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SOIL FERTILITY MANAGEMENT STRATEGIES IN BATAGARAWA LOCAL GOVERNMENT, KATSINA STATE, NORTHERN NIGERIA

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ABSTRACT

A practical and sustainable Soil Fertility Management Strategy is crucial to sustainable agricultural development. Using questionnaires, interview schedules, and Focus Group Discussions, the paper assessed the relationship between the use of fertiliser and soil fertility management among smallholder farmers in Batagarawa Local Government Area, Katsina State, Nigeria. Based on farmers' perceptions, the study established a significant relationship between the use of fertilisers and soil fertility management, considering the choice of fertilisers, method of application, preference rankings, and problems associated with soil fertility management. Results are presented using tables and simple percentages. Spearman Rank Correlation was also used to determine the degree of relationship between the use of fertiliser and soil fertility, with a P-value of 0.213. Chemical fertiliser was found to be the most widely used input for maintaining soil fertility, at 55%, followed by Cow Dung at 25%, sheep/goat dropping and ash/plant residue at 19% and 10%, respectively. The high cost of chemical fertiliser and transportation costs were identified as the top challenges faced by farmers in the study area. The study therefore recommends the provision of subsidised chemical fertiliser, encourages mixed farming practices to boost the production of organic fertiliser, and improves the transport network for the sustainable development of the sector...

Keywords: Soil fertility, Management Strategy, Fertiliser

INTRODUCTION

Before the introduction of chemical fertilisers, Organic Nutrient Cycling (ONC), also known as regenerative farming, was the widely used method of maintaining soil fertility. It is a function of Cation Exchange Capacity (CEC), i.e., the absorption and storage of nutrients in the soil particles and the quality of nutrients and cations that a given soil can absorb at a given time (Githongo, Ngatia, Kiboi, Muriuki, Fliessbach, Musafiri, & Ngetich, 2022). The system supplies nutrients to crop plants through recycling of biologically related processes, such as nitrogen (N) fixation by clover and other legumes, and limited use of off-farm minerals**.** It is concerned with the ability of the soil to sustain plant growth, which is intrinsically connected to soil formation processes (physical, chemical, and biological). It affects the quantity and quality of organic and inorganic matter in the soil. Use of Fertiliser in Soil Fertility Management Process Many soil nutrients management technologies have been developed, tested and promoted in Africa's farming system over time, however, many research gaps still exist which need to be filled, particularly on some specific type of crops, and the kind of soil fertility management practice to be employed (Matsumoto, Ishikawa, Asfaw and Asiedu, 2021). For instance, the decomposition of Soil Organic Matter (SOM) enhances soil water infiltration, which also improves the Cation Exchange Capacity (CEC) of the soil, ultimately enhancing soil fertility. The Integrated Nutrient Management (INM) is

another method widely used in maintaining soil fertility in many developing countries, such as India, since the mid-1990s. This is used to reduce the accumulation of hazardous waste from the heavy use of inorganic fertilisers, and helps explore and develop alternative sources of nutrients by using a combination of inorganic, organic, and bio-fertilisers in building soil fertility (Gaddi, Basavanneppa, & Tevari, 2020). Crop residue is also an essential source of organic matter that can be returned to the soil for nutrient recycling, thereby improving its physical, chemical, and biological properties (Gaddi et al., 2020; Githongo et al., 2022).

