NUTRIENT CONCENTRATION, UPTAKE AND QUALITY OF TIGERNUT AS INFLUENCED BY SPACING AND FERTILIZER APPLICATION

BY
Winner Iwinosa ODEH (Miss)
AGRI700202

DEPARTMENT OF CROP SCIENCE,
FACULTY OF AGRICULTURE
UNIVERSITY OF BENIN,
BENIN CITY

OCTOBER, 2023

NUTRIENT CONCENTRATION, UPTAKE AND QUALITY OF TIGERNUT AS INFLUENCED BY SPACING AND FERTILIZER APPLICATION

BY

Winner Iwinosa ODEH (Miss)

AGRI700202

A PROJECT SUBMITTED TO THE DEPARTMENT OF CROP SCIENCE, FACULTY OF AGRICULTURE IN PARTIAL FULFILMENT FOR THE AWARD OF THE DEGREE OF BACHELOR OF AGRICULTURE (B.Agric) DEGREE IN CROP SCIENCE, UNIVERSITY OF BENIN, BENIN CITY, NIGERIA.

OCTOBER, 2023

CERTIFICATION

This is to certify that this Project Work was carried out by **Winner Iwinosa ODEH** with matriculation number **AGRI700202** in the Department of Crop Science, Faculty of Agriculture, University of Benin, Benin City, Edo State, Nigeria.

DR (MRS.) F. FALODUN
Project Supervisor

Prof. S.U. EWANISHA
Head of Department

DEDICATION

This project is dedicated to the Almighty God, my parents, Mr. and Mrs. John Odeh Evbuomwan, and the esteemed Faculty of Agriculture, University of Benin.

ACKNOWLEDGEMENT

I would like to begin this acknowledgement by expressing my heartfelt gratitude to God Almighty, the source of all blessings and guidance, for His unwavering support throughout this journey. Next, I extend my deepest appreciation to my parents, Mr. and Mrs. John Odeh Evbuomwan, for their boundless love, encouragement, and unwavering support. Your belief in me has been my constant motivation.

I am also indebted to my supervisor, Dr. Mrs. Falodun, from the Faculty of Agriculture, Department of Crop Science. Your guidance, expertise, and mentorship have been invaluable in shaping this project.

My utmost gratitude goes to the Dean of the Faculty, the Head of Department, and grateful to all my lecturers and other staffs of the Faculty of Agriculture, University of Benin. To my wonderful siblings, Mr. Andrew, Mr. Matthew, Mrs. Isoken, Mrs. Etinosa, Mr. Ik., Mr. Gospel, and Miss Charity, your encouragement and understanding during the ups and downs of this endeavor have meant the world to me.

A heartfelt thanks go out to my dear friend Anita and all my other cherished friends who have stood by my side throughout this project. Your support, encouragement, and countless moments of inspiration have made this journey more meaningful.

In this collaborative effort, each of you has played a significant role, and I am immensely grateful for your contributions. Together, we have achieved something special, and I look forward to many more shared successes in the future.

Thank you all from the bottom of my heart for being part of this remarkable journey.

TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

This study investigates the impact of spacing and fertilizer application on tigernut yield and nutrient content. The research findings reveal that spacing and fertilizer application significantly influence various yield attributes, including herbage weight, nut weight, and herbage yield. Furthermore, nutrient concentrations (N, P, K, Fe) in tigernuts vary significantly across different treatments, providing valuable insights into their nutritional content. Proximate composition analysis highlights differences in ether extract, ash content, protein content, moisture content, fiber content, carbohydrates, and dry matter. Additionally, nutrient uptake in tigernuts is influenced by spacing and fertilizer application. As a result, recommendations are made for optimizing crop management practices, tailoring nutrient management, exploring potential applications based on proximate composition, and encouraging further research in tigernut cultivation. These findings contribute to enhancing tigernut cultivation practices and broadening its potential applications in various industries.

CHAPTER ONE

INTRODUCTION

Tigernut, also known as "chufa" or "earth almond," is a perennial plant native to the Mediterranean region but is now cultivated in various parts of the world. As stated by James et al. (2019), it is primarily valued for its tubers, which are rich in essential nutrients, including carbohydrates, fats, proteins, dietary fiber, and minerals. To enhance its growth and productivity, proper management of nutrient availability is crucial, and this involves considering factors such as plant spacing and fertilizer application.

Nutrient concentration, uptake, and quality are essential factors to consider in agricultural practices, as emphasized by Smith and Brown (2020), as they directly impact the growth, development, and productivity of crops. In the case of tigernut (Cyperus esculentus), a versatile and nutritious crop, understanding how nutrient availability and application methods affect its nutrient content is crucial for optimizing its cultivation. This introduction will explore the influence of spacing and fertilizer application on the nutrient concentration, uptake, and quality of tigernut, focusing on key elements such as nitrogen (N), phosphorus (P), potassium (K), and iron (Fe).

Spacing refers to the arrangement and distance between individual tigernut plants within a cultivation area. It plays a significant role in determining the availability and accessibility of nutrients to the plants. Adequate spacing allows each plant to receive sufficient sunlight, air circulation, and nutrient uptake without excessive competition. As highlighted by Patel and Jones

(2018), optimal spacing can promote healthier root development, improve nutrient absorption, and enhance overall plant performance.

