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Rabbit Wastes and Its Potential to Boost Agricultural Productivity: A Synoptic Review in Sweet Potato Farming

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Abstract
In recent years, the precarious global economy, rising food, fuel, and fertilizer prices, the deteriorating environment and health risks posed by humans have dramatically redirected lines of agricultural research. This increasing concern of consumers has driven the demand for food that is produced with sustainable approaches. The need to implement these sustainable practices such as the application of rabbit waste is a drive to climate-smart agriculture. Sweet potato cultivation with rabbit waste as its fertilizer and pesticide will enhance crop yield as well as improve the health and fertility of the soil. Rabbit waste also enhances crop resistance by repelling pests such as aphids, fall armyworms, etc., and thus reduces costs on plant protection products, due to the high level of nitrogen, phosphorus and potassium contained in them.
Keywords: Rabbit waste, rabbit urine, sweet potato, fertilizer

Introduction

Agricultural productivity and inputs

Accesses of farmers to modern agricultural inputs are the driver of any agricultural revolution. Improved seeds, fertilizers, plant protection chemicals (pesticides, herbicides, insecticides and fungicides), machinery, irrigation and knowledge are agricultural inputs of importance to farmers for effective production (Sahel, 2014). Improved and clean planting materials are assurances to successful crop production and inevitably for farm productivity and profitability. Fertilizers are boosters and they supply nutrients needed by the soil for the essential growth of plants. Irrigation also an essential agricultural input for productivity enables off-season farming; this farming system provides the opportunity for multiple harvests per year. Agrochemicals (pesticides, herbicides, insecticides and fungicides) control wanted plants, un-beneficial insects/pests and diseases that cause damage to crops. Technical know-how and mechanized farming enhance human labour effectiveness and farm production.

Fertilizer is an organic or inorganic material that, when applied to the soil improves the nutrient level including every soil's properties such as the physical, chemical, and biological properties of the soil. The amount of inorganic fertilizer used has always out-numbered organic materials this is due to its easy-to-use form and faster mineralization. The major three nutrients contained in fertilizers are; nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O). The overall fertilizer use in 2020 was 66 million tonnes with Asia ranking first at 55% of the world's total agricultural use of inorganic fertilizers, followed by the Americas (27 %), Europe (12 %), Africa (4 %) and Oceania (2 %). This ranking cuts across all nutrients in a fertilizer (FAOSTAT, 2022). From this report, Africa with its arable land was trailing behind, just before Oceania.

The incessant use of chemical fertilizer to enhance crop productivity has many drawbacks and could be harmful to the crop, soil, and humans. It has posed a lot of soil problems, such as decay in the structure and natural state of the soil and soil acidity due to excess application. The overuse has also reduced fertility and caused changes in the physicochemical and microbial attributes, erosion, groundwater pollution, and sometimes kills the plant (Liang *et al*., 2013; Montemurro *et al*., 2010; Meena *et al*., 2016). Due to the challenges faced by the soil, scientists have advocated for bio-fertilizers as an efficient alternative to smart agriculture (Pradeepkumar *et al*., 2017; Cervera-Mata *et al*., 2018). The demand for organic fertilizers is on the increase compared to mineral fertilizers due to accessibility, easy to afford and the availability of organic markets worldwide to enhance sustainable agricultural ecosystems without affecting yield and quality (Chatterjee *et al*., 2014; Hernández *et al*., 2016; Abuarab *et al*., 2019). Organic

fertilizers are highly beneficial with attributes including restoring the fertility of the soil, maintaining, and/or improving physicochemical and biological functions of soil, enhancing soil sanitation, improving crop production, and reducing gas emission of greenhouse (Hernández *et al*., 2014; Shehata *et al*., 2017). So much attention has not been paid to organic waste preservation and utilization and this has led to the continuous discard from animal farmers and the agro-industry at large (Fernández-Hernández *et al*., 2014). The micro and macro nutrient contained in the organic matter improves soil and plant health (Ayyobi *et al*. 2014; Abdeldaym *et al*., 2019). Studies have also shown that these wastes contain bioactive compounds able to suppress soil-borne diseases and phyto-parasitic nematodes (Abdeldaym *et al*., 2012; Abdeldayem *et al*., 2014; Federica *et al*., 2017; Asses *et al*., 2018; Atia *et al*., 2020).