Globally, the total crop residue production is estimated at 3.8 billion tons per year, comprising 74% from cereals, 8% from legumes, 3% from oil crops, 10% from sugar crops, and 5% from tubers. Additionally, crop residue contains a significant amount of mineral nutrients, the content of which varies among crop species depending on the soil fertility. These residues should be returned to the soil and spread uniformly over the entire field to prevent plant impoverishment due to a lack of nutrients and organic content in the soil (Araujo & Monteiro, 2006). However, it is difficult to predict how much nutrients in the residue will be available to crops during a given time because of the complex processes involved in residue decomposition and nutrient release. Additionally, the nature of crop residues and their management can significantly affect the amount of nutrients available for subsequent crops, as well as the content and quality of the soil's organic matter (Gaddi et al., 2020). Essentially, effective management of crop residues should conserve soil and its nutrients with minimal adverse environmental impacts. Moreover, after harvest, crop residues can be treated in the following manner: (1) left on the soil surface, (2) swathed and concentrated in windrows, (3) incorporated into soil, and/or (4) burnt prior to tillage or seedbed preparations for maximum benefits (Dominguez, Nunez, Pineiro, & Barra 2019).

Chemical fertiliser is one of the most significant contributors to increased global agricultural production over the past few decades; however, its adverse environmental effects limit its continuous use on a sustainable basis. Weak soil quality requires increased inputs to maintain high yields, which threatens the future of food security and raises production costs for already poor smallholder farmers in most developing countries, such as Nigeria. However, in the developed world, chemical fertilizer is becoming less popular due to its potential negative impact to the environment that caused widespread soil degradation, decrease in aggregate stability and decrease water holding capacity of the soil which reduced organic matter contents of the soil for successful plants growth (Gaddi, et'al, 2020; Thiery, et'al., 2023). The lack of adequate extension services, resulting in poor soil fertility management due to the incorrect application of chemical fertilisers (NPK), combined with inappropriate cultivation methods, has contributed to soil fertility loss in many developing countries (Zhao, Feyissa, Hailong, & Zhiping, 2022).

In Sub-Saharan Africa, it was observed that about 65% of the cultivated land was degraded due to inappropriate agricultural and soil management practices (Githongo, Ngatia, Kiboi, Muriuki, Fliessbach, Musafiri, Fu & Ngetich, 2022). Many authors have elucidated how the rapid demographic growth affects climate change and reduces the duration of fallow in most farming communities across Africa, resulting in a continuous decline in soil fertility on the continent (Gaddi et al., 2020; Tovihoudji, Akpo, TassouZakari, Ollabodé, Yegbemey, & Yabi, 2023; Matsumoto, Ishikawa, Asfaw, & Asiedu, 2021). Continuous cropping with inadequate nutrient replenishment techniques can lead to reduced Soil Organic Carbon (SOC) and nutrient content in the soil, which are essential requirements for sustainable agricultural production (Githongo et al., 2023; Gaddi et al., 2020). However, the long-term dependence on high application of chemical fertilisers has drawn the attention of experts over the past decades (Thiery et al., 2023). For instance, in most developed countries, the high use of chemical fertilisers has led to the degradation of most soils, the

accumulation of hazardous waste, and the contamination of water bodies. In the developing countries however, harsh climatic conditions, population pressure, and decline in traditional soil management practices have reduced soil fertility status in sub-Saharan Africa where over the past decades (1961-1992), agriculture has failed to increase the food production in calories per capital above 2100/day This is because most of the soils in the tropics are deficient in essential nutrients especially N. P. K., which has forced the farmers to continually cultivate the soil without proper consideration for replenishing the soil, making both the existing as well as potentially productive agricultural land prone to degradation (AGRA, 2013; Osabohien, Jaaffar, Matthew, Osabouhen, Adeleke, Olanade. Okoh & Khalid, 2024). Therefore, sustainable economic growth and the development of Africa's agricultural system require the development and management of essential agricultural resources, as well as the successful restoration of vast degraded land through appropriate soil fertility management and development strategies in the study area.

