Colloquia Series
Available online at www.publishingrealtime.com
Publishing Real Time
Colloquia SSSN 44 (2020)
Proceedings of the 44th Conference of Soil Science Society of Nigeria on Climate-smart soil management, soil health/quality and land management: synergies for sustainable ecosystem services

# Comparison of various methods for land suitability evaluation for onion and tomato production at Bayero University Orchard Kano State, Nigeria

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## Abstract

A study was carried out at Bayero University Orchard to evaluate the soils for Onion and Tomato production based on different suitability methods. The area was delineated into four soil units, and one profile was sunk in each of them. The profiles were described according to the FAO soil survey manual, and the samples were collected for each diagnostic horizon. The soils were analyzed according to standard laboratory procedures. The suitability evaluation methods employed were non-parametric (simple limitation) and parametric (Storie index and Square roots). The result revealed the soil was predominantly sand and classified as loamy sand to sandy loam with slightly acidic pH. The soil had low organic carbon, total nitrogen, cation exchange capacity, and low to moderate phosphorus. The result showed that all the soil units were not suitable for onion production based on a simple limitation method; even improvement has been made on the site. Based on parametric methods, only Rabia classified the soils as currently moderately (S2) to marginally suitable (S3), while not suitability (N) under Storie and Khidir square root method for onion cultivation. Potentially, soil units 2 and 4 are marginally suitable for onion production when the fertility of the soil has been improved (Storie and Khidir), and moderately suitable (S2) under Rabia square root method. For tomato production, all the soils were also currently not suitable (N). Thus soil unit 2 and 4 were moderately suitable (non-parametric method). Furthermore, soil unit 2 and 4 would be rise to moderately suitable (S2) for tomato production, after improvement have been made on fertility indicators (Storie and Khidir square root methods), and highly suitable (S1) based on Rabia method (current and potential). The fertility status was generally low, and the major limiting factors that may hinder proper growth and development of vegetable crops are drainage, soil texture and fertility (mostly nitrogen, phosphorus, and organic carbon), with good soil management and enhanced drainage, the soils could be used optimally for vegetable production.

**Keywords**: Land evaluation, suitability, maximum limitation, storie index and square root.

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https://doi.org/10.36265/colsssn.2020.4443

Peer-review under responsibility of 44th SSSN Conference LoC2020.

## 1.0. Introduction

Land evaluation is a process of assessing the land based on its inherent qualities to support different land uses, with emphases to climatic and environmental conditions. According to FAO (2007), land evaluation is an identification of a parcel of land for various land uses (cropping, grazing, and irrigation) which are physically acceptable, environmentally friend and financially profitable. rom each geneLand suitability is the ability of a portion of land to tolerate the production of the crop suitably. The analysis allows identified the main limiting factor of particular crop production and vegetable decision-makers to develop a crop management system for increasing land productivity. The food and agricultural organization states that land suitability is a function of crop requirement and land characteristics, and it is a measure of how well the qualities of land limit matches the requirement of the particular form of land use. Other definition, describes the land suitability evaluation as a process, which predicts the land efficiency and application for certain types of uses over time.

Decisions on land use planning are based on a comprehensive analysis of the production and potentials of national resources such as hydrology, soil and climate. Land evaluation is critical in this decision as it provides information on the potentials and constraints applied for a defined land use types in terms of crop performance as affected by many factors such as Climate physical environment, topography, drainage etc. Soil suitability classification quantified in broad terms to what extent soil conditions match crop requirements under a defined input and management (FAO, 1976), and Ande (2011) reported that soil suitability classification is mostly based on knowledge of crop requirements, prevailing conditions of land and applied soil management methods. Assessing the ability of land will enhance optimum performance and maximum productivity of the soil with higher crop yield. In the process of land evaluation, the specific crop requirements will be calibrated with the terrain and soil parameters (Dent and Young, 1981) so that the identified limiting factor could be managed to suit crop requirements and improve productivity. Land evaluation thus enhances management guidelines to promote more sustainable use of soil and environmental resources (Maniyunda *et al.*, 2007).

