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EVALUATION OF SOIL SUITABILITY FOR SESAME (*SESAMUM INDICUM*) FARMING IN GASSOL LOCAL GOVERNMENT AREA OF TARABA STATE, NIGERIA

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ABSTRACT*:* *This study evaluates the soil suitability for sesame (Sesamum indicum) farming in Gassol Local Government Area of Taraba State. The specific objectives of the study were to identify the suitable soil for sesame farming in Gassol Local Government Area of Taraba using expert Knowledge, to determine the concentration of soil nutrients for sesame farming in Gassol LGA and to compare the level of soil suitability for Sesame farming in Gassol LGA with that of FAO. The expert questionnaires were used to identify the preferred nutrients for sesame farming. The Analytic Hierarchy Process (AHP) was applied to determine the weight of the different soil nutrients by pairwise comparison matrix. The soil samples were collected from the twelve (12) political wards of the study area. The soil samples taken from each ward were air dried, crushed and sieved using a 2 mm sieve and analysed using standard soil analytical procedures at the Modibbo Adama University of Technology (MAUTECH) Yola. Soil pH was measured (soil: water ratio, 1:2) using a pH metre; total N content was determined by flame photometer. The study revealed through the pairwise comparison matrix that favourable average nitrogen in the area ranked first among the nutrients, followed by potassium, phosphorus, sulphur, electrical conductivity, organic matter, organic carbon and potential hydrogen. The Consistency Ratio (CR) of 0.05 was consistent with the experts' judgement in determining the preference of soil nutrients for sesame farming in the Gassol area. The laboratory results indicated that potential hydrogen (6.0), electrical conductivity (0.2) and sulphur (5.5) are low in soil nutrients for farming sesame in the study area based on the Food and Agricultural Organisation (FAO 1976) standard. It further shows that organic carbon (0.5) and nitrogen (0.1) are very low in the soil for sesame farming in the study area while potassium (10.5) and organic matter (2.0) are high in the soil nutrient content of the study area. It was recommended that to ensure optimal sesame production, there is a need for awareness by farmers of the suitable site for sesame farming, and farmers need adequate knowledge of the appropriate fertiliser for sesame farming to improve the soil where the nutrients are low, It further recommends for access to farm inputs such as credit facilities, fertiliser, improve seeds and other infrastructural development for farmers.*

KEYWORDS: Evaluation, Farming, Soil suitability, Sesame.

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INTRODUCTION

Sesame (*Sesamum indicum*) crop also known as *beniseed* is an oil crop grown in hot-dry areas. Nigeria is an agrarian nation where most people rely on cereal crops for their food. Due to the rapid population growth and the limited resources available, decision-makers must act quickly to feed the growing population. The nation has a significant capacity to grow varieties of crops due to agroecological variance. However, one of the biggest obstacles to agricultural diversification in Gassol Local Government Area (LGA) of Taraba State is a lack of knowledge regarding the possible appropriateness of land for various crops. High-value oil crops like sesame have been neglected as a result of a lack of understanding about soil suitability. According to Sori (2021), Chala et al. (2014), and Zarihun (2012), oil seed is crucial to the national economy and a major source of foreign exchange revenues. Sesame and groundnuts are the main oil-seed crops grown in Nigeria and have a significant economic impact. With regard to preference for soil, temperature, and precipitation, sesame is good for tropical and subtropical regions (Girmay, 2015).

In terms of oil seeds, sesame is regarded as the queen (Zaira et al., 2014). Oil, protein, carbs, vitamins B and E, and oil are all present in it (Myint, 2020). Furthermore, sesame can enable the existence of rain-fed dependent populations with limited precipitation and can resist drought occurrence (Bekele et al., 2017). This crop has high flexibility and can adapt to long growth seasons and well-drained soils (Girmay, 2015; Zarihun, 2012). Although it is susceptible to low temperature conditions, sesame grows well in tropical and subtropical regions on the plains as well as up to an altitude of 1250 metres. Nigeria, India, Sudan, Myanmar, China, Uganda, Pakistan, Mexico, and Tanzania are significant sesame-growing nations. It is grown in Bangladesh, Somalia, Turkey, Thailand, Venezuela, Ethiopia, and Egypt, among other places. Sesame was grown on 7784 thousand hectares worldwide between 2001 and 2022, producing 3150 thousand metric tons at a yield of 405 kg per hectare (Ahmed et al., 2023).

The challenges facing agriculture in the 21st century include the need to produce more food to feed a growing population while a large portion of the workforce leaves the sector, aiding in the economic growth of economies that depend on agriculture, and implementing sustainable and resource-efficient production techniques (Food and Agricultural Organization, FAO, 2012). Sustainable land use is essential given the trifecta of declining agricultural production, resource degradation, population growth, and the resulting increase in food demand. Sustainable land use has been thought to be guided by soil maps, market data, and producer input (Obrycki & Karlen, 2018). Nevertheless, crop-suitability index determination that is resource-concentrating and area-specific can also help with sustainability in land use (Ikwuakam et al., 2013; Iorlamen et al., 2014). It assesses how well a location's land quality and other resources fulfil the needs of a specific crop (Jakusko et al., 2018; Jayeoba et al., 2019). According to stable biophysical factors like soil, climate, water, and terrain, it provides information on what to grow and where to increase crop yield and agricultural sustainability (Agbenin, 2013).

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According to Oloniruha, Ogundare and Olajide (2021), Nigerian farmers produce 300 kilograms of sesame per hectare on average, compared to 1,960 kg per hectare in Venezuela, 1,083 kg per hectare in Saudi Arabia, 517 kg per hectare in the Ivory Coast, and 510 kg per hectare in Ethiopia. In sub-Saharan Africa, one of the major obstacles to agricultural productivity is low soil fertility (Jakusko et al., 2013). In Africa, farmers use less fertiliser than is advised (Umar et al., 2010). Depletion of soil nutrients has been caused by this as well as inadequate farming practices (Oloniruha, Ogundare & Olajide, 2021). In terms of oil seeds, sesame is regarded as the queen (Zaira et al. 2014). Oil, protein, carbs, vitamins B and E, and oil are all present in it (Myint, 2020). Furthermore, sesame can enable the existence of rain-fed dependent populations with limited precipitation and can resist drought occurrence (Bekele et al., 2017). This crop can adapt to long growth seasons and well-drained soils thanks to its high degree of flexibility (Girmay, 2015; Zarihun, 2012). Although it is susceptible to low temperature conditions, sesame grows well in tropical and subtropical regions on the plains as well as up to an altitude of 1250 metres.

The majority of tropical nations have very low average sesame yields because of numerous production barriers that prevent significant yield growth. Low sesame yields are mostly caused by poor soil fertility, ambiguous flowering characteristics, capsule shattering at maturity, insects, pests, diseases, heat, and drought, among other things (Chemonic, 2013). As a result of pests, diseases, inadequate weed control, excessive monocropping, a lack of mechanisation (which, among other things, results in seed shattering when there is insufficient labour available during harvest), and untapped genetic potential, the potential yield of sesame is still much higher than the actual yield. Potential yields could reach 2000 kg ha-1, according to Adebowale et al. (2010). According to Eifediyi (2016), insufficient road networks, limited access to financial options, inadequate extension services, and the high cost of inorganic fertilisers and other farm inputs are also significant obstacles to sesame cultivation in the tropics.

The importance of soil suitability in crop yield/productivity cannot be over-emphasized, particularly in Nigeria where the nutrient levels of the soils are low (Agbede, 2019; Eifediyi, 2016). To improve crop yield, fertiliser application has become a regular norm in agricultural practices in Nigeria. Fertiliser has been used to improve the yield of sesame for many years, especially in the savanna region of Nigeria, where it is a sine-qua-non in fertility management because of the inherently low organic matter content of the soils in the region (Ali et al., 2012). The effects of fertiliser on plant growth and yield vary according to the crop planted and the environmental conditions it is exposed to. According to studies conducted in Nigeria, fertiliser application improves crop yield in a variety of crops, including sesame, soybeans, maize, groundnut, wheat, and rice (Eifediyi et al., 2016; Ojeniyi et al., 2016).