Study Area

Batagarawa Local Government, Katsina State, Nigeria, covers a total land area of 433 square kilometres with an average annual temperature of 35 °C. It is located between latitudes 120 - 540 N and 120 - 320 N and longitudes $73^0 \cdot 7^0$ N and $76^0 \cdot 37^0$ E. It has a total population of 184,575 and an annual growth rate of 2.7% (NPC, 2006). The area is underlain by a basement complex of Precambrian origin, divided into three main groups: the ancient migmatite with subordinate gneiss and quartzite complex, the schist rocks, and granites that are older than 650 million years, commonly referred to as the Pan-African granite suites (Ibrahim & Shhazali, 2020). The area has a mean annual temperature of 270 °C and a rainfall duration of between 4-5 months (700mm – 750mm) (Uaman, Abdulhamid, Sawa, Yusuf & Usman, 2013). The vegetation of the area is characterised by Sudan Savannah vegetation with sandy, coloured soils. Figure 1 shows the location and extent of the study area.

Materials and Methods

The study employed both quantitative and qualitative approaches to collect the necessary data, utilising a structured questionnaire and interview schedule. A reconnaissance survey was first conducted to familiarise the researcher with the study area and to establish the significant types of soil fertility management practices used by the farmers. A questionnaire was administered to 120 respondents to obtain the required primary data. A Focus Group Discussion (FGD) was also conducted with two separate groups, each comprising five people: one from the agricultural cooperative society, a representative of the ward head, a representative of the agricultural extension workers, and two farmers randomly selected from the 10 wards in the local government area. Household heads aged 30 and above who had farming as their primary occupation were considered. The results of the findings were presented using simple percentages to show the respondents' preferences for the different types of soil fertility management practices and farmers' perceptions of the effectiveness of their choices in the study area.

Results and Discussion

The results of the questionnaire revealed that farmers are employing various methods to improve soil fertility. However, the use of inorganic fertiliser appeared to be the most common practice,

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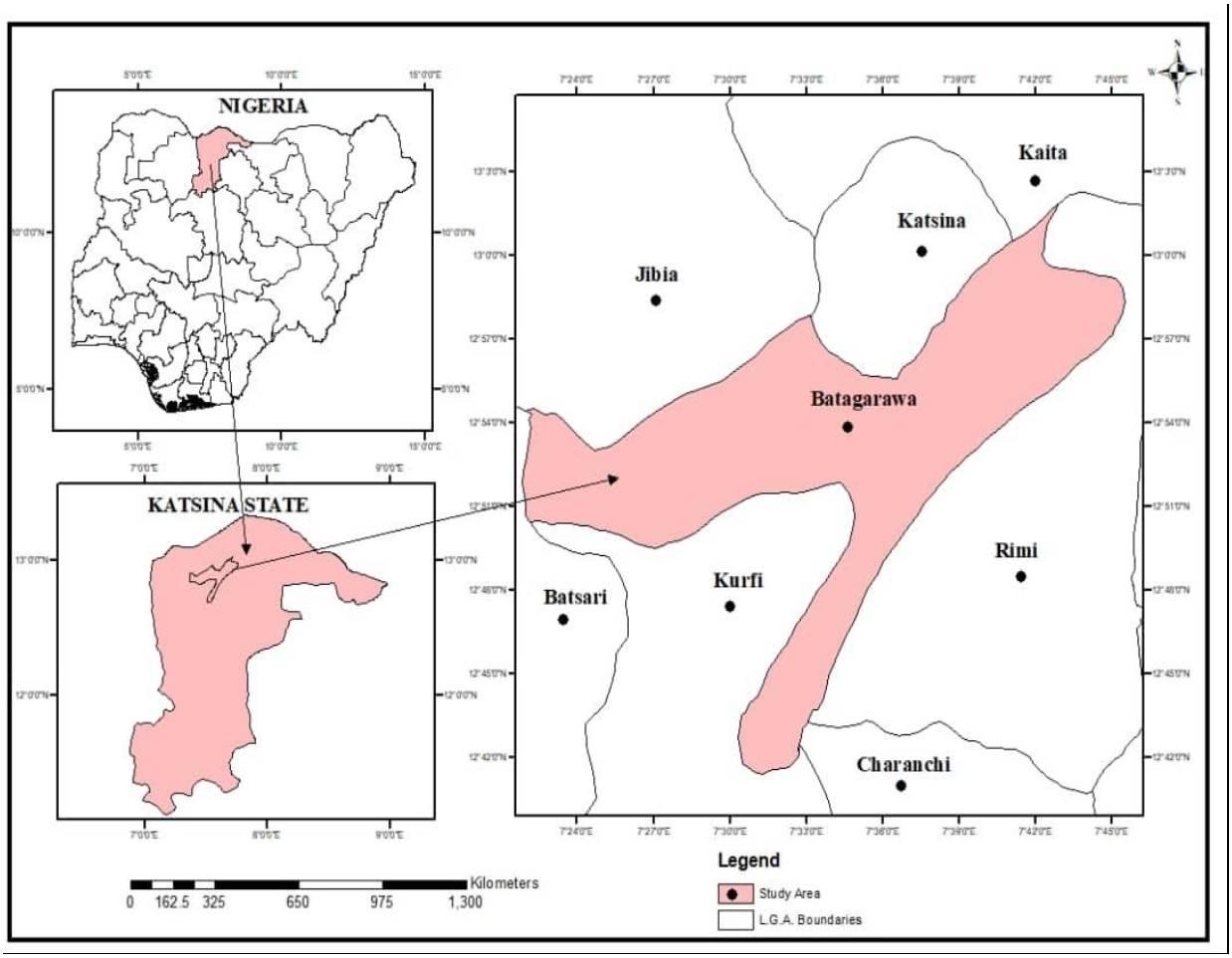