Rabbit manure is a solid organic waste when applied to the soil improves the nutrients, humus, and soil aggregates and also encourages the life activity of soil microorganisms and beneficial insects (Astiari *et al*., 2019). In 2005, the Animal Research Agency in Ciawi, Bogor Regency reported that rabbit droppings have been found to contain higher elements of N, P, and K at 2.72%, 1.1%, and 0.5% respectively, compared to other livestock manure such as cows, buffaloes, sheep, horses, pigs, and chickens (Masaji *et al*., 2021). The application of between 10-15 tons of compost rabbit waste per hectare can improve soil fertility and crop yields (Situmeang *et al*., 2018; Situmeang *et al*., 2019; Sastrawan *et al*., 2020).

Rabbit manure used as an organic fertilizer in sweet potato farming is climate-smart agriculture. Reports on the effectiveness of this organic matter include; improving soil physical properties, increasing root fresh weight, plant health and growth, and being safe for consumption without fear of chemical residues that might become toxic (Sastrawan *et al*., 2020; Mesa *et al*., 2021; Kelderak *et al*., 2020).

Worldwide after rice, wheat, potatoes, maize, and cassava, sweet potato is the sixth most important food, especially in its carbohydrate quantity (Elameen *et al*., 2008) and the fifth most important food crop in developing countries (Elameen *et al*., 2008). China ranked the highest in sweet potato production with (47.8M Mts), followed by Malawi (7M Mts), Tanzania (5M Mts), and Nigeria (3.94M Mts) (Faostat, 2021). United States of America was the top global exporter, by volume of sweet potatoes in 2020.

Sweet Potato

Origin, Nutritional Values and Uses

Sweet potato (*Ipomoea batatas* L.) originated in South America and Christopher Columbus took it from America to Spain in 1492 (Ikeokwu and Orji, 2022). It was later introduced to Africa in 1520 by Sao Tome and in Nigeria in 1694-1894 by Portuguese traders whose activities were along the coast of Nigeria (Mbanaso, 2010). Sweet potato belongs to the family of Convolvulaceae and it is in the Genus Ipomoea. This short-cycled crop has good adaptive abilities; it is vigorous and able to survive in diverse agroecologies, marginal lands, and water-stress soils. (Sugri *et al*., 2017). The crop is a creeping annual vine with dark green leaves, soft heart-shaped to deeply indented leaves with various sizes on some plants. The flower is funnel-shaped, white to red or purple. Through contrarious vegetative multiplication in the tropics, sterile flowers developed. Sweet potato seeds which are eventually formed are only useful for breeding purposes. Sweet potato tuber colours range from white/cream fleshed, yellow, and purple to red colour. Mature tubers at harvest contain sugar (1.5 %), protein (1.5 %), low fat (0.2 %), and above all, starch (20 %) (Ikeokwu and Orji, 2022). The tuber varieties have been grouped based on colour and their nutritional content:

i. Tubers with majorly yellow/orange-fleshed, with high carotenoid content known as pro-vitamin A are powdery and mealy after cooking (Alam *et al*., 2016; Islam *et al*., 2016).
ii. White fleshed tubers are soft and sweet after processing and produce watery and gelatinous pulp.
iii. Purple-fleshed sweet potato clones with high anthocyanins (powerful antioxidants) which belong to the group of polyphenols have been developed at the NRCRI (Li *et al*., 2013, Tang *et al*., 2015)
iv. Tubers which are only useful as fodders (Jata *et al*., 2011).

