EFFECT OF DIGESTATE ADMIXED WITH TOPSOIL ON DRY MATTER PRODUCTION AND YEILD OF TIGER NUT (*Cyperus esculentus* L.)

BY

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MAY, 2024

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

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CERTIFICATION

This is to certify that this research was carried out by **Chinecherem Perpetua OKORIE (Miss)** of the Department of Crop Science, Faculty of Agriculture, University of Benin, Edo State. Nigeria.

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Prof. K. E. Law-Ogbomo Date
Project Supervisor.

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Prof. K. E. Law-Ogbomo Date
Head of Department.

DEDICATION

This project is dedicated to the almighty God who has been my strength throughout the course of this research, Also to my amazing parents, Mr. and Mrs. CHRISTIAN OKORIE and entire family

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ABSTRACT

The effect of digestate admixed top soil on the dry matter production of Tiger-nut (*Cyperus esculentus* L) was evaluated between December 2023 - April 2024 at the Department of Crop Science screen house, Faculty of Agriculture, University of Benin, Benin City, Edo state, Nigeria. The Experiment involved four application rates (0,5,10 and 15 kg N ha^{-1}) of digestate per 10 kg top soil laid out in a completely randomized design (CRD) with three replications. Data were collected at 10 - 14 weeks after planting (WAP) on shoot dry weight and nut dry weight; and at harvest on number of nuts per plant, nut size, weight and yield from the results, the application of digestate brought about increase in dry matter in terms of enhanced dry shoot and nut weight. Nut yield parameters were also improved through digestate application. The heaviest nut size (8.89g), highest nut weight (34.8g) and yield (0.69g) were recorded in top soil media treated with digestate at 10 kg N ha^{-1} which was not significantly ($p>0.05$) higher than those of plants produced from 5 kg N ha^{-1} digestate. Top soil media treated with digestate at 5 kg N ha^{-1} is thereby suggested for tiger nut farmers.

CHAPTER ONE

INTRODUCTION

Tiger nut (*Cyperus esculentus L.*) is an emergent grass-like plant belonging to the sedge family Cyperaceae. It is found to be cosmopolitan perennial crop of the same genus as the papyrus plant that is common in seasonally flooded wetlands (Vilmorin, 2010, Abaejoh, *et.al*., 2006). The tuber grows freely and is consumed widely in Nigeria and other parts of West Africa, East Africa, parts of Europe particularly Spain as well as in the Arabian Peninsula. It produces edible tubers that are between 0.3-1.9 cm in diameter. The tuber is rich in dietary fiber, carbohydrate (Adejuyitan, 2011) and protein (Oladele and Aina 2007; Belewu and Abodunrin 2008). The plant is an important food of high nutritional and economic values and a good source of starch for human consumption and industrial use (Chukwuma *et al.,* 2010)
The tubers are the economical parts of the plant since they contain about 50% digestible carbohydrates, 4-8% proteins and 9% crude fibers, and about 20-36% oil. In addition, many products can be obtained from it like tiger nut oil, flour and milk (Zhang *et al*., 1996). Zhang *et al.* (1996) also reported that the oil of the tiger nut tuber contains 18% saturated fatty acids (palmitic and stearic) and 82% unsaturated fatty acids (mainly olieic and linoleic acids) and therefore, has excellent nutritional qualities with a fat composition similar to olives and can be used as food oil as well as for industrial and medicinal purposes.

Tiger nuts have long been recognized for their health benefits as they have a high content of soluble glucose and oleic acid, along with high energy content (starch, fats, sugars and proteins), (Manson, 2005). They are rich in minerals such as phosphorous, potassium, calcium, magnesium and iron necessary for bones and tissue repair. Sugar-free tiger nut milk is suitable for diabetic people and also helps in weight control (Martinez, 2003). Due to its carbohydrates content with a base of sucrose and starch, and its high content of Arginine, this enhance the liberation of hormones insulin (Chevallier, 1996). Tiger nut contains a good quantity of vitamin B, which assists in balancing the central nervous system and helps to encourage the body to adapt to stress (David, 2005).

