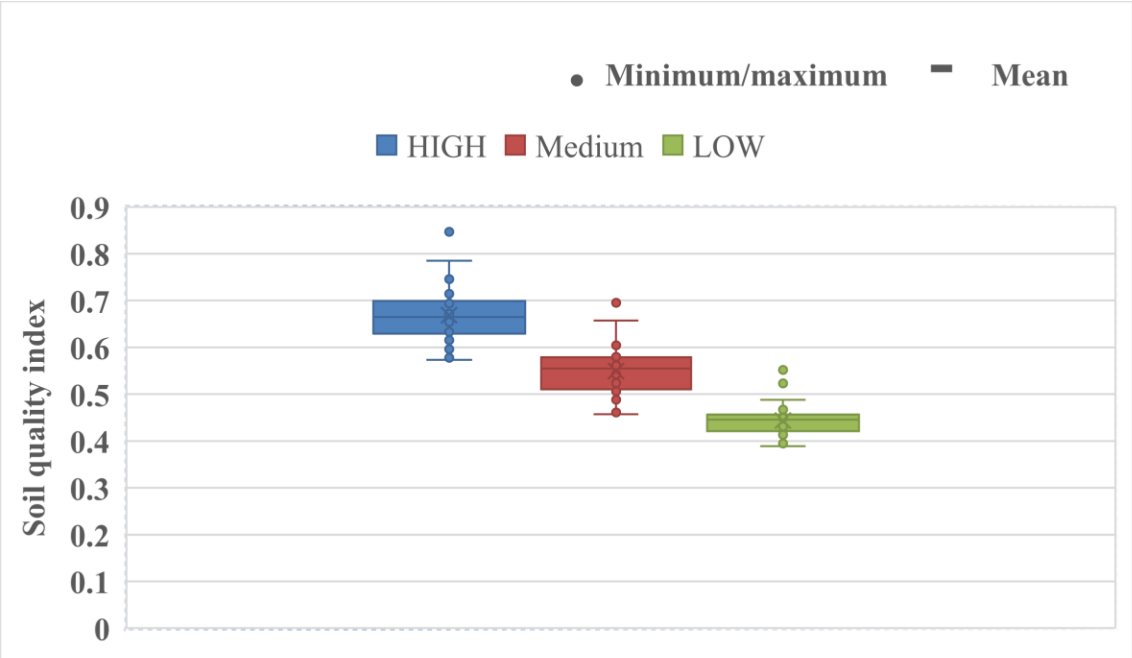

Fig.5. Soilqualityindexofhigh,mediumand low sesameproductivityzonesofNorthernTelanganaZone