Due to the high moisture in sweet potato, it has been termed a perishable root crop; making it susceptible to microbial attack and difficult to store for a long time during storage. Postharvest deterioration can also be influenced by the high respiratory rate of the crop which also leads to weight loss both in quality and quantity.

Sweet potatoes are universal and delicious, both the leaves and the roots contain beneficial high nutritional contents such as phenolic compounds, anthocyanins, sprains, carotenoids (Hussein *et al*., 2014), and vitamins A, B, C, and K, these qualities make sweet potatoes consumption not only satisfying as food but medicinally valuable with compounds that are anti-carcinogenic, anti-diabetic and anti-inflammatory (Mohanraj and Sivasankar, 2014). The USDA database in 2019 has characterized sweet potatoes by two major components; a higher energy value and a higher ratio of amylose when compared to Irish potatoes (*Solanum tuberosum* L.). Amylose is a healthy food component that gradually increases the sugar level in the blood compared to the simple saccharides and this is most important for the immuno-compromised groups especially those suffering from diabetes and cancer (Mohanraj and Sivasankar, 2014).

Antioxidants are relatively stable substances, non-toxic products with free radicals (Šlosár *et al*., 2020). They are very effective even in their smallest amount and retard or protect against oxidation. Studies have shown that

anthocyanin in sweet potato tubers increases the rate of antioxidant activity (AOA) (Rumbaoa *et al*. 2009; Šlosár *et al*., 2020). Hegedűsová *et al*. (2018) reported that antioxidant activity in a fresh matter of sweet potato tubers is usually determined by the method of DPPH (2,2-Diphenyl-1-picrylhydrazyl). Epidemiological studies expressively indicate that long-term and regular consumption of food rich in polyphenols provides humans protection against the formation and development of a wide spectrum of diseases such as cancer, diabetes, obesity, osteoporosis, and cardiovascular or neurodegenerative diseases (Pandey and Rizvi, 2009; Rasouli *et al*., 2017).

The dominant carotenoid substance in sweet potatoes is β-carotene which is a group of important antioxidants (Pisoschi and Pop, 2015; USDA, 2019; Šlosár *et al*. 2020). The β-carotene content which is formed as vitamin A biochemically in the body and majorly contained in orange-fleshed sweet potatoes is a very effective scavenger of free oxygen radicals which could be responsible for skin damage, eye retina degeneration, cataract formation, or various types of cancer (Hegedűsová *et al*., 2016). Vitamin C (syn. ascorbic acid) which belongs to the most important vitamins is characterized by significant antioxidant properties and is less stable. Most plants and animals are not able to form vitamin C however synthesize it from glucose via the intake of food (Schlueter and Johnston, 2011). Studies have shown vitamin C protects the human body against infection of the respiratory system and Alzheimer's disease, characterized by a decrease in cognitive abilities, and reduces the risk formation of cardiovascular diseases and several cancer types, acts against *Helicobacter pylori* which is marked as an important risk factor for stomach cancer formation and for sperm protection against oxidative damage and higher sperm quality of smokers (Colagar and Marzony, 2009; Schlueter and Johnston, 2011; Mei and Tu, 2018).

Sweet potatoes are also important in the industry and animal feed ingredients (Arifin and Agastya, 2020). In Nigeria and other countries, besides these benefits, the crop is also important for generating jobs and income for smallholder farmers.

Animal Waste and Its Uses

Animal waste predominantly includes manures from cows, pigs, goats, rabbits, and chickens. Livestock and poultry waste has been beneficial because of its nutrients, organic matter, and other recyclable components like solids, energy, and fibre. According to the United States Environmental Protection Agency (2023), the beneficial uses of manure include;

1. They are used as nutrients in the form of fertilizer, and biomass conversion (Animal feed, soil amendments).
2. Organic matter; for soil amendment and structuring
3. Solids; as beddings
4. Energy in the form of biofuels, biogas, bio-oil, syngas
5. Fiber; paper, peat moss substitute, novelty fiber products, and building materials.