Availability of fertile land and crop productivity are the most important factors among parameters determining the supply of food and feed stocks for bioenergy and industrial uses Spiertz (2012). Meeting the demands for food and bioenergy sustainably, we should develop highly productive cropping systems, but also robust concerning abiotic and biotic stresses. Short rotations are, in general, less robust, due to yield declines caused by biotic factors such as plant pathogens, harmful rhizosphere micro-organisms, mycorrhizas, *etc.* Bennett *et al.* (2012), and shortage of available lands to rotate. Though, the advantages of a wider rotation, and even combining food and bioenergy crops, were shown for cropping systems in the European Union as reported by Lizarazu and Monti. (2011). The effects on final yields are mostly more severe when abiotic and biotic factors interact and are not favourable with crops in question. Several studies have been carried out to analyze the availability of marginal or degraded land that might be available for growing green feedstock (Ximing *et al.* 2011).

Vegetable crops are needed continuously in all the household of African countries, especially Nigeria, and provide many nutritional benefits to humankind. Starchy staple foods dominate the daily diet of most households, vegetables are the cheapest and most readily available sources of essential proteins, vitamins minerals, and essential amino acids (Onwordi *et al*., 2009). The production and nutritional values of these vegetables are limited due to the low fertility of native soils in most parts of Nigeria (Law-Ogbomo et al., 2012). Tomato (*Solanum Lycopersicum* L. Moench) is an edible vegetable, often red fruit of the nightshade family known as Solanaceae (Spooner *et al.*, 2005). Tomato is among the essential vegetables in most regions of the world, ranking second in importance to potatoes, it can be cooked or eaten raw and can also be used to produce soup, ketchup paste and majorly used in canning industries (Ayoola and Adebayo, 2017). One major problem militating against tomato production in Africa is low soil fertility (Mbah, 2006), unpredictable climate especially rainfall and temperature. Onion is also one of the spicy food crop grown in Nigeria, and most eaten raw or processed different forms depending on the user's interest.

There were limited land suitability studies specifically for vegetable crops production in many parts of Nigeria, especially Bayero University Orchard in Kano State. The crops were mostly grown in such an environment using an irrigation system, and the yield obtained was not up to optimum level. There are many approaches used to land suitability evaluation for various crops, and each has different data requirements and various qualities of estimates. However, there are no fixed laws that specify when and any methods are adequate or when there is the need to continue to a more complex analysis level (Burrough, 1996), and the choice of most robust method was still a problem. Therefore, there is need to carry out research to identify significant factors that limit the performance of the crop in Bayero university Orchard using various land suitability evaluation methods. Hence this research was aimed to evaluate the suitability of soils for Onion and Tomato production in the study area using different methods and to compare the methods and choose best among them.

## 2.0. Materials and Methods

### *2.1. Background of the Study Area*

This study was carried out at the Bayero University, Kano Orchard, and falls within the Sudan savanna agro-ecological zone, with the total area of 7.4 hectares, and lies between latitude 11.97932$^{o}$ to 11.98194$^{o}$N, and longitude 8.41245$^{o}$ to 8.42205$^{o}$E, altitude varied from 437 to 449 m above the sea level. The soil texture of the BUK Orchard range from loam to Sandy loan in texture and classified as Typic Kandiustalfs and Typic Kanhaplustalfs at subgroup level (Abdulrahman *et al*., 2016). The climate of the study areas is the tropical wet and dry type symbolized as AW by Koppen (Adamu and Aliyu, 2012). Temperature is a very critical element in these areas, and it is averagely