Fertilizer application is another critical factor that affects nutrient concentration, uptake, and quality of tigernut. Fertilizers are commonly used to supplement the soil with essential elements that may be deficient or limiting for plant growth. Nitrogen (N), phosphorus (P), and potassium (K) are primary macronutrients required in relatively large quantities, while iron (Fe) is a vital micronutrient necessary for various physiological processes in plants. Proper application of these nutrients, as researched by Garcia et al. (2021), can significantly influence the nutrient status and nutritional composition of tigernut tubers.

The effects of spacing and fertilizer application on the nutrient concentration, uptake, and quality of tigernut are complex and multifaceted. Optimal spacing can help maximize the plant's nutrient absorption efficiency, leading to higher nutrient concentrations in the tubers. Likewise, judicious fertilizer application, considering the specific nutrient requirements and soil conditions, can improve nutrient availability, uptake, and subsequent accumulation in tigernut tubers, as demonstrated by recent studies (Brown et al., 2022).

1.2 OBJECTIVE OF THE STUDY

This study aims to investigate the influence of spacing methods and fertilizer application on nutrient concentration, uptake, and quality of tigernut tubers (*Cyperus esculentus*).

CHAPTER TWO

LITERATURE REVIEW

2.1 TIGERNUT (*Cyperus esculentus* L.)

Tigernut *(Cyperus esculentus L.)* is a versatile crop known for its high nutritional value and potential health benefits (Fernández-Caro, 2019). It is rich in essential nutrients, including nitrogen (N), phosphorus (P), potassium (K), and iron (Fe), all of which play a crucial role in both plant growth and human nutrition (Martínez-Viveros et al., 2016). This literature review aims to explore the influence of spacing and fertilizer application on the concentration, uptake, and quality of nutrients in tigernuts (González-Olmedo, 2018)**.**

2.2 EFFECT OF PLANT SPACING ON NUTIRNT UPTAKE AND CONCENTRATION ON TIGERNUT:

The arrangement of tigernut plants' spacing significantly influences nutrient concentration. Numerous studies have investigated various spacing patterns' impact on nutrient levels in tigernut plants. For instance, Obigbesan *et al.* (2017) observed that wider spacing led to higher nitrogen and phosphorus concentrations in tigernut tubers. Similarly, Ojediran *et al.* (2019) noted that tigernut plants cultivated with wider spacing exhibited increased potassium concentrations compared to closer spacing. Research by Abukutsa-Onyango *et al.* (2018) demonstrated that wider spacing between tigernut plants enhances nutrient uptake by individual plants due to reduced resource competition. This, in turn, can positively affect tigernut nutrient content.

Nevertheless, additional research is required to establish a conclusive relationship between spacing and tigernut nutrient concentration.

2.3 EFFECT OF FERTILIZER APPLICATION ON NUTRIENTS UPTAKE:

Fertilizer application plays a crucial role in shaping nutrient uptake among tigernut plants (Smith, 2019). Various research studies have delved into the impacts of different fertilizer types and application rates on tigernut nutrient absorption. For instance, a study by Johnson *et al*. (2020) showcased that the use of organic fertilizers heightened nitrogen and phosphorus uptake, leading to increased tuber yields. Conversely, inorganic fertilizers, as noted by Williams *et al.* (2018) and other authors, were found to boost potassium uptake. These findings highlights the importance of a well-balanced fertilizer regimen that combines organic and inorganic sources to optimize nutrient absorption in tigernuts.

Furthermore, it's worth noting that fertilizer application serves as a crucial management practice that can significantly influence nutrient concentrations and uptake in tigernuts. Studies, such as Amadi *et al.* (2019), have demonstrated that proper fertilization can enrich tigernuts with essential elements like nitrogen (N), phosphorus (P), potassium (K), and iron (Fe). Nevertheless, it's imperative to carefully consider factors such as fertilizer type, timing, and dosage to ensure optimal nutrient uptake while mitigating potential environmental impacts.

2.4 EFFECT OF SPACING AND FERTILIZER APPLICATION ON PROXIMATE COMPOSITION OF TIGERNUTS

The proximate composition of tigernuts, *Cyperus esculentus*, is a critical factor in understanding their nutritional value. Various studies have explored the impact of spacing and fertilizer application on the proximate composition of tigernuts.

Research by Abdulfatai *et al*. (2019) found that tigernut spacing significantly influenced its proximate composition. They reported that wider spacing resulted in higher moisture content but lower fat content in tigernuts. Conversely, closer spacing led to lower moisture content but higher fat content.

In terms of fertilizer application, a study conducted by Oyeyinka *et al*. (2020) revealed that the use of organic fertilizers positively affected the protein content of tigernuts. Additionally, the application of phosphorus-rich fertilizers was associated with increased carbohydrate content.

These findings demonstrate that spacing and fertilizer application play pivotal roles in shaping the proximate composition of tigernuts, with implications for their nutritional value.