A procedure called soil suitability evaluation (SSE) generates suitability data for various soil usage types. According to FAO (1976), it classified lands by assessing the characteristics of the soil and aligning them to the needs of various soil use types. A tool used in soil evaluation planning to find places ideal for sesame production is soil suitability analysis. Farmers now have the chance to choose the ideal soil for sesame production. Agriculturists, scientists, and decision-makers are also increasingly choosing soil based on an area's appropriateness (Diaz et al., 2017).

In sesame application, soil suitability evaluations involve certain steps. The first step entails the selection of the soil type. This means identifying the key soil type used in Sesame farming and then describing in detail the objective. At this step, the assessment of the soil characteristics for the type of land use is based on the requirements and constraints which are used as the basis for establishing an evaluation criterion. This includes a multi-criteria evaluation (MCE) which is applied to define a structured technique to determine the overall preferences among choices where the options achieve many objectives. To find optimal locations for agricultural production, the combination of the multi-criteria evaluation (MCE) technique employing the analytical hierarchy process (AHP) is primarily used. This guide focuses on crop production research. The requirements of a soil use type are then matched to the current soil attributes using a series of procedures in MCE.

The low yield of the sesame crop, which is most likely caused by farmers' ignorance or lack of access to information on ideal soil for sesame farming, was revealed by studies conducted by several researchers in the savanna regions. Oloniruha et al. (2021) assert that farming the crop early in the growing season makes it more vulnerable to insect invasion and vegetative growth. Additionally, traditional sesame growers rarely utilise fertilisers to boost yields in the research locations. Studies have demonstrated that using inorganic fertilisers and using better cultivars improves crop performance (Owolabi et al., 2016; Eifediyi et al., 2018).

According to science, effective land use planning requires the identification of available land resources, potential land uses, and relationship between particular lands units used for a certain purpose. Evaluations of the suitability of the land for agricultural use should be done before any decisions are made. According to the law, each land unit must be used for the purpose that is appropriate for it (Falusi 2012). Sustainable development is made possible by wise land use planning.

Lack of understanding of the soil and compatibility of crops has led to the abandonment of high-value oil crops like sesame farming in Gassol LGA, Taraba State. According to Sori (2021), Chala et al. (2014), and Zarihun (2012), oil seed is crucial to the national economy and a major source of foreign exchange revenues. The main crop grown in Nigeria and one that has influenced the economy is sesame. With some predilection for soil, temperature, and precipitation, sesame is suited for tropical and subtropical regions. According to Weiss (2000), sesame is regarded as the queen of oil seeds. Oil, protein, carbs, vitamins B and E, and oil are all present in it (Myint et al., 2020). Additionally, sesame can withstand the occurrence of droughts and can sustain rain-fed dependent societies under conditions of low precipitation (Bekele et al., 2017). This crop can adapt to long growth seasons and well-drained soils thanks to its high degree of flexibility (Girmay, 2015; Zarihun, 2012). Sesame production is particularly low in the local government district of Gassol. As a result, the low output of sesame in the study region was caused by a lack of knowledge about the suitability of the soil.

Potential land suitability assessment is a pre-request activity for farmers and decision-makers to obtain better yield and high-quality oil seed crops (sesame). Evaluation of land suitability is the process of forecasting future land performance based on various land use types. Similarly, it serves as a key for the management and planning of sustainable land resources since it enables us to determine whether or not the quality of the available resources has declined. As a result, the aim of this study is to evaluate soil suitability status of sesame growing areas of Gassol Local Government Area of Taraba State and the specific objectives are:

i. To identify the soil nutrient requirement for sesame farming in the study area using expert knowledge;

ii. To determine the concentration of soil nutrients for sesame farming in the study area; and

iii. To compare the level of soil suitability for sesame farming in the study area with that of the Food and Agricultural Organisation (FAO).

MATERIAL AND METHODS

Study Area

Location: Gassol is one of the sixteen local governments in Taraba State, Nigeria, with its headquarter in Mutum-Biyu town. It has a coordinate of $8^0$38’00”N and $10^{0\cdot}$46’00”E, 8.633330N and 10.76667^{0}E (Figure 1.1). The town lies along Wukari – Jalingo highway, with an altitude of 137 metres above sea level. It has an area of 5,548 km2 and a population of 244,749 (National Population Census, 2006). Gassol has an annual high temperature of 37.67^{0}C (99.81^{0}F)) and an annual low temperature of 215.81^{0}C (78.46^{0}F), with the warmest month of March (43.64^{0}C/110.55^{0}F) and the coldest month being January (22.3^{0}C/72.14^{0}F). The Northern border of Gassol is the Benue River, and the Taraba River flows north through the area to its confluence with the Benue.

Relief and Drainage: Gassol Local Government Area consists of several mountains that are of great importance, but, the highest and the most prominent among them are eleven in number, Jatau(840 ft) being the highest, followed by Garin Mallam Babba (755ft), Garwa (748 ft), Mapindi (604 ft), shimori (561 ft), Kari (545 ft), Bayo (443 ft), Mallam Hassan (433ft), Dobeli (397 ft), Garku (31 ft) Dutsen Konkoni (30 ft) respectively. The northern border of Gassol is in the Benue River, and the Taraba State River flows north through the area to its confluence with Benue.

