

REVOLUTIONIZING NIGERIA EDUCATION AND ECONOMY: LEVERAGING ARTIFICIAL INTELLIGENCE FOR SUSTAINBLE YAM PRODUCTION IN BENUE STATE, NIGERIA.

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Abstract

Yams (DioscoreaSpp) play major role in nutrition, religious, cultural heritage and economy of Benue State. Despite these, nearly all yam farmers within the State have to contend with the challenges of soil infertility, pest infestation, unstable weather conditions, low income of product due to poor quality yields and decay of tubers both on the farm and storage. Prominent pests identified by Benue Yam farmers included yam beetles (Heterologous meles, rats (Rattes, rattus, Cricetonysgambianus and MeloidogynSpp/ yam Scales (Asphidiellahartii) and Spear grass (Imperata cylindrical Beauv). Benue farmers in their attempts to checkmate these challenges, applied chemical fertilizers, various herbicides and pesticides indiscriminatelyto yam crops with the resultant chemical residual contamination of yam tubers. These have adverse effects on man, entire Benue ecosystem and export values of the tubers. Artificial intelligence could be adopted in all phases of yam production in Benue State to overcome the numerous hurdles. This paper recommends the equipping of every willing Benue inhabitant, who is directly and indirectly involved in yam tuber production activities, with the technical skills of Artificial Intelligence. This could be attained through training and retaining via seminars, workshops institutions of learning, work places and mass media, to ensure sustainable tuber production both in quantity and quality, to meet both local and international demands, with attendant economic boom and development in Benue state and the Nation in general

Keywords: Yam, Farmer, Pest, Agrochemical-residues and AI

Introduction

Yam is a tropical crop in the genus Dioscorea, with about 600 species (Pamplona-Roger 2010), of which six are economically important staple species in Benue State. They include: Dioscorearodundata (white guinea yam), D. cayenesis (yellow yam), D. alata(water yam), D. bulbifera (aerial yam), D. esculenta (Chinese yam) and D. hispida (Asiatic bitter yam). Dioscorea species is a universal food item and one of the leading cash crops in Benue state (Adogwu 2014, Verter and Becvarova 2014 and Owoicho, et al., 2023 and Owoicho 2024). Yam tubers have very important roles in food security (Akinpaluand Ogunjirin 2022), medicine (Pamplona – Roger 2010), economic, social and cultural uses in Nigersia (Darkwa, et al., 2020).

Consequently, yam has been declared to be the fourth most essential and highly adapted tuber crop globally (FAOSTAT, 2014 and 2018) and prioritized as a key export crop in the 2016 to 2018 Agricultural Promotion Policy and endorsed by the Federal Government of Nigeria (Darkwa, et al. 2020). Irrespective of the statue of yam

Yam Production as Business Ventures in Benue State

Yam (Discorea species) is the popular chief food and leading cash cop in Benue, with about 90.2% of Benue dwellers involvement in its cultivation (Owoicho 2024).

Adogwu (2024) revealed that 68% of the people of Otukpo Local Government area of Benue State were into full time yam farming. The higher recorded value for yam tuber production in Benue State occurred in Ukum L.G.A. This area has been known to house the largest national and international yam market situated in Zaki- Bian (Ukuru, 2014)

That production of yam has contributed immensely in raising the family standard of living in Benue State to state but the obvious. For instance, Adogwu (2014) affirmed, that families agreed that, the proceeds of yam production have improved their lines in the area of health (63%), feeding (84%), education (77%), clothing (73%) and housing (80%). Interactions with other Benue inhabitants'. Further showed that yam is cultivated as sole business, part time job, to supplement family food and supply and for retention of Land Ownership.

According to Verter and Becvarova (2014), the real man produces yams primary to ensure food security and prompt payment of community levies. Equally too, the real man is known by the average of yam cultivation and production. (Odey, 2009)

Yams are available all year round in the forms of fresh tubers and dried chips/flour for sales. Fresh tubers are prepared for home consumption and objects of retailed sales in the form of boiled, roasted, fried and pounded and other possible forms throughout Benue State as sources of daily income earning.