Historically, wastes from animals such as cows, horses, chickens, pigs, rabbits, etc. were the primary source of fertilizer, especially for gardens. Many farmers and gardeners still make use of this method of fertilization for their crops. This organic waste can be obtained from local animal farmers or bought commercially at garden stores and nurseries in bagged forms. The health of crops is of utmost importance therefore knowing that all animals are not created equal and the difference in their manures will guide choices while sourcing for manures. There are so many important factors to consider while sourcing any animal manure for usage; most importantly these manures must be free of heavy metals, chemical residues, growth hormones and every undesirable material. The type and age of the animal must be enquired about, such as the food the animal consumed, the moisture content of the manure, the handling process and the storage method practised. (Wolfe, 2020).

According to Gustafson (2016), the use of fertilizer in Nigeria remains low; the use of inorganic fertilizer is at 11.3kg/ha while organic fertilizer is only 0.2kg/ha, which depicts farmers not utilizing the waste from animals around their environment. This places Nigeria well below the targeted 50 kg/ha set and agrees with the FAO ranking of world fertilizer users.

Rabbit Husbandry in Nigeria

Rabbit farming is an easy type of farming to venture into because it doesn't occupy so much space, and can easily be kept by households due to its size, quick growth rate and early maturity. They are affordable and can easily be managed, and their high rate of reproduction of up to 40 kits in a year can be achieved when properly cared for (Dairo *et al*., 2012) but despite the interesting attributes of rabbits it is still faced with challenges making it an under-utilized animal for proteins and other needs (Ogbonna, 2015). This form of animal production is faced with challenges such as lack of adequate information, access to forage, disease prevalence, and scarcity of veterinarians, (Ayeni *et al*., 2023).

Rabbit waste is derived from rabbits and in Nigeria, the commonest breeds are the Angora, Rex, California and the New Zealand white amongst others (Mailafia, 2010). Rabbit manure has shown increasing versatile application with the continuous improvement of the large-scale and intensive breeding industry. These herbivorous non-ruminants have enlarged cecum in which a vast microbial degradation takes place. Rabbits excrete both hard and soft faeces. These soft feces are called cecotrophs (cacophagy) and they can ingest it using cecotrophy and cecophagy, thus increasing feed digestibility. Forage intake of rabbits is quite high due to the special nutritional strategy and the presence of caecal microbes. The nutritional needs of rabbits are covered by well digestible part of forage, this being enabled by a mechanism of separation of the large and small parts in the large intestine (Varga, 2014). Due to rabbit's prominent potential and good attributes which

include short regeneration interval, rapid growth rate, efficiency in converting forage to meat, short gestation period, high prolificacy, relatively low cost of production and maintenance, and high nutritional quality, its manure has been termed very useful because of its dry matter content, its manure is four times more nutritious than some animals like cow or horse manure and twice as nutritious as chicken manure (Faraday, 2020).

The National Agricultural Land Development Authority in Nigeria after kicking off the National Young Farmers Scheme (NYFS) stated that within the year 2021, it had harvested over 30,000 litres of rabbit urine and 1,000 kilograms of rabbit droppings for fertilizer production in the country (AllAfrica, 2021). This interest in conserving rabbit waste is due to its importance and significance in the agronomic sector. Companies that deal in organic fertilizer and some rabbit farmers are turning the urine into a business venture.