Fig 1. Location of Study Area

accounting for 55%, followed by cow dung at 21%. In contrast, sheep and goat manure, as well as ash and crop residues, accounted for 16% and 7%, respectively. This result is supported by Abayomi and Adebayo (2014) in a study that investigated the Effect of fertiliser use on the growth and yield of Amaranthus caudatus in Ilorin, the southern Guinea Savannah of northern Nigeria. The findings revealed a significant positive relationship between fertiliser use and annual crop production. However, it was observed that prolonged use of inorganic fertiliser can have a lasting effect on the productive capacity of the soil. It can also have a widespread, damaging effect on the soil through decreased aggregate stability, reduced water-holding capacity, and increased soil compaction, thereby reducing the soil's organic matter content and hindering successful plant growth (Gaddi et al., 2020). The result of the questionnaire is presented in Table 1.

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Fertility practice	Frequency	Percentage (%)
Chemical Fertilizer	66	55
Cow dung	25	21
Sheep and goat dung	19	16
Ash and crop residues	10	7
Total	**120**	**100**

Source: Field Data, 2022

Ranking of Soil Fertility Management Practice in the Study Area

Chemical fertiliser was believed to be the most important contributor to increased world agricultural productivity over the past decades. However, the adverse effects of chemical fertilisers on crops, the soil, and the environment in general are well acknowledged, especially in most developed countries (Abayomi & Adebayo, 2014). However, weak soil requires increased inputs to maintain high yields for sustainable growth. It was also reported by Marzouk & Kassem (2011) that chemical fertilisers can reduce the protein content and carbohydrate quality of crops by degrading the soil. Hence, the choice of soil fertility improvement method is very crucial and was based on accumulated years of experience. Results show a strong relationship between the use of fertiliser and soil fertility improvement strategy, with a P-value of 0.213. However, the majority of the respondents 41%, choose to use inorganic fertiliser for the simple reason that it is readily available all year round in most rural markets. This is followed by cow dung, at 22%, while sheep/goat and ash/crop residues come in third and fourth place, at 20% and 17.5%, respectively. Even though the majority choose to use inorganic fertiliser, reports from the interview revealed that all the farmers agreed to have used a combination of both chemical and organic fertiliser for maximum results. The result of the finding is presented in Table 2.