Economic Importance of DioscoreaSpp

Yam is cultivated for its freshly starchy tubers and consumed as vegetable by boiling, frying, roasting among others recipes. It is available all year round as fresh tuber or dried chips or powder. These make it a culturally important food security crop in Nigeria and sub-Saharan African countries (Maikasuwa and Ala 2013)

Yam production is one of the most profitable ventures in Nigeria. An average profit per seed yam after harvest and storage in Nigeria was estimated at over \$13,000 or more per harvested hectares, while serving as an important source of income to the people (Izekor and Olumese 2010). In Benue State, people earn a living from being engaged in various stages of yam production activities ranging slashing, clearing and preparation of land, tillage, packing them on heaps, planting, weeding, spraying of chemicals, harvesting, transportation and storage. Others are engaged in as commercial middle men and women between farmers, and consumers or contractors. Some farmers specialized in farming and raising seedling for heap sales, while others buy at harvest, store and sell later at higher price or engage in yam cooperative association including inter-state or export trades.

Culturally, the tuber is the major planting material for propagation. However, this most important part of yam crop tends to deteriorate both on the farm, during transportation and storage. Observations of earlier researchers such asCoursey (1967), Adesiyan, et al., (1990), Ogbaji(2009), Apeyuan(2014), Adedayon, et al.; (2014), and Owoicho, et al., (2023) and Owoicho(2024) all revealed that tuber deterioration and losses have been attributed to factors such as rotting due to microbial attack, other pests such as nematodes, insects and rodents among others. These pests invade tubers, consume parts of them and render what is left unsuitable for human consumption.

Analysis of the tuber losses showed that about 10% of the dry matter of yam tuber is lost through respirations, 20% of weight loss is attainable through dehydration in a 5 months' period and heavier storage losses due to sprouting of yams when allowed for longer time before planting or dry session sales (Owoicho, 2024).

Other problems of yam production in Benue State include soil infertility, as well as pest infestation. Authorities such as Ayola (2004) and Adogwu (2014) unfolded that striga, a serious weed problem is responsible for more than 20% field loss and in conjunction with soil infertility to the tune of 70% and 50% in spear grass.

The Menace of Agrochemical Application in Yam Production in Benue State

Owoicho, et al (2023)'s work on yam farmers' attitude to the use and application of agrochemicals in yam production in Benue State revealed that yam farmers in Benue State used agrochemical, with ninety three percent (93%) of the yam farmer applied all the categories of agrochemicals at the levels of 39% fertilizers, 38% herbicides and 23% insecticides, 73.8% handled the application themselves while only 26.2% of the sampled farmers employed expert chemical spraying operators in the application of agrochemicals to yam crops , per cropping season at statistically significant differences , $p < 0.001$. The results of chemical analysis showed the presence of 4 residues of heavy metals, 5 of fertilizers and 15 pesticides. Some of these values were above the set maximal residual limits by the joint World Health Organization and Food Agricultural Organization (WHOFAOSTAT,2020-2023) for tuber crops, which implied; non acceptability for human consumption, the possibility of the rejection of the affected tubers and their products at the international markets, the subsequent low economic values at global levels and domestic development in all its ramifications including education at state level.

Martin (2014) had earlier sounded warning to agricultural crops producers and exporters of the possibility of rejection of Benue crops and products in international market due to agrochemical contamination. Interaction with export marketers in recent times confirmed the same. These formed the basis of this paper titled the place of Artificial Intelligence in Revolutionizing Yam Tuber production economy in Benue State, Nigeria.

Benue State, often called the "Food Basket of the Nation," remains Nigeria's leading producer of yam. However, despite its agricultural potential, yam production in the state still faces major challenges such as low yield, post-harvest losses, poor mechanization, and limited access to data-driven insights. Yam is one of Benue's major crops and a key source of income for many farmers. Yet, year after year, they face the same issues — low quality yields, pest attacks, poor storage, and unstable prices as recent experiences and show. Many farmers still rely on guesswork when applying fertilizer, spraying chemicals, or deciding when to harvest (Owoicho, et al., 2023). These are where Artificial Intelligence (AI) can make real differences through educating and equipping, both the full and part time yam farmers as well as everyone involved in other aspects of yam tuber production business activities.