In Nigeria, tigernut is grown in the middle belt and northern region especially in Kano, Kaduna, Jigawa and Kastina states. The rainforest zone of the southwest (Oyo, Ogun, Ondo, Ekiti) and South-south (Edo and Delta) of Nigeria depend solely on tigernut supply from the Northern part of the country, this is attributed to the ignorance of intending farmers on the possibility of tigernut cultivation in the rainforest, agro ecological zone of Nigeria. Tigernut cultivation has attracted very little scientific and technological attention in recent times and there is death of information from the rainforest zone of Nigeria zone of Edo state on the effects of digestate on the dry matter production of tigernut. Hence, the study was undertaken to evaluate the effects of digestate on the dry matter production of tigernut. Hence, this study was undertaken to evaluate the effect of digestate on the dry matter production of tigernut.

CHAPTER TWO

LITERATURE REVIEW

2.1 Digestate

Digestate is a byproduct of anaerobic digestion, a process that breaks down organic matter in the absence of oxygen to produce biogas. It is a complex matrix of partially degraded organic matter, inorganic compounds, and microbial biomass, and contains all essential macro- and micro-nutrients in varying proportions, reflecting those in the feedstock (McCabe and Jensen, 2021). The nitrogen (N) content in a digestate from a mixed feedstock may typically be around 0.5% of the dry weight, and it has the potential to replace mineral fertilizers in protected horticulture (soilless systems). However, the nutrient use efficiency and harvest when digestate is used compared to commercial fertilizers have been reported to be inconsistent, and the results are often dependent on the control treatment used in different studies (Courtney and Mullen, 2008). Digestate can be used as a fertilizer in agriculture, but low concentrations of plant-available phosphorus (P) and sulfur (S) may be a limitation. During anaerobic digestion, biogas, primarily composed of methane (CH4) and carbon dioxide (CO_2), is produced through bacterial degradation of organic matter. The resulting digestate is characterized by high ammonium nitrogen (NH_4 -N) to total nitrogen ratio, alkaline pH (7.3-9.0), and a high concentration of potassium (K). The use of digestate as a fertilizer in agriculture can help reduce greenhouse gas emissions and dependence on mineral fertilizers, but the application methods and rates should be carefully considered to optimize its benefits and minimize potential risks. The nutrient composition of digestate can vary depending on the composition of the feedstock and process parameters, such as operating temperature and average retention time. Therefore, it is important to characterize the digestate and determine its nutrient content before using it as a fertilizer. Inhibition of the anaerobic digestion process can occur due to various factors, including the presence of toxic compounds, high organic loading rates, and low pH. Therefore, it is important to monitor and control the digestion process to ensure optimal performance and prevent inhibition (Van Grinsven and Bleeker, 2017).

2.2 Effect of Digesate on Soil Properties

Effect of digestate on soil properties depends on sources of digestate, processing, method of application type of soil and application dose (Achike *et al.,* 2019). Application of agricultural waste based digestate decreased soil bulk density and increase saturated hydraulic conductivity and moisture retention capacity indicating better aeration, better drainage in soil and subsequently better growth (Garg *et al.,* 2005).

The status of digested organic carbon, dissolved organic carbon, biochemical oxygen demand and their proportion are reliable parameters to predict Carbon and Nitrogen dynamics in the soil and hence the N-fertilizer potential of the digested materials (Albuquerque *et al.,* 2012). Application of digestate with less biodegradable organic fractions, availability of plant available N is ensured as ammonium is rapidly nitrified in soil. Available fraction of soil potassium and phosphorus were also reported to increase from digestate application depending upon soil type and soil layer (Baryga *et al.,* 2021). Sometimes digestate is unable to compensate for nutritional deficiencies for elements like potassium, magnesium, Ion and Zinc that occur in intensely farmed soil (Baryga *et al.,* 2021). Heavy metal accumulation from digestate varies with respect to soil type and source of digestate (Vaneeckhaute *et al.,* 2013).