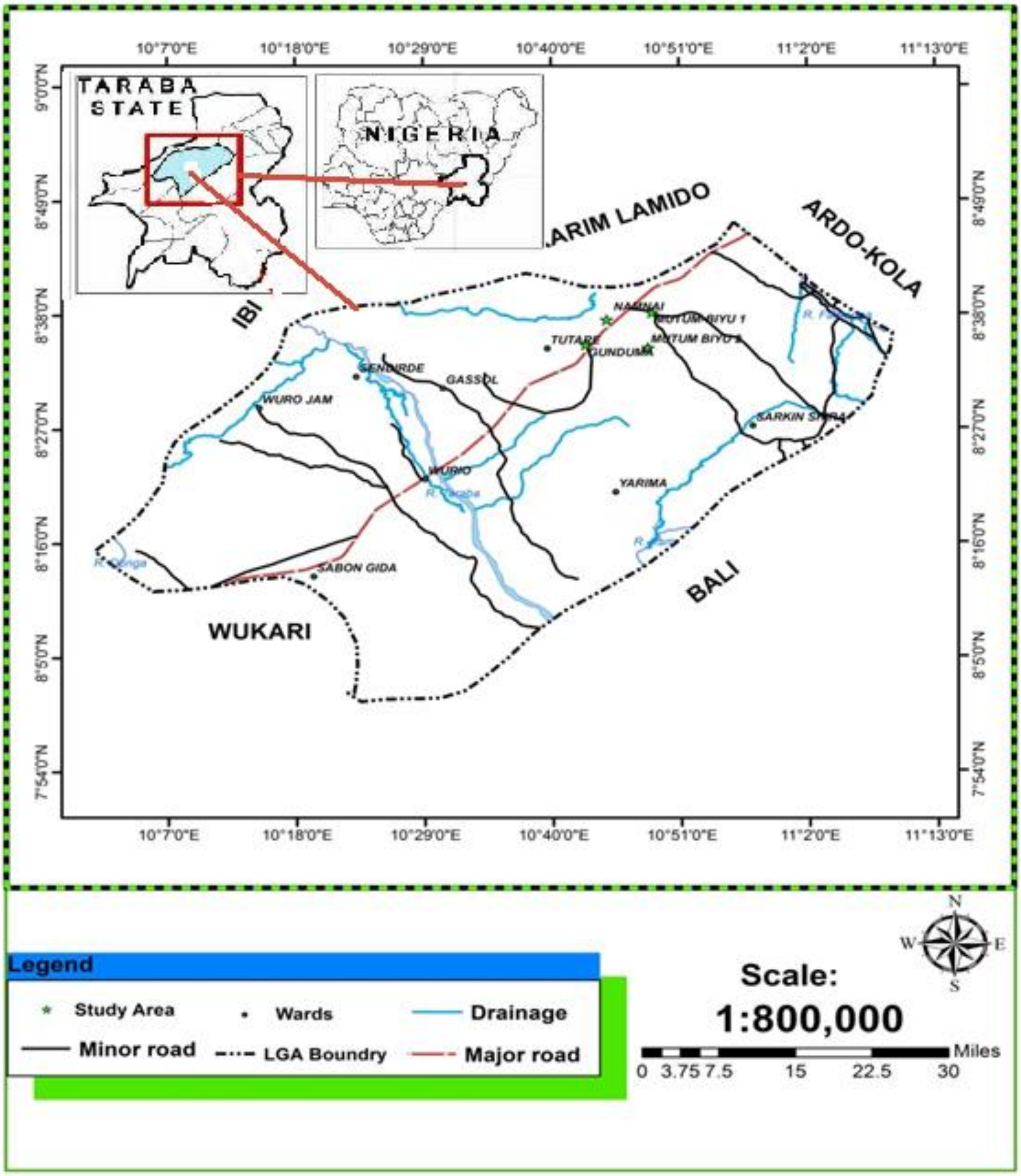

Figure 1.1 Map of Gassol L.G.A

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Climate: The climate of Gassol Local Government Area has features of the middle belt of Nigeria with wet and dry seasons. The rainy season usually records between 1250 mm to 2500 mm of rainfall, with a mean average temperature range of 26.50 and 28.200C. Gassol is located at an elevation of none metre (0 feet) above sea level. It has a tropical wet and dry savanna climate (classification Aw). Gassol typically receives about 108.6 mm (4.28 inches) of precipitation and has 158.91 rainy days (43.54% of the time) annually (Tukura, Oruonye, & Zemba, 2022).

Soil and Vegetation: The fluvisols are found near important rivers like the Taraba and Donga, Luvisols make up the majority of the land in Gassol and Bali's floodplains. Leptosols are located at the base of the highland area.

The vegetation of the Gassol is that of Guinea Savannah. This area consists of the larger parts of the Savannah Zone and it is the broadest vegetation zone in the state which occupies about half of its total area. It is a belt with a mixture of tall and short grasses as well as tall and short trees. The zone is characterised by low rainfall and long dry periods.

The area is completely covered with tall grasses that grow and quickly mature, and are therefore, fibrous during the rainy season. Whereas in the dry season, one may see for miles without any barrier, those grasses usually die and disappear. These happen because of bush burning that occurred between November and April after harvesting, as well as overgrazing by animals. (Tukura, Oruonye & Zemba, 2022).

Economic Activities: Majority of the people in Gassol area are involved in agricultural activities (farming and fishing), while a few numbers are engaged in small-scale trading through which they earn a living. The crops produced in the area include Maize, Rice, Yam, Millet, Groundnut, beniseed, Sugar Cane, Cassava, etc. Since the state experiences a short wet season like other states in the north, irrigation agriculture is needed to meet the food demand of the population. Gassols people practice the irrigation farming system very well. In Taraba State and throughout Nigeria, the advantage of irrigation—the artificial source of water for crop growth—goes beyond only ensuring a sufficient food supply. It also provides money and jobs during the lean seasons of rain-fed agriculture.

Fulani raises large herds of cattle, while Tiv and Jukun farm a lot of yams, making Dan-anacha the home of Taraba State's largest yam market (Dan-anacha yam market). Majority of the people are Tiv, Wurkun, Fulani, and Jukun. In Tella, one of the most important towns in the local government area, where the Jukun people carried out fishing activities to a large extent. There has been an attempt to rename Dan-anacha to Kwararafa due to interethnic violence. However, some people have rejected it since they think it might be biassed in favour of one particular ethnic community (Tukura, Oruonye & Zemba, 2022).

Research Design

Data for this study were collected using a survey research design. It focuses on the kinds of data required, the data sources, the sampling strategy, and the data processing techniques. An investigation was carried out using an Analytic Hierarchy Process (AHP) to collect data from the experts who are deemed knowledgeable in multi-criteria decisions on sesame farming.

The researcher conducted experiments on twenty-four (24) different plots cited in twelve (12) communities selected from twelve political wards that make up Gassol Local Government Area of Taraba State. Samples of the soil obtained from plots were dried and sieved before testing in the laboratory to evaluate the soil's suitability.

Types and Sources of Data

The primary data for the study included the information gathered by the administrations of the questionnaires to experts to identify, weigh and rank the soil nutrient preference for sesame farming. The data is on nitrogen (N), phosphorus (P), organic matter, sulphur (S), potassium (K), electrical conductivity, potential hydrogen, and organic carbon. The soil samples were collected directly from selected farms in Gassol local government area and were carried to the laboratory for analysis to determine the level of concentration of sesame nutrients in the soil.

Secondary data were collected from the reports and documents from the Ministry of Agriculture Jalingo, Taraba State, as well as relevant publications and research conducted on the nature of the soil and farming of sesame by individuals and institutions.

Sample and Sampling Technique

A purposive sampling procedure was used in selecting twelve (12) political wards. Gassol Local Government Area of Taraba State is divided into twelve political wards, namely Gassol, Gunduma, Mutum Biyu I, Mutum Biyu II, Nam Nai, Sabon Gida, Sarkin Shira, Sendirde, Tutare, Wurojam, Wuryo, and Yerima were all selected for survey because the sesame growing areas transverse all communities. All the twelve sesame-producing communities (political wards) in Gassol Local Government area were selected based on the intensity of sesame farming practised in the communities.

Soil samples were collected from twenty-four (24) different plots across twelve (12) wards that make up Gassol LGA to evaluate the suitability status of soils during the (2022) rainy season that sesame is growing. In each ward, names of farmers were collected from the Ward Head, where two names were randomly selected to visit their farms for soil sample collection, as shown in Table 1. The soil at each location was sampled to a depth of 0 – 15 cm to include top and subsoils. The topsoil was sampled at 5 cm depth, while the subsoil was sampled at 15 cm depth due to the depth of the sesame root. Sampling was randomly carried out over the entire site using a hand hoe, spade and field knife. This is done to take care of the suspected fertility gradients due to farmyard manure application in the past season in some of the farms. Each soil portion from each site was thoroughly mixed and reduced to one kg by quartering. These composite soil samples were air-dried ground and sieved through a 2 mm sieve to obtain a fine earth fraction for analysis and fertility status evaluation.