Table 2: Ranking of Soil Fertility Management Practice in the Study Area

Fertility Methods	Frequency	Percentage (%)	Rank	p-value
Chemical	50	41	1st	0.213
Cow dung	25	22	2nd	
Sheep/Goat dung	24	20	3rd	
Ash/Crop Residue	21	17	4th	
Total	**120**	**100**		

Source: Field Data, 2022

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Method of Applying Fertiliser for Soil Fertility Management in the Study Area

At various times, farmers must employ different methods of applying fertiliser to improve fertility. However, the most widely used method of application is side placement or the planting method, with 56%, followed by broadcasting at 27%, and last on the list is slush and burn, at 17%. The result is presented in Table 3.

Table 3: Method of Applying Fertiliser for Soil Fertility Management in the Study Area

Fertility Method	Procedure Frequency		Percentages %
Chemical fertilizer	Side placement/ planting	67	56
Cow dung	Broadcasting	32	27
Ash/Crop residues	Slash and burn	21	17
Total		**120**	**100**

Source: Field Data, 2022

Perception of Soil Fertility Management Effectiveness in the Study Area

Although the use of chemical fertiliser appeared to be the most common practice for improving soil fertility in the study area, with over 50% of the respondents, this may not be unconnected with the availability of the commodity in almost all rural markets. The use of animal manure, which comprises droppings from cows, sheep, and goats, comes second, at 41%. Ash and crop residue, which primarily come from leftovers and domestic ash from homes, are the least used, at only 9%. However, the use of inorganic fertiliser is now becoming less popular due to its degradation effects on the soil, which predisposes the farmer to adopt other methods for improved farming practices (Awotide, Ikudaisi, Ajala, & Kaltungo, 2015). Increasing numbers of people are now switching to organic fertilisers for sustainable agricultural growth. Table 5 summarises the results on the most effective method used for soil fertility management by farmers in the study area.

Table 4: Perception of Soil Fertility Management Effectiveness in the Study Area

Practice	Frequency	Percentage (%)
Chemical fertilizer	60	50
Cow/sheep, goat/droppings	49	41
Ash and Crop residues	11	9
Total	**120**	**100**

Source: Field Data, 2022

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Perception of Soil Fertility Management Preference in the Study Area

Similarly, respondents were asked to indicate their most preferred input for improving soil fertility. The majority believe organic fertiliser to be the most preferred and effective input for improving soil fertility. One respondent in the interview opined that this may not be unrelated to its versatility and mild effects on crops and the soil. About 86% of the respondents indicated that they preferred organic fertiliser (animal droppings, ash, and crop residue) over inorganic fertiliser. Another respondent also observed that many farmers are switching to organic fertiliser due to increasing environmental awareness of the effects of chemical fertiliser on the soil. However, chemical fertiliser has only 14%. Table 6 presents the farmers' perception of the most preferred soil fertility management method among respondents.

Table 5 Perception on Soil Fertility Management Preference in the Study Area

Practice	**Frequency**	**Percentage (%)**
Cow/sheep goat dung	64	53
Ash and crop residue	40	33
Chemical fertilizer	16	14
Total	**120**	**100**

Source: Field Data, 2022

Respondents' Perception of the Problems Associated with Soil Fertility Management

Many problems were experienced by farmers when it comes to improving soil fertility using either organic or inorganic fertilisers. However, they can be summarised mainly as including: high cost of fertiliser, high cost of transportation, prevalence of weeds, plant diseases, and water pollution, among others. A summary of some significant problems associated with soil fertility improvement is presented in Table 6

Table 6: Respondents' Perception of the Problems Associated with Soil Fertility Management

Practices	**Restriction**	**Possible solutions**
Inorganic fertilizer	High cost of transportation, non-availability of the commodity, high cost of the commodity, and lack of subsidies to farmers	Increase the Subsidy to make the commodity more affordable and create more centres so that farmers do not have to travel far to purchase it.
Organic fertilizer	Weed propagation, high cost of transportation, and high demand for herbicides.	Early weeding, subsidised transportation, and the rearing of animals by farmers (mixed farming)