Digestate are rich in plants nutrients as they retain nutrients from input raw materials and used in agriculture as soil amendment or fertilizer (Zacharof and Lovitt, 2014). In general, high concentration of total nitrogen, presence of 60-80% of it in mineralized form along with higher phosphorus and potassium make digestate a suitable consideration as soil applicants (Tambone *et al.*, 2009). The performance of digestate on soil as an amendment is found to be encouraging, though there are variations in their performance which depends on quality and nutritional value (Silkina *et al*., 2017). Digestate improve soil structures leading to increase in water holding capacity. This influence water uptake of plant, potentially affects DMC depending on rainfall patterns and irrigation practices (Xu *et al.,* 2017). Digestate introduce and activate diverse microbial communities to the soil. These microbes influence nutrients cycling and potentially impact plant growth and development through release of essential nutrients for plant uptake (Achike *et al.,* 2019).

2.3. Effect of Digestate on Crop Yield

Digestate can have both positive and negative impacts on crop growth and soil health. Properly applied digestate enhance soil fertility by increasing nutrient content, improving soil structure, and promoting microbial activities (Oppong *et al.,* 2018). It can also reduce the need for commercial fertilizers, thereby minimizing nutrient runoff and greenhouse gas emissions associated with fertilizer production and landfilling. However, excessive application of digestate can lead to high electrical conductivity (EC) levels, which can negatively affect crop growth, particularly in sensitive species like Chinese cabbage. High EC levels can cause osmotic stress, lowering plant productivity (Gabriele, 2014).

Therefore, partial substitution of fertilizer with digestates having relatively low nutrient value or partial to full substitution for digestate having relatively high nutrient value is recommended for crops sensitive to high EC level. The crops that benefit the most from digestate fertilizer include barley, Spinach, tomatoes, and lettuce. Studies have shown that digestate can increase or maintain similar growth in barley compared to mineral fertilizers, while decreasing growth in Chinese cabbages. In organic cultivation, digestate have shown favorable results in tomatoes and lettuce. Digestate have also been found to produce similar or increased yields compared with mineral fertilizers in crops such as spinach, tomatoes, and lettuce. The benefits of using digestate as a fertilizer include its nutrient-rich composition, positive impact on soil fertility and health, environmental sustainability, and cost-effectiveness compared to traditional chemical fertilizer. However, the application of digestate as a fertilizer should be carefully managed to avoid potential negative effects on crop growth and soil health (Achike *et al.,* 2019). The use of digestate as a fertilizer has positive effects on crop yield and soil quality. Digestate application increases crop yield and nutrient availability, and controlled management of digestate can suppress soil borne diseases, aid in the inactivation of certain weed seeds, and possibly reduce nutrient leaching while maintaining crop productivity (Abubaker and Risberg, 2015). A study on the use of digestate as a fertilizer for tomato in greenhouse found that digestate application increased crop yield and nutrient availabilities. Digestate-amended soils had reduced bulk density and increased soil organic matter (Doyeni and Stulpinaite, 2021). Use of digestate in an agricultural cropping system found that digestate application increased crop yield, nitrogen use efficiency, and nutritional quality of grain, the use of digestate as a fertilizer has also been shown to increase soil enzyme activities and soil water-holding capacity, and to hinder soil degradation due to salinity. However, the application of digestate is not widely acknowledged to increase crop yields and promote soil health and the effects of digestate application on crop yield and soil quality may depend on the type of digestate, the crop, and the soil type (Agron. Sustain. Dev., 2014). A study on the utilization of digestate as organic fertilization found that the utilization of digestate as fertilizer could further enhance the sustainable development of agriculture, but the application of digestate is not widely acknowledged to increase crop yields and promote soil health (Odlare and Arthurson *et al.,* 2011).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental Site

An experiment was conducted between December – April 2024 at the Department of Crop Science screen house, Faculty of Agriculture, University of Benin, Ugbowo Campus Benin City, Edo State, Nigeria. The area lies between latitude 6° 23' 37 and 6° 27' 26 North latitude 536'25 and 538'09" East, with an altitude of 162m above sea level. Benin City is in the rainforest zone of Nigeria characterized by a tropical or equatorial climate. The mean annual rainfall is 1761.90mm and daily mean temperature of 26.5°C. There is high rainfall during most months of the year and only a short period of dry season.