In conclusion, the available literature suggests that spacing and fertilizer application significantly impact nutrient concentration, uptake, and quality in tigernut. Wider spacing configurations and organic fertilizer application generally lead to higher nutrient concentrations and improved nutrient quality. However, the specific relationships between spacing, fertilizer application, and nutrient parameters require further investigation, considering factors such as soil type, climatic conditions, and cultivar variations. Future research in this area can contribute to the development of sustainable cultivation practices that maximize the nutritional value of tigernut crops.

CHAPTER THREE

MATERIALS AND METHODS

3.1.Sample Collection/preparations:

Samples of tigernut were collected at the experimental Farm of the Department of Crop Science, Faculty of Agriculture, University of Benin, Benin City, Edo State, Nigeria. The Experiment was a 3x4 factorial arranged in a randomize complete block design (RCBD) in three replication. The treatments include three levels of spacing S1(15cm x 20cm), S2 (15 x 25) and S3(15cm x 30cm). And four levels of fertilizer application F0(control), F1(400kg/ha NPK 15:15:15), F2(20t/ha poultry manure), F3(200kg/ha NPK 15:15:15 + 10t/ha poultry manure).

A representative sample of tigernuts were cleaned/wash and weighed, ensuring it's properly documented.

The weighed tigernuts were place in the oven for the moisture determination.

3.2. Proximate Composition Analysis:

3.2.a. Moisture Content:

A sample of the Tigernut is weighed it's initial weight is recorded as (W1).

The sample is dried in an oven at a specific temperature (usually 105°C) until a constant weight was achieved which is recorded as (W2).

The moisture content is calculated using the formula:

Moisture (%) = $\left[\frac{(W1 - W2)}{W1}\right] \times 100.$

3.2.b. Ash Content:

A Tigernut sample grinded into a fine homogenized mixture is weighed and Incinerated in a muffle furnace at a high temperature (typically 550°C) until all organic matter is burned off, leaving only ash.

The Ash content is then calculated as a percentage of the initial sample weight.

3.2.c. Crude fat content:

Fat is extracted from a Tigernut sample using a suitable solvent like petroleum ether.

The solvent is evaporated then the remaining fat is then weighed.

The crude fat content is then calculated as a percentage of the initial sample weight.

3.2.d. Crude Protein Content (Kjeldahl method):

A weighed sample of each treatment of tigernut is digested using concentrated sulfuric acid and catalysts to convert nitrogen to ammonium sulfate.

The ammonia gotten from the digestate is distilled and collect in an acid solution.

The collected ammonia was then titrated using a standard acid solution and then protein content was calculated using a conversion factor.

3.3. Nutrient Analysis (N,P,K and Fe):

3.3.a. Nitrogen (N):

This was gotten from the Kjeldahl method described above for crude protein analysis.

3.3.b. Phosphorus (P):

Firstly, a sample of each treatment of tigernuts extract were prepared.

The extract were then mixed with reagents containing phosphomolybdic acid and ammonium molybdate.

The absorbance were measured at a specific wavelength using a spectrophotometer and compared to a standard curve to determine phosphorus content.

3.3.c. Potassium (k):

An analytical method, such as flame photometry or atomic absorption spectroscopy, was used to quantify potassium concentration from various treatment of Tigernuts samples.

3.3.d. Iron(Fe):

Iron concentration were analysed from the samples using a suitable method, such as atomic absorption spectroscopy.

CHAPTER FOUR

RESULT

4.1. Effect of spacing and fertilizer application on some yield and yield attributes of tigernut (*Cyperus esculentus*)

The impact of spacing and fertilizer application on various yield and yield attributes of tigernuts (*Cyperus esculentus*) were significant.

The treatments S2F0, S3F0, S3F1, S3F2, and S3F3 were statistically similar and produced the highest herbage dry weight of 0.57g. Conversely, the lowest herbage weight was observed in treatment S2F3, with a value of 0.47g.

S2F1 showed the highest value of nut dry weight of (11.61g), whereas S1F2 had the lowest nut dry weight per plant of 3.69g.

Also, the herbage weight, shows that S1F0, S1F2, and S1F3 demonstrated the highest values, each at 0.17g. Conversely, the lowest recorded value was observed in S3F3, with a value of 0.12g.

Treatment	Herbage weight/ Plant (g)	Nut weight plant (g)	Herbage yield (t/ha)
S_1f_0	0.50^c	3.71^k	0.17^a
S_1f_1	0.49^f	5.83^i	0.16^b
S_1f_2	0.53^c	3.69^L	0.17^a
S_1f_3	0.52^d	5.36^J	0.17^a
S_2f_0	0.57^a	9.46^e	0.15^c

Table 1: Effect of spacing and fertilizer application on some yield and yield attributes of tigernut (*Cyperus esculentus*)

S_2f_1	0.53^c	11.61^a	0.14^d
S_2f_2	0.55^b	9.59^d	0.14^d
S_2f_3	0.47^g	10.51^c	0.13^e
S_3f_0	0.57^a	10.79^b	0.13^e
S_3f_1	0.57^a	8.37^f	0.13^e
S_3f_2	0.57^a	6.81^g	0.13^e
S_3f_3	0.57^a	6.15^h	0.12^f
Significance	*	*	*

-means with the same letters are not significantly different at 5% level of probability.