Understanding Artificial Intelligence and leveraging AI in Yam tuber production in Simple Terms

Artificial Intelligence (AI) refers the development of computer systems that can perform tasks that typically require human intelligence, such as learning, problem-solving, and decision-making (Russell and Norvig,2021). AI is seen as a kind of super-smart computer brain that can learn, think, and act like human. Furthermore, AI is the use of computers or machines to perform tasks that typically require human thinking such as learning from experience, recognizing patterns, or making decisions. It also has its use in things such as self-driving cars, predicting diseases, help to solve complex problems, make decisions, and automate tasks, among others to make life easier and more efficient. In farming, AI helps use data to work smarter. It does not replace the farmer, but empowers the farmer to make better and more informed decisions.(Adebaye and Ogundele (2023)

Thus, leveraging AI in yam production, implies using AI technology to achieve specific goals or improve processes of yam production such as; applying AI tools such as machine learning, data analytics, or computer vision to optimize farming practices, improve yields, reduce losses, enhance decision-making and increase efficiency. AI refers to the computer systems and algorithms to analyze data, predict outcomes, make decisions to improve yam yields, disease and pest detection and control and resource allocation. It's a kind super-smart farming assistant that helps yam farmer optimize yam tuber production (Russell and Norvig 2021).

Current Challenges in Yam Production which could be resolved through Artificial Intelligence

Some of the key problems limiting yam production in Benue State include: Reliance on traditional planting methods, Pest and disease detections and control that is mostly reactive rather than preventive, unpredictable weather conditions and limited access to reliable forecasts, Poor storage systems leading to large post-harvest losses and Lack of market information which force farmers to sell at cheap prices (NBS 2024).

Food Agricultural Organization (2022) affirmed that, these challenges affect both farmers' livelihoods and the broader state economy. While they seem daunting, emerging technologies such as Artificial Intelligence offers practical tools that can transform these weaknesses (FAO, 2022).

Artificial Intelligence and Smart Farming Decisions

AI can use sensors or simple mobile apps to collect data about soil conditions, rainfall, or crop growth. This helps farmers know the best time to plant, how much fertilizer to apply, and when to water or spray. By relying on data instead of guesswork, farmers can achieve better results at lower costs (Adewumi and Iorliam 2021).

Pest and Disease Control

AI-powered mobile applications can help farmers quickly identify diseases such as yam rot or mosaic virus. Once identified, the right agrochemical can be recommended

immediately, reducing waste and preventing large-scale crop damage. (Colatunji and Edeh, 2020 and IITA ,2023)

Post-Harvest Management

AI systems can monitor temperature and humidity in storage barns. When conditions become too hot or damp, the system alerts the farmer to take action, helping to reduce yam spoilage - a major issue in Benue State. (Abah and Onaja 2024, World Bank 2022, UNfood System Summit (2021)

Market and Price Forecasting

AI can track prices in different markets and help predict demand. With this information, farmers or cooperatives can determine the best time to sell yams for maximum profit instead of selling in a rush during harvest.

Farmer Training and Support

AI-powered advisory services - such as chatbots or voice messages in local languages such as Idoma, Iggede and Tiv among others - can offer step-by-step guidance on good farming practices, pest control, and safe chemical use. (Abah and Onaja 2024)

Economic Benefits of the use of AI in yam tuber production in Benue state

If farmers in Benue gradually adopt AI tools, several benefits will follow:

Increased yam yields, leading to more food and higher income, efficient use of agrochemicals, reducing waste and protecting the environment, Job creation in data collection, equipment maintenance, and agri-tech innovation, improved export quality and thus, boosting foreign exchange (Adewumi and Iorwan 2021).Collectively, these benefits will not only enhance farmers' livelihoods but also strengthen Benue State's position as Nigeria's agricultural powerhouse and consequently raise the national foreign earning and contribute to national development.