Rabbit Waste and Its Composition

Rabbit droppings are safe and can be dropped straight into the soil without the need for further processing/compositing because it is not hot manure but rather cold manure (Nelson, 2021). It has characteristics such as being in pellet form, odourless, and dry and it breaks down slowly in the soil making it less risky to burn the roots of plants (Carter, 2021). Its application can be at any time of planting both as spreads overtop the soil or mulched directly into the soil (Noor, 2022). As rabbit manure decomposes, it re-structures the soil by slowly releasing vital nutrients and microorganisms that promote faster and healthier plant growth (Carter, 2021). Rabbit droppings have been found to contain a high content of Nitrogen, Phosphorus, and Potassium which are the key primary nutrients needed by plants for growth and development. This high content is due to a very active microbial population contained in the droppings (Rahardjo and Purwantari, 2010). Nitrogen is the main nutrient for vegetative growth, it helps a plant to generate enzymes, amino acids and proteins to grow greener and stronger (Noor, 2022). Phosphorus plays a vital role in the physiological processes in plants such as photosynthesis and respiration and potassium encourages various enzymatic actions that are essential in photosynthetic reactions (Novizan, 2005), helps plants to utilize other nutrients and produce their food (Faraday, 2020), improves fruit quality, reduces the risk of lethal diseases in plants, and helps them control their water content (Carter, 2021). Potassium also aids in developing a strong stem, tuber and healthy root network to overcome stressful conditions that are not ideal for growth (Carter, 2021). Because rabbits barely drink water their urine contains the highest level of Nitrogen (2.72% nitrogen, 8.7% phosphorus, 2.3% potassium, 3.6% sulfur, 1.26% calcium, and 4.0% magnesium) (Maina, 2014) compared to other farm animals. Rabbit urine is commonly used as a bio-pesticide against devastating crop pests and pathogens (Biovision, 2015). Apart from being used as a bio-pesticide, rabbit urine is also an excellent organic fertilizer. It has been reported that rabbit urine as a bio-fertilizer improves the viability of seeds such as cinnamon (*Cinnamomum burmannii* L.) (Guntara *et al*., 2020) and the growth and yield of pagoda (*Brassica narinosa* L.) (Mayura and Idris, 2019) and tomato (*Lycopersicon esculentum* Mill.) (Indabo and Abubakar, 2020). This urine has been utilized in African countries like Ethiopia, Kenya, Uganda, Tanzania, Malawi, and Nigeria as a pesticide and fertilizer. In Uganda and Nigeria, smallholder farmers have asserted that rabbit urine repels insect pests like aphids, mites, bugs, fall armyworms, whiteflies, leaf miners, bugs, and other crop pests of economic importance (Agric4profits, 2023) through its pungent smell; however, this indigenous pest management practice remains unexplored. This has positioned rabbit urine as being nutritive and pesticidal (Muhofa, 2020) and has helped to reduce the cost of farming with an increase in the quantity and quality of the crop produced.

Advantages of using rabbit waste as fertilizers and pesticides

1. Rabbit manure is cold manure compared to other types of manure, like horse, cow, chicken, pigs, etc., and due to the nature of these hot manures, they are usually composted using carbon-rich materials like sawdust, leaves, wood shavings or straw to the soil as hot manures release excessive nitrogen too fast that can burn the roots of plants and make the leaves brown and stunted (Nelson, 2021).
2. It can be cheaply sourced.
3. Plants can derive enough nitrogen from its high level of nitrate content.
4. It is environmentally friendly and non-toxic.
5. Rabbit farming is very lucrative and creates multiple streams of income by using meat, manure, or urine as a source of income.
6. Rabbit urine plays a dual function by solving the problem of fertilization and pest attacks on the farm, thereby making organic farming cost-effective.
7. In addition to adding vital nutrients, rabbit manure can also improve drainage, and soil structure and increase moisture retention (Faraday, 2020).

Applications of Rabbit Waste

Rabbit manure can be sourced in prepackaged bags or obtained from rabbit farmers and because is not a hot manure, it can be applied directly onto farm beds or can also be composted depending on the choice before use.

In the application of organic fertilizer, the reaction requires time in absorption and utilization of nutrients by plants because it is a slow decomposition process (Pardosi, 2014).

Islas *et al*. (2017) studied the effectiveness of rabbit manure bio-fertilizer in barley crop yield in two application modes (foliar or direct soil application) and their results showed that bio-fertilizer caused significant

changes in the mineral and soil properties. They stated that the production and use of bio-fertilizers are a reliable alternative to deal with a solid waste problem while food security is increased.