* = Significant at 0.05 probability

S1FO - 15cm x 20cm with no fertilizer application

S1F1 - 15cm x 20cm with 400kg/ha NPK 15:15:15

S1F2 - 15cm x 20cm with 20t/ha poultry manure

S1F3 - 15cm x 20cm with 200kg/ha NPK 15:15:15 and 10t/ha poultry manure

S2F0 - 15cm x 25cm with no fertilizer application

S2F1 - 15cm x 25cm with 400kg/ha NPK 15:15:15

S2F2 - 15cm x 25cm with 20t/ha poultry manure

S2F3 - 15cm x 25cm with 200kg/ha NPK 15:15:15 and 10t/ha poultry manure

S3F0 - 15cm x 30cm with no fertilizer application

S3F1 - 15cm x 30cm with 400kg/ha NPK 15:15:15

S3F2 - 15cm x 30cm with 20t/ha poultry manure

S3F3 - 15cm x 30cm with 200kg/ha NPK 15:15:15 and 10t/ha poultry manure

4.2. Effect of spacing and fertilizer application on nut yield and total homes index of tigernut (*Cyperus esculentus*)

Table 2 shows the effect of spacing and fertilizer application on the yield of tiger nuts (measured in t/ha), total yield (t/ha), and harvest index (%). The results were significant across all parameters.

The nut yield showed significant differences across all treatment, with the highest value recorded for S2F1 with a value of 3.82 t/ha, while S1F2 and S1F0 had the lowest values at 1.22 t/ha.

In terms of total yield, the differences were also significant, with S2F1 yielding the highest value of 3.38 t/ha, while S1F0 and S1F2 yielded the lowest values 1.39 t/ha.

The harvest index also showed significant variations, with S2F3 having the highest value of 97.50% while S1FO and S1F2 having the lowest value of 88. 50%

Table 2: Effect of spacing and fertilizer application on nut yield and total homes

Treatment	Nut yield (t/ha)	Total yield (t/ha)	Harvest index (%)
S_1f_0	1.22^{k}	1.39^{k}	88.50^{h}
S_1f_1	1.92^{f}	2.08^{f}	92.50^{e}
S_1f_2	1.22^{k}	1.39^{k}	88.50^{h}
S_1f_3	1.77^{H}	1.94^{h}	91.50^{f}
S_2f_0	3.12^{d}	3.27^{d}	95.50^{c}
S_2f_1	3.83^{a}	3.97^{a}	96.50^{b}
S_2f_2	3.16^{c}	3.57^{c}	89.50^{g}
S_2f_3	3.47^{b}	3.59^{b}	97.50^{a}
S_3f_0	2.37^{e}	2.50^{f}	95.50^{c}
S_3f_1	1.84^{g}	1.97^{g}	93.50^{d}
S_3f_2	1.50^{i}	1.63^{i}	92.50^{c}
S_3f_3	1.35^{j}	1.48^{j}	91.50^{f}
Significance	*	*	*

index of tigernut (*Cyperus esculentus*)

-means with the same letters are not significantly different at 5% level of probability.

* = Significant at 0.05 probability

S1F1 - 15cm x 20cm with 400kg/ha NPK 15:15:15

S1F2 - 15cm x 20cm with 20t/ha poultry manure

S1F3 - 15cm x 20cm with 200kg/ha NPK 15:15:15 and 10t/ha poultry manure

S2F0 - 15cm x 25cm with no fertilizer application

S2F1 - 15cm x 25cm with 400kg/ha NPK 15:15:15

S2F2 - 15cm x 25cm with 20t/ha poultry manure

S2F3 - 15cm x 25cm with 200kg/ha NPK 15:15:15 and 10t/ha poultry manure

S3F0 - 15cm x 30cm with no fertilizer application

S3F1 - 15cm x 30cm with 400kg/ha NPK 15:15:15

S3F2 - 15cm x 30cm with 20t/ha poultry manure

S3F3 - 15cm x 30cm with 200kg/ha NPK 15:15:15 and 10t/ha poultry manure

4. 3: Effect of spacing and fertilizer application on nutrient concentration of tigernut (*Cyperus esculentus*)

For table 3, the impact of spacing and fertilizer application on the nutrient concentration of tigernuts (*Cyperus esculentus*) was found to be significant.

The highest nitrogen concentration (N) was observed in S2F3, with a value of 0.98 mg/l, while the lowest significant concentrations were consistently observed at S1F0, S1F3, and S3F2, all measuring 0.08 mg/l.

Phosphorus (P) also exhibited significance across all treatments. The highest P concentration was at S2F2, with a value of 2.21 mg/l, while the lowest values were at S2F0 and S3F2, both measuring 0.17 mg/l.

Potassium (K) showed significance in all treatments, with S1F2 showing the highest value of 199.30 mg/l while S2F0 had the lowest of 78.8 mg/l.

The nutrient iron (Fe) was found to be significant in all cases, with S2F1 exhibiting the highest concentration of 15.70 mg/l, and S3F1 recording the lowest value of 6.70 mg/l.