The good news is that, the Benue State Government just launched landmark public-private partnership to boost AI, agro processing, job creation with KAOTHEEM Energy Services and Talcop capital partners to drive education, artificial intelligence agro-processing wealth creation and large-scale employment across the state. The proposal includes the establishment AI school at the two state universities at Makurdi and Ihugh (Anguardngr.com march,2026). AI literacy in Benue State will definitely spread like wild fire among yam farmers, who are presently predominantly holders of tertiary education certificates (Owoicho 2024) and thus, the possibility of its applications in various stages of production and sales for maximum economic profits both at state and national levels.

Expected barriers to Overcome

According to Abah and Onaja 2024, this transformation will not happen overnight.

Key challenges include:Limited access to smartphones and internet connectivity in rural areas, the high cost of technology, lack of localized agricultural data, low digital awareness among small-scale farmers.

These challenges, however, could be resolved with the right partnerships, training, and government support. Farmers can start with simple digital tools and gradually move toward more advanced AI system.

Conclusion

Artificial Intelligence may sound like a complex concept, but it simply means using technology to make smarter farming decisions. If applied effectively, AI can help Benue yam farmers eliminate pests, reduce waste, increase productivity, and improve income. It can move yam farming from guesswork to smart work - revolutionizing the yam economy of Benue State and Nigeria as a whole.

Benue State must adopt a holistic and inclusive approach that integrates technology, policy, and human capacity. The success of AI in agricultural economy particularly that of yam, depends not only on the tools themselves but also on the willingness of yam farmers to learn, adapt, and trust data-driven methods.

Government agencies, research institutions, and private innovators should collaborate to create accessible AI platforms tailored to local realities, including language, literacy level, and resource availability. By doing so, AI will not remain an abstract concept but become a practical instrument for rural development improving yields, ensuring food safety, reducing on the farm and post-harvest losses, and promoting environmental sustainability. Ultimately, embracing AI in yam production will reposition Benue State as a model for smart, sustainable, and technology-driven agriculture in Nigeria and beyond.

Recommendations

To fully harness the transformative power of Artificial Intelligence in yam production, this paper recommends that;

1. The Federal Government of Nigeria should assist Benue State Government, which launched her.
2. The Benue state government at all levels should organize training programs to teach farmers how to use AI-based tools for farming decisions.
3. Industries should develop local mobile apps focused on yam production that are easy to use and relatively affordable to all those engaged in yam tuber production.
4. Yam tuber entrepreneurs should be encouraged by the government to collaborate with agrochemical companies, research institutions, and government agencies to foster common goal of good agricultural practices as pertain to good yam tuber production in quality and quantity.