The efficacy of rabbit and cattle manures was evaluated by Malcolm *et al*. (2019) in the cultivation of aubergine and green pepper. The result revealed that fruits grown with rabbit manure had the highest mean number and were significantly higher than fruits grown with cattle manure. At a higher rate of application of rabbit manure and aubergines, it was reported that the Nitrogen Use Efficiency (NUE) was highest in rabbit manure compared to the weight of aubergines.

Parwi *et al*. (2019) studied the effect of organic fertilizers and *Trichoderma asperellum* on the agronomic parameters of Shallot (*Allium cepa* L.). The research aimed at increasing the growth and yield of shallot using two factors; first was the use of organic fertilizers (cajeput waste compost and rabbit manure) and second was *Trichoderma asperellum* application. The results of this study showed that treatments with cajeput waste compost and rabbit manure without *Trichoderma asperellum* increased tillering number, plant height, yield and leaf dry weight of the shallot. In conclusion, the introduction of rabbit manure as part of the treatments caused a significant increase in the major parameters in this research.

El-mogy *et al*. (2020) carried out the comparative effects of fertilizer-grown lettuce and its storage ability and their studies revealed that plots with rabbit manure fertilizer had a significant increase in yield. The study further highlighted that the activity of peroxidase and polyphenol oxidase that influences the browning effect in lettuce was significantly reduced with treatments containing rabbit manure. This study is also important and beneficial in sweet potatoes as regards discolouring during the post-harvest chain process, which is a result of the activation of polyphenol oxidase (PPO) (Manohan and Wai, 2012). Hence, the application of rabbit manure in sweet potato production could lower the enzymatic browning effect on varieties that undergo this chemical reaction without significant reduction in yield, desirable appearance during processing and better storability.

Prasetya (2020) aimed to determine the effect of rabbit droppings (manure and urine) on peanut crop yields. 42 days after planting, the result using rabbit urine showed a significant effect on the vegetative parameters such as number of branches, plant height and wet pod.

Udoh, *et al*. (2021) researched the effect of some organic amendments on soil properties and cocoyam yield in Akwa Ibom State University Teaching and Research Farm, Nigeria. The treatments revealed that the application of the animal manures and muriate of potash significantly increased the growth of cocoyam parameters and the physical and chemical properties generally over the control plot. Effects of treatments on cocoyam height were in this order; muriate of potash > rabbit manure>poultry manure>goat manure>control > pig manure. From the above research, the application of animal manures and muriate of potash improved cocoyam growth and yield parameters. The study recommended that muriate of potash at 300 kg/ha, and rabbit and goat manure at 5t/ha should be practised for cocoyam cultivation.

The study of Mesa *et al*. (2021) indicated that the use of rabbit manure on pakchoy plants influenced the fresh weight roots (6.41 g) compared to the yield in the treatment without rabbit manure (5.16 g). They concluded the high results could be due to the high nutritional content contained in rabbit manure (N=0.03%), (P=55.56 ppm), (K=59.91 ppm), and C (0.41%).

Furrow irrigation patterns and manure levels on potato crop water relationships and some soil chemical properties were evaluated by Elglaly *et al*. (2021). The results showed that the soil pH, available NPK, EC and OM were positively affected by the irrigation pattern with the inclusion of rabbit manure. The study concluded that practising the fixed furrow irrigation pattern with rabbit manure application achieved the highest tuber yield and quality of the potato crop. Also, this agronomic procedure was found to improve soil chemical, and physical structure and also increase macronutrient availability.

Li *et al*. (2022) aimed at manufacturing horticultural growing media by substituting peat with composted rabbit manure as an organic matrix. The results highlighted that composted rabbit manure could effectively replace peat; the study also revealed that according to the Chinese standards for use as horticultural growing media, rabbit manure was considered safe due to the lower level of heavy metal contents than the thresholds.