Fig.6. PercentcontributionofMDStosoilqualityindex

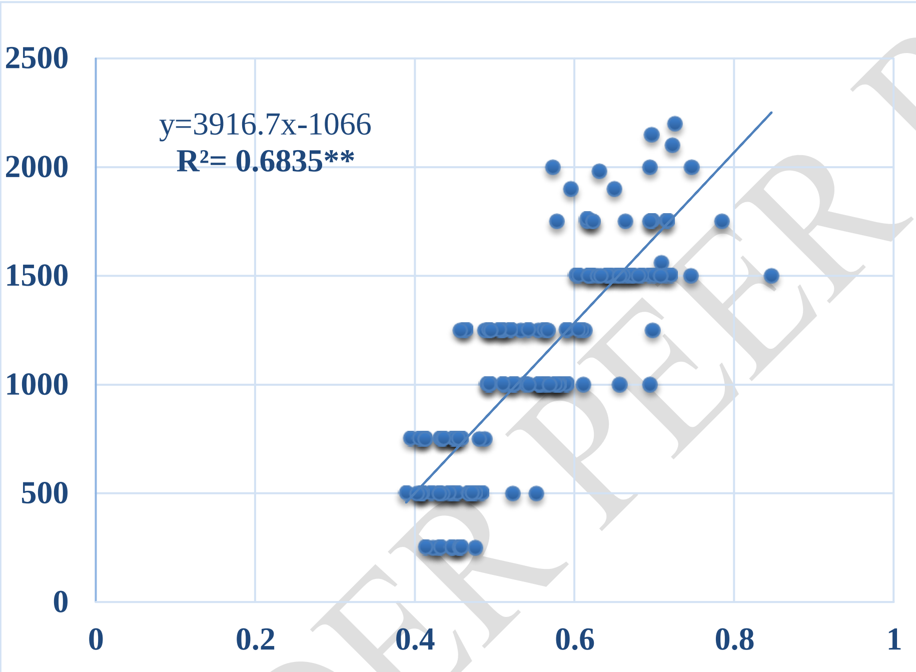

Fig.7 Correlationofsoilqualityindex(SQI)withyieldof sesameinNorthernTelanganaZoneX axis=SQI;Yaxis= yield(kg ha^{-1})

Table 1. Summary statistics of measured soil physical properties of high (HPZ), medium (MPZ) and low (LPZ) sesameproductivityzonesofNorthernTelanganaZone(mean±standarddeviationandrangeofvariation).

Parameters	HPZ			MPZ			LPZ		
	Mean	**Range**	**CV(%)**	**Mean**	**Range**	**CV(%)**	**Mean**	**Range**	**CV(%)**
Sand(%)	52.36±15.33a	10.00-82.00	29.27	55.15±15.3b	14.00-84.00	27.76	62.76±14.78b	28.00-88.00	23.55
Silt(%)	20.10±11.31a	4.00-61.30	56.26	17.06±12.03a	0.50-54.50	72.09	15.00±14.24a	0.20-54.00	9.93
Clay(%)	27.85± 6.16a	8.60-49.00	35.95	27.48±9.88b	3.00-60.50	22.11	22.25± 10.11b	15.80-43.00	45.43
BD	1.32±0.10a	1.10-1.56	7.57	1.41±0.1b	1.20-1.60	7.09	1.43±0.12c	1.20-1.63	8.39
WHC(%)	46.02± 6.35a	30.00-56.80	13.79	41.06± 9.17b	20.80-56.50	22.23	40.16 ±7.02c	19.60-51.70	17.48

Meansforthesamepropertywith differentlettersindicatesignificantdifferenceatp≤0.05.

Table 2. Summary statistics of measured soil physico-chemical properties of high (HPZ), medium (MPZ) and low (LPZ) sesameproductivityzonesofNorthernTelanganaZone(mean±standard deviation andrangeofvariation).

Parameters	HPZ			MPZ			LPZ		
	Mean	**Range**	**CV(%)**	**Mean**	**Range**	**CV(%)**	**Mean**	**Range**	**CV(%)**
pH	7.26 ±0.17a	7.11-7.82	2.34	7.39± 0.56a	6.45-8.51	7.57	7.15 ±0.15b	6.81-7.46	2.09
Electrical conductivity (dSm^{-1})	0.47± 0.13a	0.32-0.46	27.65	0.41 ±0.07b	0.32-0.56	17.07	0.34 ±0.10c	0.12-0.56	29.41
OC(%)	0.71± 0.13a	0.48-1.08	18.30	0.50 ±014b	0.23-0.72	28.00	0.42± 0.11c	0.21-0.64	26.19

Meansforthesamepropertywithdifferentlettersindicatesignificantdifference atp≤0.05.

Table 3. Summary statistics of measured soil chemical properties of high (HPZ), medium (MPZ) and low (LPZ) sesame productivity zonesofNorthern Telangana Zone(mean±standarddeviationandrangeof variation).