3.2 Sources of Planting Materials

The top soil for this experiment was obtained from the Department of Forestry and Wildlife and transported to the screen house for further use. A total bucket of 45 were filled with 10kg of soil each weighed in a weighing balance and perforated to prevent water logging. Tigernut seeds were obtained from Ring Road market Benin City. The Organic fertilizer was obtained from the Faculty of Life Sciences Department of Plants Science and Biotechnology, University of Benin, Benin City.

3.3 Experimental Design

The trial involved five application rates (0,39,78,117 and 150 ml representing 0,5,10,15, and 20 kg of N) of digestate per 10kg top soil laid out in a completely randomized design (CRD) with three replications. Each replications comprised 15 buckets making it a total of 45 buckets for the trial.

3.4 Laboratory Analysis of Top Soil admixed with Digestate

The soil sample was taken from 0-20 cm top soil, air dried and sieved and admixed with digestate and analyzed for their physical and chemical properties. Soil pH was measured using a glass electrode pH meter. Following the modified Mclean method (1982). The total nitrogen availability was determined using the Kjedahel method. Available phosphorus using the Bray-1 method and organic carbon using the adopted Walkey- black method (Walkey and Black,1934). To determine exchangeable acidity, 1N Kcl solution was used, while the exchangeable base was determined using Leachate with 1M ammonium acetate solutions. Atomic absorption spectrum were used to determine the available sodium and potassium levels. Total exchangeable base where calculated by summing up the value of all the bases (Ca, Mg,K and Na). The particle size distribution was determined using hygrometer methods by Bouyoucos (1951) as modified by Day (1965). Bulk density were determined by the core of sampler method (Grossman and Reinch, 2002), Porosity (PO)was obtained from the bulk density value with an assumed particle density value of 2.56gm^3 as follows, porosity (PO)

3.5 Experimental Procedure

The admixed topsoil and digestate were left for seven days with each being watered with 100ml of water every day for stability. After which the tiger nut seeds were sown at three (3) seeds per buckets at a depth of two (2) cm. The seeds were allowed to grow for seven (7) days after which seedlings were thinned to one (1) seedling per bucket. Irrigation took place daily, weeds and insect pest were done through hand picking

3.6 Data Collection

Data were collected at ten (10) and twelve (12) weeks after sowing on two (2) randomly selected plants from each treatment in all replications for dry matter determination. After which they were cleaned of soil and weighed to obtain the fresh weight. They were spiltted into aerial and nut portions and weighed separately then wrapped separately with aluminum foil paper, labelled and oven dried at 60°C to a constant weight. After oven dried, the dried shoot and nut were reweighed and harvest index HI computed as thus:

At harvest, number of fresh weight of nut (g), nut diameter (cm) and nut yield (t/ha) were determined.

Number of nuts

At harvest, the uproot nuts were counted from the two randomly selected plants and average computed to obtain the number of nuts per plant.

Fresh weight of nut (g)

The uprooted nuts obtained from the two randomly selected plants were weighed and average computed to obtain the nut weight per plant. The nut weight was divided by the number of nuts per stand to obtain the nut size (g).

Nut yield (t/ha)

The nut yield was established from nut weight and thus: Nut yield =200 ×w\10× 100 t ha-1 = 0.2w t ha^{-1}

Where W = nut weight (kg) per plant.

3.7 Data Analysis

Data collected were subjected to analysis of variance using SAS statistical package and the significant difference treatment means were separated using Least Significant Difference (LSD) at 5% level of significance.

CHAPTER FOUR

RESULT

4.1. Chemical composition of the digestate

The chemical composition of digestate shows that the pH is neutral. Electrical conductivity was moderate with adequate organic carbon, total nitrogen and exchangeable cations (Ca, Mg, Na) H^+ and Al were not detected. However, available phosphorus was low.