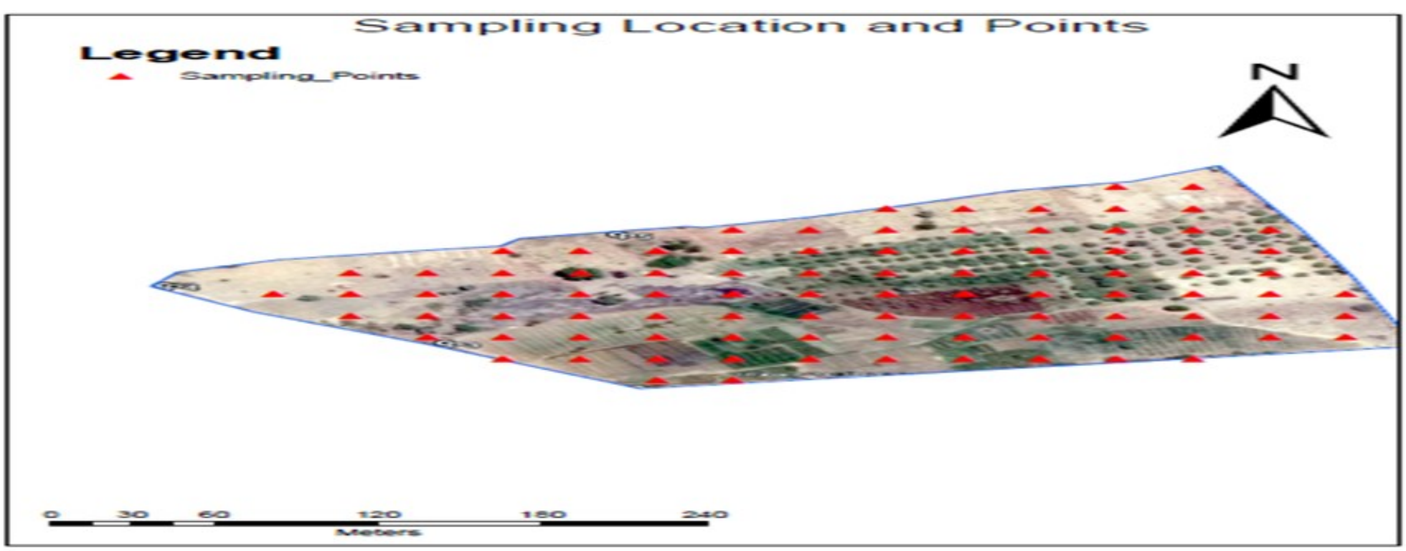


Figure 1: Sampling Location and Points

warm to hot throughout the year at about 25± 7$^{o}$C (Olofin, 1978). The vegetation of the farm is Sudan Savannah type, composed of short grasses with varieties of scattered trees. Most of the trees are adapted to drought condition through the long taproot system and shading of the leaves during the dry period (Olofin, 1978).

*2.2. Field Study*

The Study area (7.4ha) was delineated with the aid of Google earth and imported into SMS Ag Software (Figure 1). The grid of 27 by 27m was created and superimposed on the site, and the coordinates of the central point of each grid were extracted and imported into GPS for locating the sampling points. The soil units were delineated using auger observations at each grid. One profile pit was sunk in each of the soil unit, described according to USDA soil survey manual (Soil Survey Staff, 1993)., and bulk soil samples were collected from each genetic horizon, adequately packed and labelled for analysis.

*2.3. Laboratory analysis*

Soil samples were air-dried, crushed gently with porcelain pestle and mortar and sieved through 2mm sieve mesh for physical and chemical analysis using systematic techniques. Particle size distribution was determined using Bouycous (1962) Hydrometer method, soil pH was measured in a solution using 1:2.5 soil to water ratio, and Electrical Conductivity (EC) was measured in distilled water with a ratio of 1:2.5 with dry soil in digital EC meter. Organic carbon of the soil was determined using Walkey and Black (1934) wet oxidation method as described by Nelson and Summer (1982), while Nitrogen content was determined using the Macro-Kjeldahl technique as described by Bremmer (1996). Available phosphorus was extracted using the Bray 1 method (Bray and Kurtz, 1945) and Exchangeable Ca, Mg, K and Na were extracted with 1M ammonium acetate solution buffered at pH 7.0 as described by Anderson and Ingram (1998), Ca and Mg were read on an atomic absorption spectrophotometer (AAS), while K and Na were determined on a flame photometer.

$$ESP(\%) = \frac{\text{Exchangeable sodium}}{CEC\ (NH_4OAc)} \times 100$$

Cation exchange capacity (CEC) of the soil was determined with 1M ammonium acetate (NH4OAc), buffered at pH 7.0 (Chapman, 1965; Rhodes, 1982). Exchangeable sodium percentage was calculated using the following relationship;

*2.4. Land Evaluation*

The suitability evaluation of the land was done using the conventional Non-parametric (simple limitation) and parametric (Storie index and Square Roots) methods as described by FAO, (1976), Storie (1976), Khiddir (1986) as well as Rabia and Terribile, (2013). All the methods were based on FAO (2007) framework and Sys *et al.* (1991). The classification involved five classes namely S1, S2, S3 and N for both parametric and non-parametric approaches, and percentages numerical values were assigned to parametric alone ranging from 100 most suitable to 0 not suitable. Most of the method employed the Leibig's law of minimum as overall class was determined based on most limiting factors for all the approaches (equation 1 and 2), except Rabia and Terribile method which used most maximum value (equation 3). The formulae used for the parametric study were presented below;

$$I = A \times \frac{B}{100} \times \frac{C}{100} \times \frac{D}{100} \times \cdots \times \frac{Ni}{100} \quad \text{- - - - - (1)}$$

$$I = R_{min} \times \sqrt{\frac{A}{100} \times \frac{B}{100} \times \cdots \times \frac{Ni}{100}} \quad \text{- - - (2)}$$

$$I = W_{max} \times \sqrt{\frac{A}{100} \times \frac{B}{100} \times \frac{C}{100} \times \cdots \times \frac{Nt}{100}} \quad \text{- - - - - (3)}$$