Table 1: Sample Location

S/N	Sample Ward	Sample Community	Sample Farms
1	Mutum Biyu I	Badiya	Mal. Abbas A.Y Farm and Mal. Sani Tukur
2	Mutum Biyu II	Jenjo 'B' Pastor (Special education area)	Elijah's Farm and Mr. Jonah Isa
3	Gassol	Rice Mill	Uba B. Kwanti Farm and Mr. Moses Haziel
4	Sarkin Shira	Kufai Debu	Tekura Farm and Mal. Bulus Shopiti
5	Gunduma	Garin Magaji	Usman Farm and Alpha Livinus Farm
6	Namnai	New Jerusalem	Mama Maryam Yohanna and James Santi
7	Sabon Gida	Angwan Yelwa	Alh. Haruna Mai-Gari Farm and Mal. Sanusi
8	Sendirde	Angwan Jukunawa	J.P Dauda Akila and Mr. David Cletus
9	Tutare	Garin Bahago	Mr. Ayuba Kwah frm & Mrs. Jummai farm
10	Wurojam	Awan Dakka	Sesugh Moses Farm and Sgt. Kolo Joel
11	Wuryo	Yosha	Samuel John Farm and Ismail Sanda
12	Yarima	Anguwan Major	Mal. Bitrus Jacob Farm and Bonshak Farm

Source: *Field Survey 2022*

Expert Interview

Experts from the State Ministry of Agriculture Jalingo and its branch in Gassol were interviewed using expert questionnaires to determine the required soil nutrients and their preference for sesame farming in Gassol Local Government Area. From the Ministry, twenty (20) experts were chosen for in-depth interviews. However, only 12 of these 20 experts were utilised because of their consistency in judgements. The expert's brain stomped to give rank to the criteria (nutrients) based on their preference for sesame farming. These experts were chosen from the Department of Crop Production. They are believed to have useful knowledge of sesame crop farming and other related agriculture productions.

It is not necessary to use a sizable sample when using the AHP because it is a subjective technique (Wong & Li, 2008). Additionally, a large sample size may make the survey procedure impractical because the respondents may give illogical or inconsistent answers (Cheng & Li, 2002). It turns out that if an expert is knowledgeable and well-versed in a field, he may make consistent judgments without compromising the accuracy, by involving other experts who might not be as qualified (Saaty & Özdemir, 2014). Saaty also recommended that the ideal sample size for an AHP comparison study be between 7 and 8 experts.

Furthermore, it is unclear if sample size matters for probability sampling in multiple criteria analysis (Harrison & Qureshi, 2000; Sahin & Mohamed, 2013). As a result, AHP is a strategy for making decisions that use objective mathematics to resolve difficult decision-making problems. The fewer sample size is therefore sufficient for using the AHP approach.

Field Survey

A six-month field survey was carried out between April and October 2022. A combination of qualitative and quantitative methodologies, including expert questionnaire interviews and key informant interviews for the analytical hierarchy process (AHP), were utilised to obtain the primary data.

Based on the informant interviews and questionnaire surveys, the AHP criteria were identified by related ratings. A pairwise comparison matrix was applied at each level of the hierarchy to determine the ranking of the criteria. The AHP ratings of the criteria were based on the experts' opinions. A face-to-face AHP questionnaire interview with crop agriculture experts from the Ministry of Agriculture Jalingo and its branch in the Gassol local government Area, were conducted.

Soil Data Collection

Prior to planting for both cropping seasons at both locations, surface (0-15 cm) soil samples were collected from the twenty four selected plots across twelves' (12) political wards in Gassol Local Government Area of Taraba State. The soil samples taken from each ward were air-dried, crushed and sieved using 2 mm sieve and analysed using standard soil analytical procedures at the Modibbo Adama University of Technology (MAUTECH) Yola. Particle size distribution was determined by the Hydrometer method (Bouyoucos, 1951).

Using a glass electrode pH metre and a soil solution of 1:2 in 0.01 M CaCl2, the pH of the soil was measured. The Walkey and Black technique was used to calculate the organic carbon (OC) of the soil. Total N was determined using the Bray and Kurtz (1945) extraction method, while Available P was determined using the macro-Kjeldahl digestion method (Bremner and Mulraney, 1982). Using NH4OAC solution to remove exchangeable cations, K and Na were measured using a flame photometer.

Method of Data Analysis

Data that are collected from experts, were subjected to analytical analysis, which later involves a laboratory analysis and the result was presented in a table.

Laboratory Analysis

Soil pH was measured (soil: water ratio, 1:2) using a pH metre; total N content was determined by flame photometry (Bremner, 1965); available phosphorus was determined by using the colourimetric extractant by vanadomolybdo phosphoric acid method (Kuo, 1996), organic carbon was determined by using the modified Walkley Black method (Nelson & Sommers, 1996).

The machines used for the suitability test are;

i. Flame photometer for potassium (K) and sulphur (Na) test

ii. Colorimeter for testing of sulphur and phosphorus (P)

iii. Digital conductivity metre for electrical conductivity (EC) test

iv. pH metre for measuring pH, that is the hydrogen ion concentrations to determine the acidity or alkalinity in the soil

Total porosity was determined according to Ahamefule et al. (2014), and soil moisture contents at a depth of 15 cm were calculated as weight of wet soil (g) - weight of dried soil/weight of dried soil multiplied by 100 using standard procedure.

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Deriving the Criterion (Soil Nutrients) Weights using AHP

The relationship between these eight (8) soil nutrients and the relationship between their various attributes were derived using AHP. The methodology for deriving the weights of the soil nutrients and their corresponding attributes using AHP involved the following steps:

Step 1: Defining the problem clearly and decomposing it into various thematic layers containing the different features/classes of the individual themes so that they form a network of the model.

Step 2: Generation of Pairwise Comparison Matrices: The relative important values are determined with Saaty's 1-9 scale (Table 2) where a score of 1 represents equal importance between the two attributes, and a score of 9 indicates the extreme importance of one attribute compared to the other one (Saaty, 1980).

Table .2: Fundamental Scale for Pairwise Comparison

Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favour one element over another
5	Strong importance	Experience and judgement strongly favour one element over another
7	Very Strong importance	One element is favoured very strongly over another; its dominance is demonstrated in practice
9	Extreme importance	The evidence favouring one element over another is of the highest possible order of affirmation
	2,4,6, and 8 are intermediate values	

Source: *Saaty (1980)*

Based on thematic layers used for delineating sesame soil nutrient ranking (weight), a pairwise comparison matrix is derived using Saaty's nine-point importance scale. The AHP captures the idea of uncertainty in judgments through the consistency index (Saaty, 2008). Saaty gave measures of consistency, which are as follows

- Consistency Ratio (CR) is a measure of consistency of judgement amongst the criteria.
- The rule of thumb states that the CR should be less than or equal to 0.1
- Thus a value of 0-0.1 is accepted in practice.
- Any higher value indicate that the judgement warrant re-visitation
- CR thus is evaluated as follows: $= \frac{CI}{RI}$ where

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CI- represents Consistency Index which reflects the consistency of one's (experts) judgement

$CI=\lambda max-n/1-n$

λ is calculated by averaging the value of the consistency vector (calculated factor weight)

RI- denotes Random Inconsistency index that is dependent on the sample size (Table 3).

Table 3: Random Inconsistency Indices (RI) for N-10

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.89	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty (1980)

RESULT AND DISCUSSION

Results

The study was designed to evaluate the soil suitability of sesame farming in the study area. The broad objective was to identify the soil nutrients for sesame farming, to determine the concentration of soil parameters for sesame farming and also to compare the level of soil suitability for sesame farming in Gassol LGA with that of FAO.

A purposive sampling method was used to select the twelve political wards in the study area. Soil samples were collected from twenty-four (24) different plots in (12) wards that make up Gassol LGA to evaluate the suitability status of soils during the rainy season. An Analytic Hierarchy Process (AHP) was used to identify the required soil nutrient for sesame farms through a pairwise comparison matrix.