4.2. Properties of top soil admixed digestate potting mixture prior to planting Tiger nuts

Results of the physical and chemical properties of the different potting media before planting tiger nut is presented in Table 2. The sand content was highest in top soil without digestate application and lowest in top soil treated with 15 kg N digestate per ha^{-1}. Slit content respond positively to digestate application as top soil without digestate treatment had the lowest while that which received 10 kg N digestate ha^{-1} had the highest content. Clay values minored the distribution trend of slit. However, the highest content were recorded in top soil treated with 10 and 15 kg N digestate ha^{-1}. This was repeated for bulk density and electrical conductivity. Porosity was reverse of the distribution trend of clay content. The most porous was recorded in top soil without digestate application while least porous was recorded in top soil treated with 10 and 15 kg N digestate ha^{-1}. The pH values was lowest and highest in top soil treated with 0 and 15 kg N of digestate ha^{-1}, respectively. This trend was repeated for available Phosphorus, organic carbon, total nitrogen and exchangeable Ca and Mg. Exchangeable k were identical with top soil treated with 0 and 5 kg N of digestate but significantly lower than those recorded in top soil treated with digestate at the rate of 10 and 15 kg N ha^{-1}. This trend was mirror for exchangeable Na. However, all digestate treated with top soil had similar values.

Table 1: Chemical composition of digestate

Parameters	**Values**
pH	7.24
Electric conductivity	10.0
Organic carbon	32.4
Total N (g kg^{-1})	2.56
Available P (mg kg^{-1})	7.86
Exchangeable cations (cmol kg^{-1})	
K	0.80
Ca	10.2
Mg	9.25
Na	6.26
H^{+}	0
Al^{3+}	0

Table 2: Physical and chemical properties of topsoil admixed digestate before cropping with Tiger nut

Digestate	Particle size(g kg^{-1})			Porosity	Bulk density	EC	pH (H_20)	Avail P	Organic C	Total N	Exchangeable cations (cmol kg $^{-1}$)				EA(cmol/kg^{-1})	
(Kg N ha^{-1})	Sand	slit	Clay	%	(g cm^3)	($dsml^{-1}$)		(mg kg^{-1})	(g kg $^{-1}$)	(g kg $^{-1}$)	Ca	Mg	K	Na	H	Al
0	896	55	49	54	1.0	0.23	4.24	8.11	12.0	0.73	0.56	0.19	0.18	0.08	0.30	0. 20
5	894	56	50	52	1.1	0.25	4.14	11.20	13.6	0.84	0.58	0.20	0.18	0.10	0.25	0.16
10	890	57	53	50	1.2	0.27	4.92	13.60	13.0	0.81	0.60	0.20	0.20	0.10	0.23	0.18
15	891	56	53	50	1.0	0.28	5.03	15.50	14.6	0.86	0.68	0.21	0.20	0.10	0.22	0.12
LSD $_{(0.05)}$	2.5	0.7	1.9	2.1	0.013	0.328	0.268	0.91	2.81	0.051	0.027	0.007	0.010	0.09	0.032	0.031

4.3 Days To Emergency Of Tiger Nut Seeds

Results in Table 3 indicated that the application of digestate at 10 kg N/ha had the earliest seedling (5 days) which is significantly not earlier than the 0 kg N/ha. The latest emergency was recorded in top soil treated with digestate at the rate of 15 kg N ha $^{-1}$ (12 days).

4.4: Dry matter production of tiger nut

The response of shoot dry weight, nut dry weight and harvest index of tiger nut as influenced by digestate application to top soil is presented in Table 4 Increasing rate of digestate application from 0 - 15 kg N ha^{-1} led to a progressive increase in the shoot dry weight of the tiger nut plants at 10 weeks. The highest shoot dry weight was obtained with the TS + 15 kg N ha^{-1} digestate treatment. Media without digestate application had the lowest shoot dry weight throughout the sampling periods. At 12 WAP, all digestate treated top soil media had comparable shoot dry weight values which were significantly higher than plants produced from media without digestate treatment. At 14 WAP, plants raised from top soil without digestate application had the lowest shoot dry weight while plants raised from media treated with digestate at 5 and 10 kg N ha^{-1} had the highest shoot dry weight. Nut dry weight at 10 WAP was not detected in top soil without digestate application. plants grown from all media with digestate application had similar nut dry weight values which were significantly higher than those produced from top soil without digestate application. At 12 WAP, the highest and lowest nut dry weight were observed on plants raised in media treated with digestate at 0 and 5 kg N ha^{-1}, respectively. At 14 WAP, all plants with digestate treatment produced similar nut dry weights which were significantly higher than those produced from top soil without digestate application. Harvest index (HI) lowest value at 10 WAP was observed on plants produced on top soil without digestate application while the highest values were recorded in top soil treated with digestate at 5 and 10 kg N ha^{-1}. At 12 and 14 WAP, the highest and lowest HI were recorded on plants raised in media treated with digestate at 0-5 kgN ha^{-1} respectively.