Where *I* is suitability index, *Rmin* and *Wmax* were the minimum, and maximum rating criteria *A B*, *C*, *D* are the rating values for parameters, other than minimum and maximum.

*2.5. Final Suitability Classes*

The matching of land qualities with the crop requirements (table 1 and 2) was lead to various suitability classes The

**Table 1; Land suitability criteria (crop requirement) for toma-**

| Land Quality | | Unit | S1 | S2 | S3 | N |
|---|---|---|---|---|---|---|
| | | | Suitability rating | | | |
| Climatic (c) | Mean temperature | $^{0}$C | 25-28 | 29-32, 20-24 | 33-36, 15-19 | <15, >36 |
| | Total rainfall | mm | 600-750 | 500-600, 750-1000 | 450-500, >1000 | <450, >1000 |
| Topography (t) | Slope | % | 1-3 | 3-5 | 5-10 | >10 |
| Wetness (w) | Soil drainage | Class | Well-drained | Moderate | Imperfect | Poor |
| Soil physical Properties (s) | Texture | Class | Sl, l, cl, scl | Sicl, sic, sc, c | c | Ls, s |
| | Soil depth | Cm | >75 | 50-75 | 25-50 | <25 |
| Fertility | pH | 1:2.5 | 6.0-7.0 | 5.0-5.9, 7.1-8.5 | <5, >8.5 | |
| | OC | % | >1 | 0.8-1 | 0.4-0.5 | <0.4 |
| | N | % | >2 | 1.5-2 | 1.0-1.4 | <1 |
| | P | % | >20 | 15-20 | 10-15 | <10 |
| | K | % | >0.3 | 0.2-3 | 0.15-0.2 | <0.15 |
| Soil toxicity (n) | Salinity (EC) | dsm$^{-1}$ | <4 | 4-8 | 8-16 | >16 |
| | Sodicity (ESP) | % | <15 | 15-20 | 19-25 | >25 |

S1 = Highly suitable (100-75%), S2 = Moderately suitable (75-50%), S3 = Marginally suitable (49-25%), N = Not suitable (24-0%).
Source: Modified from NBSS&LUP, 1994

Table 2; Land Suitability Criteria (Crop Requirement) for Onion

| Land quality/soil site characteristics | | Rate | 100-75 | 75-50 | 50-25 | <25 |
|---|---|---|---|---|---|---|
| | | Class | S1 | S2 | S3 | N1 |
| Climate (c) | Mean | | 14-19 | 20-25 | 26-30 | >30 |
| | Temperature in the growing season | $^0$C | | 20-24 | 15-19 | >36 |
| | Total rainfall | mm | 500-600 | 450-500<br>600-700 | 700-800 | >450<br>>800 |
| Topography (t) | Slope | % | 1-3 | 3-5 | 5-10 | >10 |
| Wetness (w) | Soil drainage | class | Well-drained | Moderate | Imperfect | Poor |
| Soil physical | Texture | Class | Sl, l, cl | Sicl, sic, sc, c | c | Ls, s |
| | Soil depth | Cm | >75 | 50-75 | 25-50 | <25 |
| Properties (s) | | | | | | |
| Fertility (f) | pH | 1:2.5 | 5.8-6.5 | 5.4-5.7,<br>6.6-7.5 | 5-5.4,<br>7.5-8.0 | <5,>8 |
| | Organic carbon | % | >1.5 | 1.5-1 | 0.5-1 | <0.5 |
| | Nitrogen | % | >2 | 1.5-2 | 1.0-1.4 | <1 |
| | CEC | cmol(+)kg$^{-1}$ | >15 | 10-15 | 10-5 | <5 |
| Soil toxicity (n) | Salinity (EC) | dsm$^{-1}$ | <4 | 4-8 | 8-16 | >16 |
| | Sodicity (ESP) | % | <15 | 15-20 | 19-25 | >25 |

S1 = Highly suitable (100-75%), s2 = Moderately suitable (74-50%), s3 = Marginally suitable (49-25), N = Not suitable (24-0%). Source; M0dified from NBSS&LUP, 1994

aggregate suitability classes were divided into two; currently suitable and potentially suitable. Currently suitable class include all the parameter that control tomato and onion production, while potential class exclude all liable to change variable such as organic carbon, total nitrogen, available phosphorus in the computation.