Identification of the Soil Nutrients Requirement for Sesame Farming in Gassol LGA using the Expert Knowledge

To identify the soil nutrient requirement for sesame farming in Gassol LGA using expert knowledge, it was shown through the pairwise comparison matrix in Table 4 that favourable Average Nitrogen (21.8%) in the area rank first among the nutrients, followed by phosphorous (18.6%), potassium (15.0%), sulphur (12.2%), electrical conductivity (11.6%), organic matter (6.7%), organic carbon (7.7%) and potential hydrogen (6.4%). The Consistency Ratio (CR) for the sesame farming calculated was 0.051 which indicated that the expert's judgments in identifying the soil nutrients requirement for sesame farming was consistent. The soil nutrients identified are considered as the major nutrients required for sesame production. The result agreed with the study by Babajide and Oyeleke (2014) who identified pH (H_2O), total nitrogen (N), organic carbon, available phosphorus (P), the exchangeable cations (Ca, Na, Mg, and K) as required soil nutrients for sesame farming.

Table 4: The Pairwise Comparisons Decision Matrix: For the Nutrients for *Sesame* Farming in Gassol LGA

	Av.N	P	K	S	EC	SOM	Org.C	pH	**Priority**	**Rank**	**(+)**	**(-)**
1Av.N	1	1.00	2.00	2.00	3.00	3.00	3.00	2.00	21.8%	1	6.4%	6.4%
P	1.00	1	1.00	2.00	2.00	3.00	2.00	3.00	18.6%	2	3.2%	3.2%
K	0.50	1.00	1	2.00	1.00	3.00	1.00	3.00	15.0%	3	5.3%	5.3%
S	0.50	0.50	0.50	1	2.00	3.00	1.00	2.00	12.2%	4	5.4%	5.4%
EC	0.33	0.50	1.00	0.50	1	2.00	3.00	2.00	11.6%	5	5.0%	5.0%
SOM	0.33	0.33	0.33	0.33	0.50	1	2.00	1.00	6.7%	7	3.3%	3.3%
Org. C	0.33	0.50	1.00	1.00	0.33	0.50	1	1.00	7.7%	6	3.7%	3.7%
pH	0.50	0.33	0.33	0.50	0.50	1.00	1.00	1	6.4%	8	1.7%	1.7%

Consistency Ratio (CR) = 0.051 (5.1%)

Av N=Average Nitrogen, Av P=Average Phosphorus, K=Potassium

S=Sulphur, EC=Electrical Conductivity, Org C=Organic Carbon

SOM=Soil Organic Matter, pH= Potential Hydrogen

Concentration of Soil Nutrients in Gassol

This section focuses on the concentration of sesame soil nutrients in the Gassol Local Government area.

Table 5: Laboratory Result of Soil Chemical Properties

S/N	**Sample Name**	**pH (1:2)**	**EC (dS/m)**	**Org.c (%)**	**SOM (%)**	**Av-N (%)**	**Av-P (mg/kg)**	**S**	**K (cmol/kg)**
1	Sarkin shira	7.370	0.226	1.203	2.074	0.0013	10.160	6.151	0.365
2	Sendirde	7.250	0.350	1.233	2.126	0.0031	11.262	7.170	0.391
3	Sabon gida	7.030	0.331	1.243	2.143	0.0024	10.334	7.245	0.340
4	Gassol	7.377	0.340	1.269	2.188	0.0029	11.262	7.170	0.494
5	Wuryo	7.150	0.811	1.225	2.111	0.0007	10.994	8.151	0.596
6	Mutum Biyu 1	6.890	0.493	1.353	2.333	0.0017	11.191	7.905	0.340
7	Mutum Biyu 2	7.360	0.288	1.293	2.230	0.0019	11.262	5.811	0.314
8	Tutare	7.270	0.349	1.253	2.161	0.0026	10.266	5.434	0.545
9	Namnai	7.570	0.359	1.584	2.731	0.0027	12.798	5.660	0.263
10	Gunduma	6.960	0.238	1.364	2.351	0.0029	11.726	8.151	0.442
11	Yarima	7.240	0.556	1.384	2.385	0.0021	11.138	5.434	0.468
12	Wuro-Jam	7.390	0.325	1.524	2.627	0.0013	12.726	5.208	0.699

Source: Field Survey, 2022

The result obtained from Table 5 of this study reveals the soil nutrients from the study area. The findings show that the potential hydrogen (pH) in Sarkin Shira is high since it is 7.370a, Electrical Conductivity (EC) is low (0.226a), Organic Carbon (Org. C) is low (1.203a), Soil Organic Matter (SOM) is low (2.074a), Average Nitrogen (Av-N) is low (0.0013a), Average

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Phosphorus (Av-P) is high (10.160d), Sulphur (S) is also high (6.151a) and Potassium (K) is low (0.365bc).

In Sendire ward, findings show that the potential hydrogen (pH) is high since it is 7.250a, Electrical Conductivity (EC) is low (0.350a), Organic Carbon (Org. C) is low (1.233a), Soil organic matter (SOM) is low (2.126a), Average Nitrogen (Av-N) is low (0.0031a), Average Phosphorus (Av-P) is high (11.262b), Sulphur (S) is also high (7.170a) and Potassium (K) is low (0.391abc).

Findings from Table 5 shows that in Sabon Gida the potential hydrogen (pH) is high since it is 7.030a, Electrical Conductivity (EC) is low (0.331a), Organic Carbon (Org. C) is low (1.243a), Soil Organic Matter (SOM) is low (2.143a), Average Nitrogen (Av-N) is low (0.0024a), Average Phosphorus (Av-P) is high (10.334cd), Sulphur (S) is also high (7.245a) and Potassium (K) is low (0.340bc).

From Table 5 study reveals that in Gassol the potential hydrogen (pH) is high since it is 7.337a, Electrical Conductivity (EC) is low (0.340a), Organic Carbon (Org. C) is low (1.269a), Soil Organic Matter (SOM) is low (2.188a), Average Nitrogen (Av-N) is low (0.0029a), Average Phosphorus (Av-P) is high (11.262b), Sulphur (S) is also high (7.170a) and Potassium (K) is low (0.494abc). Analysis from table 2 reveals that in Wuryo the potential hydrogen (pH) is high since it is 7.150a, Electrical Conductivity (EC) is low (0.811a), Organic Carbon (Org. C) is low (1.225a), Soil Organic Matter (SOM) is low (2.111a), Average Nitrogen (Av-N) is low (0.0007a), Average Phosphorus (Av-P) is high (10.994bcd), Sulphur (S) is also high (8.151a) and Potassium (K) is low (0.596ab).

Table 5 reveals that in Mutum Biyu 1 the potential hydrogen (pH) is high since it is 6.890a, Electrical Conductivity (EC) is low (0.493a), Organic Carbon (Org. C) is low (1.353a), Soil Organic Matter (SOM) is low (2.333a), Average Nitrogen (Av-N) is low (0.0017a), Average Phosphorus (Av-P) is high (11.191b), Sulphur (S) is also high (7.905a) and Potassium (K) is low (0.596bc).

Table 5 reveals that in Mutum Biyu 2 the potential hydrogen (pH) is high since it is 7.360a, Electrical Conductivity (EC) is low (0.288a), Organic Carbon (Org. C) is low (1.293a), Soil Organic Matter (SOM) is low (2.2390a), Average Nitrogen (Av-N) is low (0.0019a), Average Phosphorus (Av-P) is high (11.262c), Sulphur (S) is also high (5.811a) and Potassium (K) is low (0.314bc).

From Table 5, the study reveals that in Tutare the potential hydrogen (pH) is high since it is 7.270a, Electrical Conductivity (EC) is low (0.349a), Organic Carbon (Org. C) is low (1.253a), Soil Organic Matter (SOM) is low (2.161a), Average Nitrogen (Av-N) is low (0.0026a), Average Phosphorus (Av-P) is high (10.266cd), Sulphur (S) is also low (5.434a) and Potassium (K) is low (0.545abc).

In Nanmai, the potential hydrogen (pH) is high since it is 7.570a, Electrical Conductivity (EC) is low (0.359a), Organic Carbon (Org. C) is low (1.584a), Soil Organic Matter (SOM) is low (2.161a), Average Nitrogen (Av-N) is low (0.0026a), Average Phosphorus (Av-P) is high (10.266cd), Sulphur (S) is also low (5.434a) and Potassium (K) is low (0.545abc).