4.5 Nut yield component of Tiger nut

Results in Table 5 showed the nut yield component of Tiger nut plant as influenced by digestate application. Number of nut per plant was not influenced by digestate application. Nut size was smallest in non digestate media and heaviest in media treated with digestate at the rate of 5 and 10 kg N ha^{-1} and declined at 15 kg N ha^{-1}. However, the highest nut weight and yield were observed in plants grown in media treated with digestate at 5 and 10 kg N ha^{-1}.

Table 3: Days to emergence of tiger nut plant as influence by top soil admixed with digestate.

Digestate (kg N ha^{-1})	Value
0	6
5	8
10	5
15	12
LSD $_{(0.05)}$	1.2

Table 4: Effect of top soil admixed with digestate on dry matter production of tiger nut plant.

Digestate (kg N ha^{-1})	Shoot dry weight(g), Week after planting			Nut dry weight (g), Week after planting			Harvest index		
	10	12	14	10	12	14	10	12	14
0	0.40	1.49	1.38	0.00	0.09	0.06	0.00	0.05	0.05
5	0.81	2.34	3.03	0.07	0.90	0.73	0.09	0.42	0.32
10	0.91	2.70	3.46	0.09	0.54	0.69	0.09	0.25	0.20
15	1.56	2.57	2.19	0.07	0.69	0.49	0.05	0.21	0.19
$LSD_{(0.05)}$	0.419	0.393	0.933	0.024	0.261	0.305	0.022	0.114	0.082

Table 5. Nut yield components of Tiger nut plant as influenced topsoil admixed with digestate.

Kg N ha^{-1} digestate	Nos of nuts per plants	Nut size (g)	Nut weight(g)	Nut yield (t ha^{-1})
0	4	4.17	14.5	0.28
5	6	7.50	30.7	0.61
10	5	8.89	34.8	0.69
15	5	6.04	21.7	0.44
LSD $_{(0.05)}$	ns	2.14	8.94	0.185

n.s _ not significant at 0.05 level of probability

CHAPTER FIVE

Discussion, Conclusions and Recommendations

5.1 Discussion

This study was carried out between December 2023 – April 2024 at the Department of Crop Science screen house, Faculty of Agriculture, University of Benin, Ugbowo Campus, Benin City, Edo State to evaluate the effects of digestate admixed top soil on the dry matter production of Tigernut. There were variations in shoot dry weights, nut dry weights and harvest index among potting media at different growth stage. Differential plants might be as a result of the properties in the media. Increasing digestate from 0-15 kg N ha^{-1} lead to a progressive increase in the shoot dry weights of tiger nut plant. Highest shoot dry weight at 10 WAP was observed in TS +15 kg N ha^{-1} media and highest at 12 and 14 weeks after planting were observed in TS+ 10 kg N ha^{-1} this is in supports with the findings of Xu *et al*. (2018) whose finding did not differ from those reached at higher digestate rates. This could as a result of the acid content in the soil following the increase in digesate application and environmental conditions.

Highest nut dry weights was observed on top soil+ 5kg N ha^{-1} of digestate on top soil + 0 kg N ha^{-1}, this may be as a result of some environmental conditions. This report is in agreement with the work of Li, *et al.* (2016) who concluded that the decrease in digesate application will lead to an increase in nut yield of Crop and increase in digesate will lead to the reduction in yield of crop.

Conclusion

This study shows that the application of digestate admixed topsoil brought about increase in dry matter production in terms of enhanced dry shoot and nut weight. But yield parameters were also improved through digestate application.

The heaviest nut size, highest nut weight and yield were recorded in top soil media treated with digestate at 10 kg N ha^{-1} which was not significantly higher than those of plants produced from 5 kg N ha^{-1} digestate.

Recommendations

Top soil media treated with digestate at 5 kg N ha^{-1} is thereby suggested for tiger nut farmers

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