### 3.0. Results and Discussions

The land characteristics of onion and tomato production site were presented in tables 3. The Temperature varied from 25-30$^o$C with the total rain of 800mm per annum. The soil texture of all the soil units was a sandy loan, except unit 1 that had loamy sand. The drainage conditions were well-drained (unit 1 and 4), moderately drained (unit 2) and poorly drained (unit 3). The depth of the soil varied from 150 to 188cm. The topography was 1-2% for unit 2 and 3, and 3-4% for unit 1 and 4 respectively. The dominant values of the sand contents in the soil may be partly attributed to parent material rich in quartz mineral, an essential component in granite, and partly to geological processes involving sorting of soil materials by biological activities, clay migration through eluviation and illuviation, or surface erosion by runoff or their combinations (Akinbola *et al.*; 2009).

The chemical properties of the soil showed that the soil pH in water was slightly acidic with values ranged from 6.39 to 6.42 in all the soil units. The pH value was within the acceptable range preferred for most crops. Brady and Weil (2010) established that pH range of 5.5-7.0 as optimal for overall satisfactory availability of plant nutrients. Organic carbon, total nitrogen, and exchangeable potassium were generally low in all the soils, with also available phosphorus that was rated low in all the soil units <10mgkg$^{-1}$ except soil unit 2 with moderate value (11.50mgkg$^{-1}$). Cation exchange capacity (CEC) was low (<6 cmolkg$^{-1}$) in most of the soil units with moderate values of 6.05 cmolkg$^{-1}$) in soil unit 1. The low values of CEC in the surface soils

Table 3: Land Characteristics of Site of Study

| Soil parameter | Class unit | | | |
|---|---|---|---|---|
| | Unit 1 | Unit 2 | Unit 3 | Unit 4 |
| Temperature $^0$C | 25-30 | 25-30 | 25-30 | 25-30 |
| Rainfall mm/annum | 800 | 800 | 800 | 800 |
| Topography (t) | | | | |
| Slope | 3-4 | 1-2 | 1-2 | 3-4 |
| Drainage (w) | WD | M | P | WD |
| Texture | loamy sand | Sandy loam | Sandy loam | Sandy loam |
| Depth (cm) | >175 | 187 | 150 | 188 |
| pHw | 6.42 | 6.39 | 6.39 | 6.39 |
| Organic carbon (%) | 0.45 | 0.47 | 0.46 | 0.47 |
| Nitrogen (%) | 0.85 | 0.75 | 0.73 | 0.74 |
| Phosphorus (%) | 11.5 | 9.03 | 9.46 | 9.19 |
| Potassium (%) | 0.22 | 0.21 | 0.21 | 0.22 |
| CEC | 6.05 | 5.33 | 3.5 | 4.8 |
| Salinity (EC) ds/m | 0.12 | 0.12 | 0.11 | 0.11 |
| Sodicity(ESP) % | 0.48 | 1.74 | 0.71 | 1.09 |

Note; OC = organic carbon, EA = exchangeable acidity, EC = exchangeable cation, ESP = exchangeable sodium percentage, AV. P = available phosphorus, PHw = pH in water were mostly attributed to low organic carbon and clay minerals in the soils. The result was in agreements with findings of Egbuchua *et al.* (2011), Yakubu *et al.* (2011) and Abdulrahman *et al*. (2016).

### *3.1. Suitability Classification*

The factors rating of land use requirement for onion (Table 1) and tomato (Table 2) were matched with the current land qualities of the studied soils (table 3). Depending on the extent of matches, current and potential suitability classes were obtained from each of the soil unit considering the impact of the property to change over the period. Therefore, each of the approaches to the suitability evaluation generated different classes.