From Table 5, the study shows that in Gunduma the potential hydrogen (pH) is high since it is 6.960a, Electrical Conductivity (EC) is low (0.238a), Organic Carbon (Org. C) is low (1.364a), Soil Organic Matter (SOM) is low (2.351a), Average Nitrogen (Av-N) is low (0.0029a), Average Phosphorus (Av-P) is high (11.726b), Sulphur (S) is also high (8.5151a) and Potassium (K) is low (0.442abc).

In Yerima ward, analysis shows that the potential hydrogen (pH) is high since it is 7.240a, Electrical Conductivity (EC) is low (0.556a), Organic Carbon (Org. C) is low (1.384a), Soil Organic Matter (SOM) is low (2.385a), Average Nitrogen (Av-N) is low (0.0021a), Average Phosphorus (Av-P) is high (11.138bc), Sulphur (S) is also low (5.434a) and Potassium (K) is low (0.468abc).

Soil nutrients in Wuro-Jam Ward show that the potential hydrogen (pH) is high since it is 7.390a, Electrical Conductivity (EC) is low (0.325a), Organic Carbon (Org. C) is low (1.524a), Soil Organic Matter (SOM) is low (2.627a), Average Nitrogen (Av-N) is low (0.0013a), Average Phosphorus (Av-P) is high (12.726a), Sulphur (S) is also low (5.208a) and Potassium (K) is low (0.699a).

Therefore, the grand mean of the soil nutrients in twelve political wards that make up Gassol Local Government area of Taraba State is; potential hydrogen (pH) is high since it is 7.238, Electrical Conductivity (EC) is low (0.3888), Organic Carbon (Org. C) is low (1.3273), Soil Organic Matter (SOM) is low (2.2883), Average Nitrogen (Av-N) is low (0.00213a), Average Phosphorus (Av-P) is high (11.26), Sulphur (S) is also high (6.6242) and Potassium (K) is low (0.4381).

Table 6: Least Significant Difference (LSD) Comparisons Test of the Study Area

S/N	Sample Name	pH (1:2)	EC (dS/m)	Org.c (%)	SOM (%)	Av-N (%)	Av-P (mg/kg)	S	K (cmol/kg)
1	Sarkin shira	7.370a	0.226a	1.203a	2.074a	0.0013a	10.160d	6.151a	0.365bc
2	Sendirde	7.250a	0.350a	1.233a	2.126a	0.0031a	11.262b	7.170a	0.391abc
3	Sabon gida	7.030a	0.331a	1.243a	2.143a	0.0024a	10.334cd	7.245a	0.340bc
4	Gassol	7.377a	0.340a	1.269a	2.188a	0.0029a	11.262b	7.170a	0.494abc
5	Wuryo	7.150a	0.811a	1.225a	2.111a	0.0007a	10.994bcd	8.151a	0.596ab
6	Mutum Biyu 1	6.890a	0.493a	1.353a	2.333a	0.0017a	11.191b	7.905a	0.340bc
7	Mutum Biyu 2	7.360a	0.288a	1.293a	2.230a	0.0019a	11.262c	5.811a	0.314bc
8	Tutare	7.270a	0.349a	1.253a	2.161a	0.0026a	10.266cd	5.434a	0.545abc
9	Namnai	7.570a	0.359a	1.584a	2.731a	0.0027a	12.798a	5.660a	0.263c
10	Gunduma	6.960a	0.238a	1.364a	2.351a	0.0029a	11.726b	8.151a	0.442abc
11	Yarima	7.240a	0.556a	1.384a	2.385a	0.0021a	11.138bc	5.434a	0.468abc
12	Wuro - Jam	7.390a	0.325a	1.524a	2.627a	0.0013a	12.726a	5.208a	0.699a
	Grand mean	7.238	0.3888	1.3273	2.2883	0.00213	11.26	6.6242	0.4381
	SE	0.0574	0.0469	0.0350	0.0603	0.2443	0.00022	0.3249	0.0371
	CV	**4.59**	**37.28**	**3.20**	**3.18**	**6.63**	**0.45**	**22.35**	**4.20**

Source: Field Survey, 2022

SE= Standard Error CV= Cumulative Variance pH= Potential Hydrogen

EC=Electrical Conductivity Org C=Organic Carbon SOM=Soil Organic Matter

Av N=Average Nitrogen Av P=Average Phosphorus S=Sulphur K=Potassium

Table 6 shows the Least Significant Difference (LSD) Comparisons Test of twelve political wards that constitute Gassol Local Government Area of Taraba State as presented below.

Sarkin Shira Ward

From Table 6, the study revealed that the potential hydrogen (pH) in Sarkin Shira is high since it is 7.370a, Electrical Conductivity (EC) is low (0.226a), Organic Carbon (Org. C) is low (1.203a), Soil organic matter (SOM) is low (2.074a), Average Nitrogen (Av-N) is low (0.0013a), Average Phosphorus (Av-P) is high (10.160d), Sulphur (S) is also high (6.151a) and Potassium (K) is low (0.365bc).

Sendire Ward

In Sendire ward, findings (Table 6) show that the potential hydrogen (pH) is high since it is 7.250a, Electrical Conductivity (EC) is low (0.350a), Organic Carbon (Org. C) is low (1.233a), Soil Organic Matter (SOM) is low (2.126a), Average Nitrogen (Av-N) is low (0.0031a), Average Phosphorus (Av-P) is high (11.262b), Sulphur (S) is also high (7.170a) and Potassium (K) is low (0.391abc).

Sabon Gida Ward

Results in Table 6 show that in Sabon Gida the potential hydrogen (pH) is high since it is 7.030a, Electrical Conductivity (EC) is low (0.331a), Organic Carbon (Org. C) is low (1.243a), Soil Organic Matter (SOM) is low (2.143a), Average Nitrogen (Av-N) is low (0.0024a), Average Phosphorus (Av-P) is high (10.334cd), Sulphur (S) is also high (7.245a) and Potassium (K) is low (0.340bc).

Gassol Ward

Table 4.3 reveals that in Gassol the potential hydrogen (pH) is high since it is 7.337a, Electrical Conductivity (EC) is low (0.340a), Organic Carbon (Org. C) is low (1.269a), Soil Organic Matter (SOM) is low (2.188a), Average Nitrogen (Av-N) is low (0.0029a), Average Phosphorus (Av-P) is high (11.262b), Sulphur (S) is also high (7.170a) and Potassium (K) is low (0.494abc).

Wuryo Ward

Analysis in Table 6 reveals that in Wuryo the potential hydrogen (pH) is high since it is 7.150a; Electrical Conductivity (EC) is low (0.811a), Organic Carbon (Org. C) is low (1.225a), Soil Organic Matter (SOM) is low (2.111a), Average Nitrogen (Av-N) is low (0.0007a), Average Phosphorus (Av-P) is high (10.994bcd), Sulphur (S) is also high (8.151a) and Potassium (K) is low (0.596ab).

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Mutum Biyu 1 Ward

Table 6 reveals that in Mutum Biyu 1, the potential hydrogen (pH) is high since it is 6.890a; Electrical Conductivity (EC) is low (0.493a), Organic Carbon (Org. C) is low (1.353a), Soil Organic Matter (SOM) is low (2.333a), Average Nitrogen (Av-N) is low (0.0017a), Average Phosphorus (Av-P) is high (11.191b), Sulphur (S) is also high (7.905a) and Potassium (K) is low (0.596bc).