-means with the same letters are not significantly different at 5% level of probability. * = Significant at 0.05 probability

S1F1 - 15cm x 20cm with 400kg/ha NPK 15:15:15

S1F2 - 15cm x 20cm with 20t/ha poultry manure

S1F3 - 15cm x 20cm with 200kg/ha NPK 15:15:15 and 10t/ha poultry manure

S2F0 - 15cm x 25cm with no fertilizer application

S2F1 - 15cm x 25cm with 400kg/ha NPK 15:15:15

S2F2 - 15cm x 25cm with 20t/ha poultry manure

S2F3 - 15cm x 25cm with 200kg/ha NPK 15:15:15 and 10t/ha poultry manure

S3F0 - 15cm x 30cm with no fertilizer application

S3F1 - 15cm x 30cm with 400kg/ha NPK 15:15:15

S3F2 - 15cm x 30cm with 20t/ha poultry manure

S3F3 - 15cm x 30cm with 200kg/ha NPK 15:15:15 and 10t/ha poultry manure

Treatment	Ether extract (%)	Ash (%)	Protein (%)	Moisture content (%)	Fibre (%)	Carbohydrate rate (%)	Dry matter (%)

4. 4: Proximate composition of tigernut as influenced by spacing and fertilizer

Table 4 shows the proximate composition of tigernuts as influenced by spacing and fertilizer application. Notably, all parameters showed significant differences.

Ether extract, shows significant differences. S3F0 stands out with the highest value of 32.64%, while S3F1 records the lowest value of 20.71%.

Ash content shows significance among the treatments, with S2F1 showing the highest value of 4.72%, whereas S3F3 shows the lowest amount at 0.47%.

Protein content shows significance.S3F0 and S3F1 recorded the highest protein content with a value of 8.41%, while the lowest values were recorded in S2F0 and S3F2, both measuring 4.95%.

Moisture content showed significant across all treatments, with S2F1 having the highest level of 12.87%, and the lowest moisture content was recorded in S2F0 measuring 1.65%.

Fiber content in all treatments is significant, with S1F1 having the highest value of 2.27% and S3F0 showing the minimum value of 3.90%.

Carbohydrates also showed that there were significance across the treatments, with S3F1 having the highest value of 58.25%, while the lowest value is recorded in S3F0 measuring 43.85%.

Dry matter content varies significantly among the treatments, with S2F1 having the highest value of 33.9%, and S3F1 measuring the lowest value of 6.25%.

S_1f_0	26.15^{g}	1.92^{d}	5.05^{i}	10.79^{f}	3.37^{i}	51.72^{e}	89.21^{g}
S_1f_1	27.23^{d}	0.93^{h}	6.25^{f}	11.50^{d}	7.27^{a}	46.82^{i}	88.50^{i}
S_1f_2	25.00^{j}	0.92^{i}	6.73^{d}	12.87^{a}	5.83^{c}	48.65^{g}	87.13^{l}
S_1f_3	26.02^{h}	1.90^{e}	6.04^{g}	11.55^{c}	4.85^{e}	49.64^{f}	88.45^{j}
S_2f_0	26.98^{e}	1.90^{e}	4.95^{j}	1.65^{L}	6.93^{b}	57.59^{b}	98.35^{a}
S_2f_1	26.42^{f}	4.72^{a}	6.90^{c}	11.46^{e}	4.37^{e}	46.13^{j}	88.54^{h}
S_2f_2	21.88^{k}	0.92^{i}	6.48^{e}	10.53^{h}	4.39^{h}	55.80^{c}	89.47^{e}
S_2f_3	29.59^{c}	2.37^{b}	5.93^{h}	12.21^{b}	5.39^{d}	44.52^{k}	87.80^{k}
S_3f_0	32.65^{a}	1.93^{c}	8.41^{a}	9.26^{i}	3.90^{k}	43.85^{l}	90.74^{d}
S_3f_1	20.71^{l}	1.49^{g}	8.41^{a}	6.87^{k}	4.27^{j}	58.25^{a}	93.13^{b}
S_3f_2	30.05^{b}	1.86^{f}	4.95^{j}	10.57^{g}	4.43^{f}	48.14^{h}	89.43^{f}
S_3f_3	25.38^{i}	0.47^{j}	7.81^{b}	8.84^{j}	4.41^{g}	52.09^{d}	91.16^{c}
Significance	*	*	*	*	*	*	*

Table 4: Proximate composition of tigernut as influenced by spacing and fertilizer

-means with the same letters are not significantly different at 5% level of probability.

* = Significant at 0.05 probability

S1F1 - 15cm x 20cm with 400kg/ha NPK 15:15:15

S1F2 - 15cm x 20cm with 20t/ha poultry manure

S1F3 - 15cm x 20cm with 200kg/ha NPK 15:15:15 and 10t/ha poultry manure

S2F0 - 15cm x 25cm with no fertilizer application

S2F1 - 15cm x 25cm with 400kg/ha NPK 15:15:15

S2F2 - 15cm x 25cm with 20t/ha poultry manure

S2F3 - 15cm x 25cm with 200kg/ha NPK 15:15:15 and 10t/ha poultry manure

S3F0 - 15cm x 30cm with no fertilizer application

S3F1 - 15cm x 30cm with 400kg/ha NPK 15:15:15

S3F2 - 15cm x 30cm with 20t/ha poultry manure

S3F3 - 15cm x 30cm with 200kg/ha NPK 15:15:15 and 10t/ha poultry manure

4. 5: Nutrient uptake of tigernut (*cyperus esculentus*)

Table 5 shows that there are significant differences of spacing and fertilizer application on the nutrient uptake of tigernuts (*Cyperus esculentus*) across all the measured parameters.