### *3.2. Simple Limitation Method*

The suitability assessment for both tomato and onion were presented in table 4 and 5. It was observed that all the soil was currently not suitable (N) for tomato production with varying limitations across the soil units. The major limiting factor in the area was fertility which affected all the soil units. Organic carbon, total nitrogen and phosphorus are the most deficient nutrients that might limit the crop production. Potential suitability classes were raised to moderately suitable (S2) in soil unit 2 (S2cw) and unit 4 (S2ct) and remained N for the other units (unit 1 and 2). For onion production, the current suitability class of all the soil units was not suitable (N) with varying limitation in terms of climate, topography, texture and fertility. Though after improvement had been made to fertility, soil unit 2

Table 4; Suitability Class Scores of the Study Area for Tomato Production using Simple Limitation

| **Soil parameter** | **Soil Units** | | | |
|---|---|---|---|---|
| | **Unit 1** | **Unit 2** | **Unit 3** | **Unit 4** |
| Climate (c) | | | | |
| Rainfall (mm) | S2 | S2 | S2 | S2 |
| Temperature ($^0$C) | S2 | S2 | S2 | S2 |
| Topography (t) | | | | |
| Slope (%) | S2 | S1 | S1 | S2 |
| Drainage (w) | S1 | S2 | N | S1 |
| Soil phy. Property (s) | | | | |
| Soil depth (cm) | S1 | S1 | S1 | S1 |
| Soil texture | N | S1 | S1 | S1 |
| Soil chem. Property (f) | | | | |
| pH ($H_2O$) | S1 | S1 | S1 | S1 |
| OC (g/kg) | N | N | N | N |
| % Nit (g/kg) | N | N | N | N |
| %phos (g/kg) | S3 | N | N | N |
| %pota (g/kg) | S2 | S2 | S2 | S2 |
| Salinity/sodicity (n) | | | | |
| Salinity EC (ds/m) | S1 | S1 | S1 | S1 |
| Sodicity ESP (%) | S1 | S1 | S1 | S1 |
| Current suitability class | Nctsf | Ncwf | Ncwf | Nctf |
| Potential suitability class | Ncts | S2cw | Ncw | S2ct |

Table5; Suitability Class Scores of the Study Area for Onion Production by Means of Simple Limitation

| **Soil parameter** | **Class unit** | | | |
|---|---|---|---|---|
| | **Unit 1** | **Unit 2** | **Unit 3** | **Unit 4** |
| Climate (c) | | | | |
| Rainfall (mm) | S3 | S3 | S3 | S3 |
| Temperature ($^0$C) | S3 | S3 | S3 | S3 |
| Topography (t) | | | | |
| Slope (%) | S2 | S1 | S1 | S2 |
| Drainage (w) | S1 | S2 | N | S1 |
| Soil phy. Property (s) | | | | |
| Soil depth (cm) | S1 | S1 | S3 | S1 |
| Soil texture | N | S1 | S1 | S1 |
| Soil chem. Property (f) | | | | |
| pH ($H_2O$) | S2 | S1 | S2 | S2 |
| OC (g/kg) | N | N | N | N |
| Total Nit (g/kg) | N | N | N | N |
| Salinity/sodicity (n) | | | | |
| Salinity EC (ds/m) | S1 | S1 | S1 | S1 |
| Sodicity ESP (%) | S1 | S1 | S1 | S1 |
| Current Suitability Class | Nctsf | Ncwf | Ncwsf | Nctf |
| Potential Suitability Class | Ncts | S3cw | Ncws | S3ct |

and 3 might raise to marginally suitable (S3cw and S3ct), and the rest remained unchanged in terms of suitability classes. Generally, the potentials of these soils could be improved since most of the crops were supplemented by irrigation during both rainy and dry seasons.

*3.3. Parametric Suitability Classification*

The parametric evaluation for both tomato and onion was presented in table 6 and 7. The evaluation involved rating with numerical scores and index of suitability class was obtained based multiplicative processes of various parameters. For tomato production, all the soil units were currently not suitable (N) based on Storie, and Square root Khddir approaches with various limitation, and highly suitable (S1) under Rabia method with the index values of 86.6% (Table 6). For potential suitability classification, the indices of Storie and Rabia were increased (14.1 - 21.7%) in soil unit 1 and 3, but still within non-suitable classes. There was an improvement in the evaluation based on the two methods in soil unit 2 and 3 from not suitable to moderately suitable (S2) with some minor limitations. All the soil units were still highly suitable based on the Rabia method, as there was no improvement between current and potential classes due to the absence of limitations within the soil units.