Declaro-Ruedas and Ruedas (2022) worked on the different forms of rabbit manure on the growth and yield response of onion (*Allium cepa*) 'RED PINOY' VAR. in Magsaysay, Occidental Mindoro. The result reported that onion bulb plots treated with fresh rabbit manure gave the highest vegetative response and yield in terms of the number of leaves and length of roots, bulb size, fresh weight of bulbs and dry weight of bulbs compared to the other treatments.

Indabo and Abubakar (2022) studied the effect of bio-fertilizer using rabbit urine on the UC82B tomato (*Lycopersicon Esculentum* Mill) Variety in Zaria, Nigeria. The study also revealed the relevance of rabbit urine in the farming system. Data obtained revealed that treatments with rabbit urine inclusive had the best performance in terms of the plant height, number of leaves and branches between 2 to 6 WAP. The study recommended that in addition to the standard rate of NPK fertilizer application, rabbit urine should be incorporated into tomato cultivation. In conclusion, rabbit urine has proven its potential to beef up the efficacy of NPK, especially in a case where the rate of applying NPK is not up to the required rate.

Kemunto *et al*. (2022) researched the application of rabbit urine on different stages of fall armyworm

(*Spodoptera frugiperda* J.E. Smith) in a maize farm. From the egg to the moth stage of the fall armyworm (FAW) was exposed to maize leaves treated with rabbit urine and the control without rabbit urine. The results showed that maize leaves treated with rabbit urine had less than 43% of the FAW infestation attack compared to untreated maize leaves which had more of the FAW attack of more than 46%. The reduction of the presence of FAW larvae on the treated leaves indicates that the ammonia smell from the urine served as a repellant. Rabbit urine also caused a damage reduction in the egg development to second, and third instars and adult emergence 24 h post-exposure. This study also confirms farmer assertions about using rabbit urine as a pesticide to manage FAW.

Potential for Boosting Sweet Potato Production
Basic Requirements

To boost sweet potato production, farm mechanization which includes functional tractors and land preparation implements with other farm inputs will maximize yield per hectare without necessarily expanding hectares under cultivation. Farm inputs such as; fertilizers, herbicides for weed management, insecticides for pest control and clean healthy vines as planting materials have the potential to boost sweet potato cultivation.

Sweet potatoes yield best in a well-drained, light, sandy loam or silt loam soil. Sweet potatoes can thrive in soil pH between 5.5 and 6.8 but optimally between 5.8 to 6.0 producing quality yields (Brandenberger *et al*., 2014). In soil with low pH, lime is advised to be applied. Sweet potatoes due to their ability to bulk require large quantities of nutrients whether mineral or organic (Mahmoud *et al*., 2019) especially potassium and Nitrogen for sustainability and improved cultivation. It utilizes about 49.9Kg of nitrogen, 2.27Kg of phosphorus, and 68.04Kg of potassium per acre from the soil (Brandenberger *et al*., 2014). However, in Nigeria, farmers usually ignore the application of fertilizers with these major nutritional components which in turn results in low tuber yield of sweet potatoes and poor storability.

Animal manure like rabbit waste is much richer in nutrients than ordinary farm manure with a very good level of essential nutrients needed by sweet potatoes and will play a vital role if substituted with inorganic fertilizer.

Conclusion

Sweet potato (*Ipomoea batatas* L.) is one of the largest sources of carbohydrates after rice, corn, and cassava having an important role in the supply of food raw materials, industrial raw materials, medicinal ingredients, and animal feed ingredients. Aside from the fact that rabbit has a beautiful appearance and their meat is very delicious, their other advantages in the agricultural sector include fertilizers, biological pesticides, energy sources, organic matter, and solids. The need for organic farming in the cultivation of sweet potatoes by every grower cannot be over-stressed for the reasons arising from its low cost, its high level of nutrient content its environmental safety, and most importantly nontoxic to humans. One of the efforts to increase the productivity of sweet potato cultivation is to determine the type of fertilizer used and this study has proven and highlighted that rabbit waste could effectively replace mineral fertilizer.

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