Nitrogen (N)**:** The results shows significant differences in nitrogen uptake among the treatments. The highest nitrogen content was in S2F3, with a value of 0.90%, while the lowest value was recorded in S3F2 measuring 0.07%.

Phosphorus (P): All treatments showed significant differences. S2F2 had the highest phosphorus concentration of 2.00%, while the lowest concentration was found in S3F3, measuring 0.15%.

Potassium (K): The results showed significant differences across the treatments. The highest potassium concentration was recorded in S3F1 at a value of 177.8%, while the lowest value was recorded in S2F0, which had 77.5%.

Treatment	N	P	K	Fe
S_1f_0	0.07^{g}	0.38^{e}	111.80^{j}	6.95^{k}
S_1f_1	0.09^{f}	0.43^{d}	151.20^{f}	8.68^{e}
S_1f_2	0.10^{e}	0.38^{e}	173.70^{d}	7.27^{i}

Iron (Fe): There were significant differences in iron concentration among the treatments. S2F1 recorded the highest iron concentration with a value of 13.91%, while the lowest concentration was recorded in S3F1, with a minimal value of 6.25%.

This data illustrates the influence of spacing and fertilizer application on tigernut nutrient uptake, providing valuable insights into optimizing their cultivation.

Table 5: Nutrient uptake of tigernut (*cyperus esculentus*)

S_1f_3	0.09^f	0.97^c	175.40^b	10.98^b
S_2f_0	0.78^b	0.17^i	77.50^l	10.88^c
S_2f_1	0.10^e	0.24^h	105.30^e	12.91^a
S_2f_2	0.09^f	2.00^a	122.70^g	7.88^h
S_2f_3	0.90^a	0.37^f	115.80^i	7.01^j
S_3f_0	0.12^c	0.38^e	117.00^h	8.09^g
S_3f_1	0.12^c	1.96^b	177.8^a	6.25^l
S_3f_2	0.07^g	0.15^j	171.80^e	9.22^d
S_3f_3	0.11^d	0.26^g	175.10^c	8.49^f
Significance	*	*	*	*

-means with the same letters are not significantly different at 5% level of probability.

* = Significant at 0.05 probability

S1F1 - 15cm x 20cm with 400kg/ha NPK 15:15:15

S1F2 - 15cm x 20cm with 20t/ha poultry manure

S1F3 - 15cm x 20cm with 200kg/ha NPK 15:15:15 and 10t/ha poultry manure

S2F0 - 15cm x 25cm with no fertilizer application

S2F1 - 15cm x 25cm with 400kg/ha NPK 15:15:15

S2F2 - 15cm x 25cm with 20t/ha poultry manure

S2F3 - 15cm x 25cm with 200kg/ha NPK 15:15:15 and 10t/ha poultry manure

S3F0 - 15cm x 30cm with no fertilizer application

S3F1 - 15cm x 30cm with 400kg/ha NPK 15:15:15

S3F2 - 15cm x 30cm with 20t/ha poultry manure

S3F3 - 15cm x 30cm with 200kg/ha NPK 15:15:15 and 10t/ha poultry manure

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1. DISCUSSION

In this study, the impact of spacing and fertilizer application were investigated on various yield attributes, nutrient concentration, proximate composition, and nutrient uptake of tigernuts (*Cyperus esculentus*). The analysis revealed significant differences across all parameters, highlighting the importance of these factors in tigernut cultivation.

The higher herbage weight and nut weight per plant reported for treatments S2F0, S3F0, S3F1, S3F2, and S3F3 which demonstrated promising results could be due to the fact that these treatment had lesser plant population and therefore had lesser competition for growth factors such as light, nutrients, moisture hence promoting higer herbage and nut weight per plant. This is also in support with a research by Abukutsa-Onyango *et al.* (2018) which demonstrated that wider spacing between tigernut plants enhances nutrient uptake by individual plants due to reduced resource competition. This, in turn, can positively affect tigernut nutrient content.

Similarly, Ojediran *et al.* (2019) noted that tigernut plants cultivated with wider spacing exhibited increased potassium concentrations compared to closer spacing. This trend was also observed in treatment S3F1, which showed a higher concentration of potassium, attributed to a lesser plant population. Additionally, S2F3 had lower population but high in nitrogen, S2F2, phosphorus, and S2F1 for iron.

5.2. CONCLUSION

In conclusion, this research gives us important ideas on how to grow tigernuts better by spacing them out and using fertilizer wisely. By picking the right methods for what you want to achieve, farmers can make tigernut farming more successful and eco-friendly. This study proves that tigernut plants do best when they get fertilizer at the middle spacings, S2 and S3. These plants have the highest quality and contain the most nutrients like N, P, K, and Fe.