Table 6: Land Suitability Assessment for Tomato Production Based on Parametric Method

| **Soil parameter** | **Class Unit**<br>**Unit 1** | **Unit 2** | **Unit 3** | **Unit 4** |
|---|---|---|---|---|
| Climate (c) | | | | |
| Rainfall (mm) | S2 (75) | S2 (75) | S2 (75) | S2 (75) |
| Temperature ($^0$C) | S2 (75) | S2 (75) | S2 (75) | S2 (75) |
| Topography (t) | | | | |
| Slope (%) | S2 (75) | S1 (100) | S1 (100) | S2 (75) |
| Drainage (w) | S1 (100) | S2 (75) | N (25) | S1 (100) |
| Soil phy. Property (s) | | | | |
| Soil depth (cm) | S1 (100) | S1 (100) | S1 (100) | S1 (100) |
| Soil texture | N (25) | S1 (100) | S1 (100) | S1 (100) |
| Soil chem. Property (f) | | | | |
| pH ($H_2O$) | S1 (100) | S1 (100) | S1 (100) | S1 (100) |
| OC (g/kg) | N (25) | N (25) | N (25) | N (25) |
| % Nit (g/kg) | N (25) | N (25) | N (25) | N (25) |
| %phos (g/kg) | S3 (50) | N (25) | N (25) | N (25) |
| %pota (g/kg) | S2 (75) | S2 (75) | S2 (75) | S2 (75) |
| Salinity/sodicity (n) | | | | |
| Salinity EC (ds/m) | S1 (100) | S1 (100) | S1 (100) | S1 (100) |
| Sodicity ESP (%) | S1 (100) | S1 (100) | S1 (100) | S1 (100) |
| Current Suitability | | | | |
| Storie | N (3.5) | N (14.1) | N(4.7) | N (14.1) |
| Khiddir | N (9.4) | N (18.8) | N (10.8) | N (18.8) |
| Rabia | S1 (86.6) | S1 (86.6) | S1 (86.6) | S1 (86.6) |
| Potential Suitability | | | | |
| Storie | N(14.1) | S2 (56.3) | N(14.1) | S2 (56.3) |
| Khiddir | N (18.8) | S2 (66) | N (21.7) | S2 (66) |
| Rabia | S1 (86.6) | S1 (86.6) | S1 (86.6) | S1 (86.6) |

The evaluation of soil for onion production showed almost similar results as all the soils based current situation as not suitable according to Storie and Khiddir, with slight differences with that of tomato in Rabia as soil init 1 and 2 were marginally suitable (S3). At the same time, unit 3 and 4 were moderately suitable (S2) as presented in table 7. The potential suitability classes showed that soil unit 1 and 3 were not suitable for onion production as obtained in Storie and Khiddir method, with moderately suitable obtained in Rabia method with minor limitations.

All four methods of land suitability evaluations were compared in table 8. The result showed that there was a strong agreement between simple limitation, Storie Index and Square root Khiddir method, as in most case moved toward the same direction in all the soil units considering the current and potential suitability classes for tomato production. The Rabia method Exaggerate the suitability classes in the two crops, especially for tomato production as classified the soil as highly suitable.

Conversely, simple limitation performed poorly in the evaluation of land for onion production, as it classified all the soils as not suitable currently and potentially. The method that performed best was Rabia as it considered all the soil units as moderately to marginally suitable as Storie and Khiddir considered only soil unit 2 and 4 as potentially marginally suitable, and all were currently not suitable for onion production.

## 4. 0. Conclusion

The study area was predominantly sandy. The soil pH was slightly acidic with low fertility status and not saline. Soil unit 1 and 3 were currently and potentially not suitable for tomato production based on all the approaches, except Rabia method that described it as highly suitable (S1). The soils of unit 2 and 3 were currently not suitable (N) for tomato cultivation, and moderately soil table when liable to change variable were excluded in the computation. For onion production, both current and potential classes were all rated not suitable in all the soil units according to simple limitation, storie and Khiddir, except unit 2 and 4 for storie and Khiddir which rated marginally suitable (S3).