Source: Field Data, 2022

Conclusion and Recommendation

Effective soil fertility management is crucial to the development of agriculture and a precursor to sustainable food security among smallholder farmers. However, increasing agricultural production can only be achieved through the appropriate application of the right kind and quantity of fertiliser to maintain soil fertility. The use of chemical and organic fertilisers in soil fertility management has been a common practice among smallholder farmers in the study area for ages. However, prolonged use of chemical fertiliser in particular could have a damaging effect by causing soil degradation, which makes the soil less productive. To achieve and maintain effective and sustainable soil fertility, the general performance of the soil can be enhanced through the combined use of organic and inorganic fertilisers. Although an increasing number of farmers prefer to use organic fertiliser due to its versatility, it is locally sourced and can cause minor damage to the soil. It is, however, recommended that adequate provision of chemical fertiliser at a subsidised price should be made available to ease its scarcity. Mixed cropping and mixed farming should be encouraged among smallholder farmers to produce sufficient organic fertiliser and to enhance the growth of nitrogen-fixing bacteria in the soil. This will enhance the circulation of essential nutrients and mitigate soil exhaustion resulting from continuous cropping. Extension services should be made available and readily accessible to farmers, and governments should construct more rural road networks to ease the hardship being experienced by farmers in evacuation and transporting farm produce to consumers.

References

Abayomi, A. O., & Adebayo, O. J. (2014). Effect of Fertiliser Types on the Growth and Yield of Amaranthus caudatus in Ilorin, Southern Guinea, Savannah Zone of Nigeria. Hindawi Publishing Corporation. *Advances in Agriculture,* 1–5. http://dx.doi.org/10.1155/201/947062,

African Agricultural Status Report (AGRA, 2013). African Agricultural Status Report: Focus on Staple Crops. Nairobi, Kenya: *Alliance for Green Revolution in Africa*, .1-204. ISBN: 978-92-990054-4-6

Araujo A.S.F. and Monteiro R.T.R. (2006). Microbial Biomass and Activity in Brazilian Soil Amended with Untreated and Composted Textile Sludge. *Chemosphere*, 64: 1-4 Doi: 10.1016/j.chemosphere.2006.01.040

Awotide, D. O., Ikudaisi, O. J., Ajala, S. O., & Kaltungo, J. H. (2015). Input Use and Profitability of Arable Crops Production in Nigeria. *Journal of Sustainable Development*, 8(3): 139-146. http://dx.doi.org/10.39/jds.v8n3p139.

Dominguez M., Nunez R.P., Pineiro J., Barra M.T. (2019). Physico-Chemical and Biochemical Properties of an Acid Soil Under Potato Culture Amended with Municipal Solid Waste Compost. *International Journal of Recycled Organic Waste in Agriculture*, 8 (1): 171–178. http//doi.org/10.1007/s40093-019-0246-x

Gaddi, A. K., Basavanneppa, M. A. & Tevari, P. (2020). Effects of Long-Term Use of Organic and Inorganic Fertilisers on Soil Fertility and Productivity Under Paddy-Sesame Cropping System. *Bangladesh Journal of Botany 49*(3): 585–591. http//doi.org/10.3329/bjb. v49i3.49988

Githongo, M., Kiboi, M., Muriuki, A., Fliessbach, A., Musafiri, C., Ngetich, F.K. (2023). Organic Carbon Content in Fractions of Soils Managed for Soil Fertility Improvement in Sub-Humid Agroecosystems of Kenya. *Sustainability.* 1–17. 15,683. http://doi.org/10.3390/su15010683

Githongo, M., Ngatia, L., Kiboi, M., Muriuki, A., Fliessbach, A., Musafiri, C., F, R. & Ngetich, F. (2022). The Structural Quality of Soil Organic Matter under Selected Soil Fertility Management Practices in the Central Highlands of Kenya. *Sustainability*, 2023, 15, 6500, 1-13. https://doi.org/ 10.3390/su15086500,