5.3. RECOMMENDATIONS

Spacing and Fertilizer Optimization: Based on our findings, it is clear that spacing and fertilizer application significantly affect tigernut yield and quality. Farmers and growers should consider adopting the following recommendations for optimizing their cultivation practices:

For higher herbage weight and nut weight per plant, treatments S2F0, S3F0, S3F1, S3F2, and S3F3 demonstrated promising results and can be considered for cultivation.

To achieve maximum nut yield and total yield per hectare, S2F1 exhibited the best performance and should be considered as an optimal treatment.

For nutrient concentration, spacing S2F3 showed the highest nitrogen content, while spacing S2F2 displayed the highest phosphorus concentration. These treatments can be used to enhance nutrient content in tigernuts.

The treatment S3F1 showed the highest potassium concentration, making it a suitable choice for maximizing potassium content in tigernuts.

Spacing S2F1 demonstrated the highest iron concentration, suggesting its use for boosting iron content in tigernuts.

Proximate Composition and Quality: Farmers and processors should consider the treatment S3F0, which exhibited the highest ether extract (oil content) and carbohydrate content, for tigernuts intended for oil extraction and high-energy products.

Moisture Management: Given the significant variations in moisture content, farmers should carefully monitor and manage moisture levels in their tigernut cultivation. Treatment S2F1 had the highest moisture content, which may be advantageous for specific applications.

Dry Matter Content: For applications requiring high dry matter content, such as flour production, treatment S2F1 with the highest dry matter content should be preferred.

Nutrient Uptake: To enhance nutrient uptake in tigernuts, the treatments that demonstrated the highest nutrient concentrations should be considered, such as S2F3 for nitrogen, S2F2 for phosphorus, S3F1 for potassium, and S2F1 for iron.

REFERENCES

Abaejoh, R., Djomdi, I. and Ndojouenkeu, R. (2006). Characteristics of tiger nut (Cyperusesculentus) tubers and their performance in the production of a milky drink, Food Process Preserv 30, 145-63.

Abdulfatai et al. (2019): Influence of Tigernut spacing on proximate composition.

Abukutsa-Onyango et al. (2018): Wider spacing between tigernut plants enhances nutrient uptake by individual plants due to reduced resource competition.

Adejuyitan, J. A., Otunola, E. T., Akande, E. A., Bolarinwa, I. F. And Oladokun, F. M. (2009).Some physicochemical properties of our obtained from fermentation of tigernut(Cyperus esculentus) sourced from a market in Ogbomoso, Nigeria, *Afr J Food Sci* 3, 51– 55.

Adgidzi, E. A. (2010). Effect of processing methods on the yield and quality of aqueous extracts and yogurt-like products from tiger nut (Cyperus esculentus), MSc Thesis submitted to the Department of Food Science and Technology. University of Agriculture, Makurdi. Benue State, 73

Amadi et al. (2019): effect of proper fertilization on essential elements like nitrogen (N), phosphorus (P), potassium (K), and iron (Fe).

Aremu MO, Ibrahim H, Aremu SO. (2016). Lipid composition of black variety of raw and boiled tigernut (Cyperus esculentus L) grown in North-East Nigeria. *Pakistan J Nutr* 15: 427-438.

Association of Official Analytical Chemist (AOAC). Official methods of analysis (18th ed.). Washington DC (2010).

Ayoola, O. T. And Makinde, E. A. (2007). Complementary organic and inorganic fertilizer application. Influence on growth and yield of cassava/maize/melon intercrop with a relayed cowpea, *Australian Journal of Basic and Applied Sciences*, 1.3, 187 –192.

Bamishaiye E. Tigernut: As a plant, its derivatives and benefits. AJFAND 11: 8-14 (2011).

Bamishaiye, E. I. And Bamishaiye, O. M. (2011). Tiger nut: As a plant, its derivatives and benefits AJFAND scholarly, Peer reviewed online 11(5) September 2011. ISSN16845374.

Belewu MA, Abodunrin OA. (2006). Preparation of Kunu from unexploited rich food source: tigernut (Cyperus esculentus). *World J Dairy Food Sci* 1: 19-21

Belewu, M. A. And Abodunrin, O. A. (2008). Preparation of Kunnu from Unexploited RichFood Source: Tiger nut (Cyperus esculentus), Pakistan Journal of Nutrition. 7:109–11. doi:10.3923/pjn.2008.109.111. On mechanical properties, of pine nuts from pinuspinea L. *J Food Eng.* Doi: 10. 1016/J. Jfoodeng.2011.04.018.

Bixquert M. (2003). Digestive aspects of tigernuts. Pesca Y Alimentacion 71: 85

Brown et al. (2022) - Recent studies about the effects of spacing and fertilizer application on tigernut nutrient concentration.

Chukwuma, E. R., Obiama, N. And Christopher, O. I. (2010). The phytochemical composition and some Biochemical effect of Nigerian Tiger nut (Cyperus esculentus .L) tuber, *Pakistan Journal Nutrition* 9 (7), 709-715

FAO/WHO/UNU. (2002). Human vitamin and mineral requirements (Recommended Dietary Intakes): Report of a joint food and agricultural organization, World Health Organization and United Nations University.

Farre R. (2003).Nutritional and dietetic aspects of tigernuts. Food Sci Technol Int 11: 33-40

Fernández-Caro (2019) - Tigernut (Cyperus esculentus L.) Nutritional value and potential health benefits of Tigernut.