Parameters	HPZ			MPZ			LPZ		
	Mean	Range	CV(%)	Mean	Range	CV(%)	Mean	Range	CV(%)
AvailableN (kgha^{-1})	218.59±26.79a	176.20-279.70	12.25	154.19±31.7b	116.50-261.50	20.55	97.19±13.82c	76.40-139.80	14.21
AvailableP (kgha^{-1})	41.50 ±15.53a	13.41-82.33	37.42	39.38±15.66a	11.81-64.71	39.76	26.88±5.48b	19.98-49.06	20.38
AvailableK (kgha^{-1})	411.86±83.85a	213.00-562.00	20.35	332.53±100.84b	126.25-585.00	30.32	300.5±88.79b	182.50-562.50	29.54
Available S (mgkg^{-1})	20.17±2.98a	15.33-24.84	14.77	12.85 ±1.21b	10.34-14.31	9.41	6.37± 1.92c	2.35-9.53	30.14
ExchangeableCa (c.mol(p+)kg^{-1})	23.78 ±2.68a	18.30-28.40	11.26	22.55± 2.53a	16.00-28.00	11.21	21.38± 4.39b	11.00-32.50	20.53
ExchangeableMg (c.mol(p+)kg^{-1})	12.71 ±3.45a	5.90-19.00	27.14	12.50 ±3.3a	3.80-18.00	26.40	11.21± 2.36b	7.50-17.10	21.05
ExchangeableK (c.mol(p+)kg^{-1})	0.47 ±0.14a	0.23-0.92	29.78	0.43 ±0.09a	0.21-0.57	20.93	0.35± 0.11b	0.20-0.65	31.42
ExchangeableNa (c.mol(p+)kg^{-1})	1.27± 0.10a	1.10-1.52	7.87	1.33± 0.34a	0.59-1.90	25.56	1.24 ±0.19a	0.56-1.65	15.32
Available Fe(mg kg^{-1})	18.12± 4.35a	10.36-26.40	24.00	12.62± 1.64b	10.22-16.20	12.99	5.19 ±1.46c	1.35-8.62	28.13
Available Cu(mg kg^{-1})	2.57 ±0.96a	1.22-4.01	37.35	1.96 ±0.61b	1.02-3.05	32.10	0.87± 0.52c	0.12-1.98	59.77
Available Mn(mg kg^{-1})	17.33± 1.64a	12.30-19.90	9.46	12.84± 1.41b	10.50-15.00	10.98	6.49 ±1.80c	1.32-9.65	27.73

AvailableZn (mg kg^{-1})	1.29 ±0.38a	0.34-1.95	29.45	1.07± 0.36b	0.11-1.63	33.64	1.02± 0.52b	0.12-1.81	51.96

Meansforthesamepropertywithdifferentlettersindicatesignificantdifference atp≤0.05.

Table 4. Summary statistics of measured soil biological properties of high (HPZ), medium (MPZ) and low(LPZ) sesame productivityzonesofNorthern Telangana Zone(mean±standarddeviationandrangeof variation).

Parameters	**HPZ**			**MPZ**			**LPZ**		
	Mean	**Range**	**CV(%)**	**Mean**	**Range**	**CV(%)**	**Mean**	**Range**	**CV(%)**
Urease (μgNH4^{+}-N g^{-1}soilh^{-1})	1.31± 0.14a	1.02-1.68	10.68	1.24± 0.20b	1.02-1.87	16.12	1.19± 0.07b	1.03-1.32	5.88
AcidP (μg PNP g^{-1}soil h^{-1}	99.34±25.09a	59.30-172.00	25.25	48.42±20.33b	21.00-102.00	41.98	22.12±9.31c	10.00-46.00	42.08
Alkaline P(μg PNP g^{-1}soil h^{-1})	39.80±8.97a	22.00-58.00	22.53	19.82 ±6.3 b	11.00-36.00	32.13	13.16±4.88c	6.00-28.00	37.08
Labile C(Mgha^{-1})	2.56 ±0.62a	1.07-3.88	24.21	2.01 ±0.50b	1.14-2.65	24.87	1.39± 0.49c	0.38-3.11	35.25

Meansforthesamepropertywithdifferentlettersindicatesignificantdifferenceatp≤0.05.