Gruhn P., Gelotti F. and Yudelman M. (2000). Integrated Nutrient Management, Soil Fertility Challenges: Current Issues and Future Challenges. *Food, Agriculture and Environment Discussion Paper* 32: 20–33. https//www.scielo.cl/pdf/jsspn/v17n2/a0o3517.pdf

Ibrahim, A. & Shazali, N. (2020). Geology and Petrography of Precambrian Rocks of Katsina Urban Area, North-Western Nigeria. *Research Review,* 1–14. Doi 10.5937/ZbDght2002113A

Kochakinezhad, H., Peyvast, G. A., Kashi, A. K., Olfati, J. A., & Asadi, A. (2012). A Comparison of Organic and Chemical Fertilisers for Tomato Production. *Journal of Organic Systems,* 7(2), 14–25.

Marzouk, H. A., & Kassem, H. A. (2011). Improving Fruit Quality, Nutritional Value, and Yield of Zaghloul Dates by Application of Organic and /or Mineral Fertilisers. *Scientia Horticulturae*. 127: 249-254.

Matsumoto R., Ishikawa H., Asfaw, A. & Asiedu, R. (2021). Low Soil Nutrient Tolerance and Mineral Fertiliser Response in White Guinea Yam (Dioscorea Rotundata) Genotypes. *Frontiers in Plant Science.* 1- 9. doi: 10.3389/fpls.2021.629762

Moral, J. F., & Rebollo, F. J. (2017) Characterisation of Soil Fertility Using the Rasch Model. *Journal of Soil Science and Plant Nutrition*. 17 (2): 486-498. http://www.scielo.cl/pdf/jsspn/v17n2/a0o3517.

National Population Commission (NPC). (2006). Unpublished, *Population Census Report,* National Population Commission. Federal Republic of Nigeria

Osabohien, R., Jaaffar, A. H., Matthew, O., Osabohien, E., Adeleke, O. K., Olanade. O. Y., Okoh, G. O. & Khalid, A. A. (2024). Soil Management Practice and Smallholder Agricultural Productivity in Nigeria. *Discover Sustainability*, 1–16. http://doi.org/10.1007/s43621-024-00467-0

Owen B., & Collins D. (2012). *A 2020 Vision for Food, Agriculture and Environment in Sub-Saharan Africa.* International Food Policy Research Institute, Washington, D.C.

Thiery, E., Brunschwig, G., Veysset, P., Mosnier, C. (2023). Estimation of Short- and Long-Term Floor and Ceiling Prices for Manure in a Crop and Livestock Farms Exchange. *Renewable Agriculture and Food Systems*. 1–10. https://doi.org/10.1017/ S1742170523000108,

Tovihoudji, P.G., Akpo, F.I., TassouZakari, F., Ollabodé, N., Yegbemey, R.N., and Yabi, J.A. (2023). Diversity of Soil Fertility Management Options in Maize-Based Farming Systems in Northern Benin: A quantitative survey. *Frontiers in Environmental Science.* 1–12. doi:10.3389/fenvs.2023.1089883

Usman, S. U., Abdulhamid, A. I., Sawa, B. A., Yusif, Y. O., & Usman, A. K. (2016). Assessment of Spatial Coverage of Rainfall Data in Katsina State. BEST: *International Journal of Humanities, Arts, Medicine and Sciences.* 2 (7): 27–32. ISSN: 2348-0521

Zhao, S., Feyissa, T., Hailong, M., & Zhiping, D. (2022). Optimising Plant Density and Balancing NPK Inputs in Combination with Innovative Fertiliser Product for Sustainable Maize Production in North China Plain. *Scientific Reports.* 1-12 http://doi.org/10.1038/s41598-022-13736-7,