Mutum Biyu 2 Ward

Table 6 reveals that in Mutum Biyu 2, the potential hydrogen (pH) is high since it is 7.360a, Electrical Conductivity (EC) is low (0.288a), Organic Carbon (Org. C) is low (1.293a), Soil Organic Matter (SOM) is low (2.2390a), Average Nitrogen (Av-N) is low (0.0019a), Average Phosphorus (Av-P) is high (11.262c), Sulphur (S) is also high (5.811a) and Potassium (K) is low (0.314bc).

Tutare Ward

From Table 6, the study reveals that in Tutare the potential hydrogen (pH) is high since it is 7.270a; Electrical Conductivity (EC) is low (0.349a), Organic Carbon (Org. C) is low (1.253a), Soil Organic Matter (SOM) is low (2.161a), Average Nitrogen (Av-N) is low (0.0026a), Average Phosphorus (Av-P) is high (10.266cd), Sulphur (S) is also low (5.434a) and Potassium (K) is low (0.545abc).

Namnai Ward

Table 6 of this study reveals that in Nanmai the potential hydrogen (pH) is high since it is 7.570a, Electrical Conductivity (EC) is low (0.359a), Organic Carbon (Org. C) is low (1.584a), Soil Organic Matter (SOM) is low (2.161a), Average Nitrogen (Av-N) is low (0.0026a), Average Phosphorus (Av-P) is high (10.266cd), Sulphur (S) is also low (5.434a) and Potassium (K) is low (0.545abc).

Gunduma Ward

In Guduma Ward, Table 6 shows that the potential hydrogen (pH) is high since it is 6.960a; Electrical Conductivity (EC) is low (0.238a), Organic Carbon (Org. C) is low (1.364a), Soil Organic Matter (SOM) is low (2.351a), Average Nitrogen (Av-N) is low (0.0029a), Average Phosphorus (Av-P) is high (11.726b), Sulphur (S) is also high (8.5151a) and Potassium (K) is low (0.442abc).

Yerima Ward

Table 6 indicates that in Yerima ward the potential hydrogen (pH) is high since it is 7.240a, Electrical Conductivity (EC) is low (0.556a), Organic Carbon (Org. C) is low (1.384a), Soil Organic Matter (SOM) is low (2.385a), Average Nitrogen (Av-N) is low (0.0021a), Average Phosphorus (Av-P) is high (11.138bc), Sulphur (S) is also low (5.434a) and Potassium (K) is low (0.468abc).

Wuro-Jam Ward

The soil nutrients in Wuro-Jam Ward shows that the potential hydrogen (pH) is high since it is 7.390a; Electrical Conductivity (EC) is low (0.325a), Organic Carbon (Org. C) is low (1.524a), Soil Organic Matter (SOM) is low (2.627a), Average Nitrogen (Av-N) is low (0.0013a), Average Phosphorus (Av-P) is high (12.726a), Sulphur (S) is also low (5.208a) and Potassium (K) is low (0.699a) (Table 4.3).

The soil nutrients in Wuro-Jam Ward show that the potential hydrogen (pH) is high since it is 7.390a, Electrical Conductivity (EC) is low (0.325a), Organic Carbon (Org. C) is low (1.524a), Soil Organic Matter (SOM) is low (2.627a), Average Nitrogen (Av-N) is low (0.0013a), Average Phosphorus (Av-P) is high (12.726a), Sulphur (S) is also low (5.208a) and Potassium (K) is low (0.699a) (Table 4.3).

Therefore, the grand mean of the soil nutrients in twelve political wards that make up Gassol Local Government Area of Taraba State is potential hydrogen (pH) fall within the standard of FAO since it is 7.238, Electrical Conductivity (EC) (0.3888) is within the FAO standard. Organic Carbon (Org. C) is 1.3273 within the FAO standard. The grand mean for Soil Organic Matter (SOM) is 2.2883, Average Nitrogen (Av-N) is 0.00213a, Average Phosphorus (Av-P) is 11.26, Sulphur (S) is 6.6242 and Potassium (K) is 0.4381. All fall within the approved range by FAO for framing sesame (Table 7).

Table 7: FAO Soil Threshold for sesame farming

S/N	Nutrients	Below	Approved	Above
1	Potential Hydrogen (pH)	5.9	6.0-7.3	7.4
2	Electrical Conductivity (EC)	0.1	0.2-0.4	0.5
3	Organic Carbon (Org. C)	0.9	1.0-1.3	1.4
4	Soil Organic Mater (SOM)	2.0	2.1-2.5	2.6
5	Average Nitrogen (Av-N)	0.001	0.01-0.03	0.03
6	Average Phosphorus (Av-P)	10.0	10.1-11.2	11.3
7	Sulphur (S)	5.3	5.4-7.3	7.4
8	Potassium (K)	0.3	0.3-0.5	0.6

Source: FAO, 1976

DISCUSSION OF THE FINDINGS

Potential of hydrogen (pH): This determines the acidity or alkalinity in the soil. Sesame prefers moderately fertile, pH 5-8, slightly acidic to alkaline soils and grows best on medium to light, well-drained soil (Mushtaq, Hanif, Ayub, Bhatti & Jilani, 2020). pH determines what nutrients are available in the soil. It can cause sesame to suffer ill or even die off, because when too high or low some nutrients cannot dissolve into the sesame root, causing it to grow poor or even die completely. Therefore, pH should be moderate in every soil for proper growth of sesame. In the study area, the mean pH was 7.238 as seen in Table 6 which falls within the acceptable level by FAO. This agreed with the study by Usman, Ali and Olatunji (2021) that the slightly acidic pH of the soils (6.96 – 6.70) shows that the soils are suitable for sesame farming as this pH range is the optimal pH for most crops and microbial activities in the soil.

In Gassol, the soil may require a little liming of the soil by application of potassium (K) to lower the pH slightly since sesame is intolerant of highly acidic and salty soil (Bennet, 2011).

Soil organic matter (SOM): It helps to improve the soil capacity to store and supply essential nutrients, retain them, and decompose soil nutrients faster to make it fertile. From the result in Table 6, Soil Organic Matter (SOM) has a mean of 2.2883. The result indicated that organic matter from the study area is moderate for sesame farming as required by FAO. When organic matter is added, soil organic carbon levels may rise linearly, indicating the soil's ability to store organic matter (Carter, 2002). With a few notable exceptions, the research area's soil organic matter contents were moderately low, falling between 2.0 and 2.7%. In every soil profile pit, located throughout the study area, SOM values dropped with depth. Therefore, it may be said that the soil fertility that dominates is quite low.

Organic Carbon: It helps to increase microbial activities in the soil, protect soil from erosion and retain nutrients and water in the soil. According to the results of the analysis of soil organic carbon 1.3273, it shows there was high soil organic carbon, this could be following the application of organic fertilisation in the area Table 6, which is in line with the findings of Rodrigues, de Souza, Marques, Souto, and da Silva (2016), who reported an increase in soil organic carbon following the continuous application of manure. According to Robertson et al. (2015), residual inputs like organic fertilisation appear to be what regulate soil organic carbon levels. From the study, organic carbon in the area falls within the FAO's (1976) required soil nutrient for sesame farming which agreed with Maia, Otutumi, de Sá Mendonça, Neves, and de Oliveira (2019) that Soil Organic Matter (SOM) pools and Soil Organic Carbon (SOC) in the semiarid region of Brazil where beans, sesame, and pigeon peas are grown can be an option for sustainable soil management.

Electrical Conductivity (E-C): This is an indicator of water quality and soil salinity, and helps determine the amount of salt dissolved by carrier liquid (normally water), when E.C is high in the soil it can cause the soil not to assist any plant growth, thereby making it to be barren, (because the plant cannot absorb the salty water). Measurements of electrical conductivity (EC) are used to estimate the total amounts of soluble salts present in soils. According to the general interpretation of EC value, the range between 0 and 4 is regarded salt-free, 4 and 8 are considered somewhat saline, 8 and 15 are considered moderately salty, and >15 is considered severely saline (Al-Mashreki, Atroosh, Muflahi, Obaid & Caroline, 2015).