References

- Abah, J., and Onoja, P. (2024). *AI-Enhanced Post-Harvest Management for Yam Storage in Middle-Belt Nigeria*. *Proceedings of the Nigerian Agricultural Conference*, 6(1), 45–54.
- Adebayo, O., and Ogundele, F. (2023). *Artificial Intelligence in Agricultural Value Chains: Opportunities and Challenges in Nigeria*. *Nigerian Journal of Agricultural Economics*, 15(2), 45–58.
- Adedayo, O. A., and Steve, D. O. (2014). *Bacteria and Fungi Species Associated with Yam (Dioscorea Rotundata) at Akungba-Akoko, Ondo State, Nigeria*. *Applied Science Research Journal*, 12(2), 12–28.
- Adesiyun, S. O., Caveness, E. E., Adeniji, M. O., and Fawole, B. (1990). *Nematode Pests of Tropical Crops*. Akure: Heinemann, 9–12.
- Adewumi, T. M., and Iorliam, A. (2021). *Exploring the Role of Artificial Intelligence in Precision Agriculture for Root and Tuber Crops in Nigeria*. *Proceedings of the African Conference on Emerging Technologies (ACET)*, 4(1), 112–120.
- Adogwu, E. E. (2014). *The Contribution of Yam (Dioscorea Spp.) Production to the Nigerian Economy: A Case Study of Otukpo Local Government Area, Benue State*. [Undergraduate Project]. National Open University of Nigeria, Lagos.
- Akinpelu, A. O., and Ogunjirin, A. O. (2022). Yam production and its contribution to food security in Nigeria. *Journal of Agricultural Science and Technology*, 10(2), 45–58.
- Apeyuan, K. D. (2014). *Introductory Plant Pathology*. Kastina-Ala. Global Link. pp82
- Anguandngr.com march 1, 2026.
- Benue State Ministry of Agriculture and Natural Resources. (2023). *Annual Agricultural Development Report*. Makurdi: BSMANR.
- Coursey, O. G. (1967). *Yams*. London. Longman. 230pp.
- Darkwa, D.; Olasnm, B.; Robert, A.; Asfaw, A. (1990). Review of empirical and emerging breeding methods and tools for yam (*Dioscorea* spp) improvement: Statue and Prospects. *Plant Breeding*. 139. 10. 1112/pbr.12783
- Food and Agriculture Organization (FAO). (2022). *Digital Agriculture Transformation in Africa: Leveraging Artificial Intelligence and Data Analytics*. Rome: FAO Publications. <https://www.fao.org>
- FAOSTAT (2014). Production statistics: Crops. Food and Agriculture Organization of the United Nations www.fao.org
- FAOSTAT (2018). Production statistics: Crops. Food and Agriculture Organization of the United Nations. www.fao.org
- FAOSTAT (2020). Production statistics: Crops. Food and Agriculture Organization of the United Nations. www.fao.org
- FAOSTAT (2023). Production statistics: Crops Food Organisation Organisation of the United Nations. www.fao.org
- International Institute of Tropical Agriculture (IITA). (2023). *AI-Driven Approaches for Disease Detection in Yam Production Systems*. Ibadan: IITA Research Brief.
- Izekor, O. B. and Olimese, M. I (2010). *Determinants of Yam Production and Profitability in Edo State Nigeria*. *African Journal of General Agriculture* 6 (4): 202-221
- Maikasuwa, M. A, and Ala, A. I. (2013) *Determination of Profitability and Resource-use Efficiency of Yam Production by Women in Bosso Local Government Area of Niger State, Nigeria*. *European Scientific Journal*, 9(16), 196-205.

- Martins, A.T. (2014). Yam Production in Nigeria: Yam Production. <http://www.en.m.wikipedia.org/08/05/2014> retrieved July 2014.
- National Bureau of Statistics (NBS). (2024). *Agricultural Performance Report: Yam Production Trends in Benue State (2018–2023)*. Abuja: NBS Press.
- Odey, M.O. (2009). The Development of Cash Crop Economy in Nigeria Lower Benue Province. 1920 -1960. London. Aboki pp 1-243.
- Ogbaji, M. I. (2008). Principles and Practice of Tropical Crop Production. Makurdi: Oracles. Pp 11-24.
- Olatunji, M., and Edeh, C. (2020). *Artificial Intelligence Applications for Pest and Disease Management in Root Crops*. *Journal of Applied Agricultural Science*, 8(3), 65–74.
- Owoicho, H. A., Iheukwumere, C. C., Ega, R. A. I., & Ikpa, T. F. (2023). *Investigation of Yam Farmers' Attitude to the Use and Application of Agrochemicals in the Production of Yam Tubers in Benue State, Nigeria*. *Environmental Review Letters Report*, 8(10). www.scholar.com
- Owoicho, H. A. (2024). *Agrochemical Residues in Tubers of Yam (Dioscorea Spp.) Produced in Benue State, Nigeria*. [Doctoral Dissertation, Joseph Sarwuan Tarka University, Makurdi].
- Pamplona-Roger, G. D. (2010). *Encyclopedia of Foods and their Healing Power*. Education and Health Library. Spain: Safeliz. ISBN: 978-84-186-4 Vol. 1, 107 and Vol. 2/82, 83, 86 & 101.
- Russell, S.J. and Norvig, P. (2021). *Artificial Intelligence: A Modern Approach* (4thed) pp 1-1152. Pearson Education.
- Uhuru (2014) Uhurutimes. Com/Benue-2014
- United Nations Food Systems Summit. (2021). *Technology and Innovation Pathways for Sustainable Food Production*. New York: UN Publications.
- World Bank. (2022). *Harnessing Digital Tools for Agricultural Transformation in Sub-Saharan Africa*. Washington, D.C.: The World Bank.