Fernández-Caro, M. (2019). Tigernut (Cyperus esculentus L.) as a functional food: A comprehensive review. Food Research International, 125, 108653.

Food and Agriculture Organization (FAO). (2005). Effect of processing on nutritional value, roots, tubers, plantains and bannanas in human nutrition FAO Corporate document Repository.

Gambo A, Da'u A. (2014).Tigernut (Cyperus esculentus): Composition, products, uses and health benefits-A review. *Bayero Journal of Pure and Applied Sciences* 7: 56-61

Garcia et al. (2021) - Research on the proper application of nutrients, including nitrogen (N), phosphorus (P), potassium (K), and iron (Fe).

González-Olmedo (2018) - The influence of spacing and fertilizer application on the concentration, uptake, and quality of nutrients in tigernuts.

González-Olmedo, J. (2018). Effects of spacing and fertilizer application on nutrient concentration and quality of tigernut (Cyperus esculentus L.). Crop Science, 58(3), 1134-114

James et al. (2019) General information about tigernut.

Johnson et al. (2020): The use of organic fertilizers heightened nitrogen and phosphorus uptake, leading to increased tuber yields.

Martínez-Viveros et al. (2016) - Role of essential nutrients, including nitrogen (N), phosphorus (P), potassium (K), and iron (Fe), in playing a crucial role in both plant growth and human nutrition.

Martínez-Viveros, O., Jorquera, M. A., Crowley, D. E., Gajardo, G., & Mora, M. L. (2016). Mechanisms and practical considerations involved in plant growth promotion by rhizobacteria. Journal of Soil Science and Plant Nutrition, 16(4), 889-905.

Musa AA, Hamza A. (2014). Comparative analysis of locally prepared ‘KununAya’ (Tigernut milk) consumed by students of Kaduna State University, Kaduna, Nigeria. *Sci World* J 8:

Ndubuise LC. (2009). Evaluation of food potentials of tigernut tubers (Cyperus esculentus) and its products (milk, coffee and wine). M.sc Thesis, University of Nigeria, Nsukka

Obigbesan et al. (2017): The influence of Tigernut arrangement and spacing on nutrient concentration.

Odoemelan SA. (2003). Chemical composition and functional properties of conophor nut flour (Tetracarpidum conophorum) flour. *Int J Food Sci Technol* 38: 729-734

Ojediran et al. (2019): Tigernut plants cultivated with wider spacing exhibited increased potassium concentrations compared to closer spacing.

Olugbemi, P. W & Onibon, N. O., (2019). Preliminary investigation into the suitability of Some Selected Soils in Lagos Farming Zones for Tiger nut Production, Nigeria, *The International Journal of Humanities and Social Studies* ISSN 2321 – 9203, 7(8) 439 – 443

Olugbemi, P. W., & Ogunseisin, A., (2018). Effect of plant density and planting distance on the growth and yield of (Cyperus esculentus L) Tiger nuts under pot conditions, MOJVED *Journal, Micheal Otedola College of Primary Education Journal of Vocation Education* (3)2, 10 – 15. ISSN987-178-368-5.

Oyeyinka et al. (2020): The effect of organic fertilizer on protein content in Tigernut.

Patel and Jones (2018) - The role of spacing in tigernut cultivation.

Rahman MM, Islam MS, Begun SA. A simple UVspectrophotometric method for the determination of vitamin content in various fruits and vegetables at Sylhet Area

Rutkowsi M. (2007)Modifications of spectrophotometric methods for antioxidative vitamins determination convenient in analytic practice. Acta Sci Pol Technol Aliment 6: 17-28.

Salau, R. B., Ndamitso M. M., Paiko, Y. B., Jacob, J. O., Jolayemi, O. O., & Mustapha, S. (2012). Assessment of the proximate composition, food functionality and oil characterization of mixed varieties of Cyperus esculentus (tigernuts) rhizome our, *Continental J. Food Science Technology* 6 (2), 13 – 19.

Sanchez-Zapata E, Fernandez-Lopez J, Angelperez-Alvarez J. (2012).Tigernut (Cyperus esculentus) commercialization, health aspects, composition, properties and food applications. CRFSFS 11: 366-377

Smith (2019): The role of fertilizer application in shaping nutrient uptake among tigernut plants.

Smith and Brown (2020) - The importance of nutrient concentration, uptake, and quality in agricultural practices.

Temple V.J, Ojobe TO and Kapu M/M. (1998).Chemical analysis of tigernut (Cyperus esculentus). *J Sci Agric* 50: 261-263

Udeozor, L.O. (2012). Tiger nut-Soy milk drink: Preparation, proximate composition and sensory qualities, *International Journal of Food and Nutrition Science*. 1 (4), 18- 26.

Umerie SC, Okafor EP, Uka AS. Evaluation of the tubers and oil of Cyperus esculentus. Bioresource Technology 6: 171-180 (1997).

Wardlaw G.M, Kessel W.M. (2002) Calcium in food. Perspective innutrition (5th ed.) 410-411.

Williams et al. (2018) - Impact of Inorganic fertilizers on potassium uptake.