The research area's cultivated soils have exceptionally low salinity levels, as shown by the result of the EC (0.3888) of saturation paste. This is in agreement with Al-Mashreki et al. (2015) Moisa, Merga, Gabissa, and Gemeda (2022) and Yunusa, Usman, Nangere, and Usman (2019) that the soils' electrical conductivity (EC) was low.

Average Nitrogen: It helps to increase the height of sesame and the number of branches and leaves in a plant. A decline in nitrogen can cause the plant to have low height and few branches and leaves, thereby reducing the yield of the sesame. From the result in Table 6 it indicated that the study area has an average Nitrogen of 0.00213 which was within the recommended requirement by FAO (1976). This agreed with a study by Babajide and Oyeleke (2014) that the total seed production of sesame was greatly increased after nitrogen fertiliser was applied. Application of 80 kg N ha-1 resulted in a considerably higher overall seed production of 2.5 tons ha-1, which is equivalent to all other fertiliser treatments examined. From 20 to 80 kg N ha-1, the total seed output increased noticeably before gradually decreasing to 140 kg N ha-1.

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Numerous experts had previously claimed that nitrogen played a significant role in determining crop output. According to studies, increases in N supply are only associated with an increase in crops' growth and yield (Babajide & Oyeleke, 2014; Golan, Peleg, Tietel & Erel, 2022; Olaniyi & Akanbi, 2008). This includes the leaf area and weight, carboxylases, and the amount of chlorophyll, all of which determine the photosynthetic activities of leaves and, consequently, the yield of sesame. However, a sufficient amount of evidence has been provided to support their findings by the notable decline in sesame yield metrics, notably above the nitrogen needs limit of 80 kg Nha-1. These results supported those published by Golan et al. (2022), Lee et al. (2022), Thuc et al. (2022) who claimed that when nitrogen is administered excessively, crop growth and development may not be significant and may even shrink, resulting in a decline in nitrogen use efficiency (NUE).

Average Phosphorus and Sulphur: Both increase the number of sesame seeds in each of the capsules, whenever there is low or too high phosphorus and sulphur. The capsules can be much, but the seeds inside will be just a few. The result in Table 6 indicated that average phosphorus and sulphur are relatively high with 11.26 and 6.62 respectively in the study area based on FAO (1976).

Studies showed that with increased application of phosphorus and sulphur in the sesame farm will result in increases in the leaves and seed of sesame but at a certain level with addition or increase in the application of the phosphorus and sulphur, the yield will not increase (Kalegore, Kirde, Bhusari, Kasle & Shelke, 2018; Okpara, Muoneke & Ojikpong, 2007).

Potassium (K): This increases the number of the capsules per sesame plant, when potassium is low or too high, the capsule production will be very few, thereby making the yield very low. The results of the soil's laboratory study (Table 5) revealed that the soils have low levels of potassium; this is in agreement with Okpara et al. (2007) who stated that nitrogen, phosphorus, and potassium are low in the soil of Nigeria for increase yield sesame farmers need to apply some required amount of these vital nutrients to the soils.

The essential sesame soil nutrients viz Average Nitrogen (Av. N), average Phosphorus (P), Potassium (K), Sulphur (S), Electrical Conductivity (EC), Organic Carbon (Org. C), Soil organic matter (SOM), and pH were generally low for crop cultivation but within the FAO (1976) acceptable limits for sesame farming in the study area. This is in line with Ter, Ali and Olatunji's (2022) study on the assessment of soil for sesame cultivation in Makurdi, Nigeria, who reported that the organic matter level was between 0.90 and 0.89 per cent, available Nitrogen (N) was 0.02% and 0.04 per cent, pH values were 6.01 and 5.98 and there were 2.30 mg/kg and 2.31 mg/kg of phosphorus (P). Like most soils in sub-Saharan countries, the soil had a relatively low amount of phosphate and nitrogen. This could be a result of poor farming practices that result in nutrient loss owing to leaching or erosion without corresponding nutrient inputs to restore the nutrient loss.

The soil's poor nutrition status is typical of many tropical soils where slash-and-burn farming practices, along with high insolation and rainfall, hinder the accumulation of organic matter which is the storehouse of most soil nutrients (Usman et al., 2021). The results of poor soil fertility, which require the application of fertiliser to replenish nutrients lost during crop harvest and to supplement nutrients to increase sesame yields, are significant.

Fertiliser applications on sesame farms in Gassol are highly limited due to the traditional belief in sub-Saharan Africa and particularly Nigeria that sesame growing does not require fertiliser application (Okpara et al., 2007). A study by Terefe, Wakjira, Berhe and Tadesse (2012) shows a 35% increase in yield in sesame as a result of application of 38/29 kg/ha NP2O5 fertilisers during the planting period. At another plot at Humera, Terefe et al. (2012) reported a fertilisation treatment of 120 kg/ha NPK (19:19:19) + 50 kg/ha K2SO4 + 50 kg/ha urea during planting resulted in a 32% increase in yield of sesame above no fertilisation. In any case, one has to take into account the plant's growth stage, population, and the amount of soil moisture present before applying fertilisers. The results of soil examinations should be used to guide fertiliser applications. Organic sesame farming excludes the use of commercial inorganic fertilisers.

CONCLUSION

The findings show that AHP and laboratory analysis are functional instruments in determining the required soil nutrients for sesame farming in Gassol Local Government Area of Taraba State, Nigeria. In general, the findings of this study provide important insights into soil suitability evaluation for farming sesame. Soil testing can and should be highly informative for the agronomist and farmers. Information from a well-conducted soil sampling and nutrient suitability such as this can be useful in monitoring changes in soil fertility, developing fertiliser recommendations and improving farm nutrient efficiency. Regardless of the soil sampling, a consistent, well conducted and organised approach will lead to useful and informative soil results.

Sesame is in greater demand both domestically and internationally as it is a key ingredient in many healthy foods and represents a positive step toward ensuring food security and increasing income generation. This is especially true given that sesame is a significant import and export crop in many nations and has the potential to generate a large number of jobs, particularly in the developing world.

This study and several others have indicated the need for improved sesame farming practices as it has a direct impact on achieving sustainable agricultural development in Nigeria, actualization of the green revolution, and combating the global food crisis and food insecurity through improved yield of sesame produce. This, therefore, stimulates the need for investigational research such as this. The study thus settles on a soil that is rich in potential hydrogen (pH), Electrical Conductivity (EC), Organic Carbon (Org. C), Soil Organic Matter (SOM), Average Nitrogen (Av-N), Average Phosphorus, Sulphur (S) and Potassium (K). Based on this research, the study concluded that soil nutrients can affect the yield of crops in an area, especially sesame.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations are made.

i. To ensure optimal sesame production, there is a need for awareness among farmers on the suitable site (soil) for sesame farming by experts. Based on the recommendation of this study, soil nutrient for sesame growth in Gassol LGA is very moderate in most of the wards but high in a few and low in others. Therefore, the result of this study will help farmers, researchers and the Government in assisting farmers in knowing the suitable soil to plant their crops for a more yield and bountiful harvest.

ii. There is a need for farmers to have adequate knowledge of the appropriate fertiliser for sesame farms.

iii. Sesame farmers should be guided on the appropriate quantity of inputs used per hectare by extension agents to avoid wastage.

iv. Farmers should have access to farm inputs, such as credit facilities, fertiliser, improved seeds and other infrastructural development.

v. Further study may be carried out on the spatial analysis for a suitable site for sesame farming.

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