Table 7: Land Suitability Assessment for Onion Production Based on Parametric Method

| Soil parameter | Class unit | | | |
|---|---|---|---|---|
| | Unit 1 | Unit 2 | Unit 3 | Unit 4 |
| Climate (c) | | | | |
| Rainfall (mm) | S3 (50) | S3 (50) | S3 (50) | S3 (50) |
| Temperature ($^0$C) | S3 (50) | S3 (50) | S3 (50) | S3 (50) |
| Topography (t) | | | | |
| Slope (%) | S2 (75) | S1(100) | S1(100) | S2 (75) |
| Drainage (w) | S1(100) | S2 (75) | N (25) | S1(100) |
| Soil phy. Property (s) | | | | |
| Soil depth (cm) | S1(100) | S1(100) | S3 (50) | S1(100) |
| Soil texture | N (25) | S1(100) | S1(100) | S1(100) |
| Soil chem. Property (f) | | | | |
| pH ($H_2O$) | S1 (100) | S1 (100) | S1 (100) | S1 (100) |
| OC (g/kg) | N (25) | N (25) | N (25) | N (25) |
| Total Nit (g/kg) | N (25) | N (25) | N (25) | N (25) |
| Salinity/sodicity (n) | | | | |
| Salinity EC (ds/m) | S1(100) | S1(100) | S1(100) | S1(100) |
| Sodicity ESP (%) | S1(100) | S1(100) | S1(100) | S1(100) |
| Current Suitability | | | | |
| Storie | N (2.3) | N (9.3) | N (1.6) | N (9.4) |
| Khiddir | N (7.7) | N(15.3) | N(6.3) | N(15.3) |
| Rabia | S3 (50) | S3 (30) | S2(61.2) | S2(53.0) |
| Potential Suitability Class | | | | |
| Storie | N (7.0) | S3 (37.5) | N (4.7) | S3 (37.5) |
| Khiddir | N (15.3) | S3 (43.3) | N (12.5) | S3 (43.3) |
| Rabia | S2 (70.7) | S2 (70.7) | S2 (70.7) | S2 (70.7) |

Rabia classified all the soil units as moderately suitable (S2), except unit 1 and 2 which were classified as marginally suitable. Generally, all the three methods performed well for tomato production, and Rabia method Exergerate the suitable class, and conversely, Rabia method performed better than any method for onion production as simple limitation method was poorly performed. The major limiting factors identified that may hinder proper growth and development of vegetable crops are climate, topography, drainage, soil texture and fertility (mostly nitrogen, phosphorus, and organic carbon).

## 5.0. Recommendation

i. Simple limitation, Storie and Square root Khiddir should be used for evaluating land for Tomato production, and desist from using Rabia method as it may exaggerate the suitability classes.

ii. Rabia method is recommended for evaluating land for onion production, and simple limitation should not be used.

iii. Good soil management, irrigation and enhanced drainage are recommended, so as the soils could be used optimally for vegetable production.

Table 8: Comparison of various Land Suitability Approaches for Tomato and Onion

| Soil Units | Final Class | Tomato | | | | Onion | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | SLM | Storie | Khiddir | Rabia | SLM | Storie | Khiddir | Rabia |
| Unit 1 | Current | Ncsf | Nctsf(3.5) | Nctsf (9.4) | S1(86.6) | Nctsf | Ncsf(2.3) | Ncsf(7.7) | S3csf(50.0) |
| | Potential | Ncs | Ncts(14.1) | Ncts(18.8) | S1(86.6) | Ncts | Ncs(7.0) | Ncs(15.3) | S2cs(70.7) |
| Unit 2 | Current | Ncfw | Ncwf(14.1) | Ncwf(18.8) | S1(86.6) | Ncwf | Ncf(9.3) | Ncf(15.3) | S3cf(30.0) |
| | Potential | S2cw | S2cw(56.3) | S2cw(66.0) | S1(86.6) | Ncw | S3c(37.5) | S3c(43.3) | S2c(70.7) |
| Unit 3 | Current | Ncfw | Ncwf (4.7) | Ncwf (10.8) | S1(86.6) | Ncwsf | Ncsf(1.6) | Ncsf(6.3) | S2csf(61.2) |
| | Potential | Ncw | Ncw(14.1) | Ncw(21.7) | S1(86.6) | Ncws | Ncs(4.7) | Ncs(12.5) | Scs2(70.7) |
| Unit 4 | Current | Ncf | Nctf(14.1) | Nctf(18.8) | S1(86.6) | Nctf | Ncf(9.4) | Ncf(15.3) | S2cf(53.0) |
| | Potential | S2c | S2ct(56.3) | S2ct(66.0) | S1(86.6) | Nct | S3c(37.5) | S3c(43.3) | S2c(70.7) |


## 6. Acknowledgement

- I acknowledged the support by Bayero University Kano for providing a fund to attend 44th SSSN Conference at Enugu State.
- I also want to acknowledge the assistance offered by OCP Africa Fertilizer Company


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