Ahmadu Bello University, Zaria

EXPLORING THE FUNDAMENTAL PRINCIPLES OF GOOD AGRONOMIC PRACTICES FOR SUSTAINABLE CROP PRODUCTION, HUMAN NUTRITION, HEALTH, AND ENVIRONMENTAL PRESERVATION

AN INAUGURAL LECTURE

Series No. 08/24

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B. Agric. ABU; M.Sc. (Agronomy) ATBU; Ph.D. (Agronomy) ABU

Professor of Agronomy

Ahmadu Bello University, Zaria

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By

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Dedication

I dedicate this lecture to Allah, the Lord of the Worlds. Indeed, my prayers, my sacrifices, my life, and my death are all for Allah, the Lord of the Worlds.

قُلْ إِنَّ صَلَاتِي وَنُسُكِي وَمَحْيَايَ وَمَمَاتِي لِلَّهِ رَبِّ ٱلْعَٰلَمِينَ

(Sura al-An'am, Verse 162)

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First and foremost, I thank Allah, the Lord of the heavens and the earth, for granting me the knowledge, skills, and opportunities to become an authority in Food Systems Agronomy. His divine guidance has enabled me to teach, research, and engage in community service focused on crop production for human nutrition, health, and environmental sustainability.

Special thanks to my father, Mallam Ibrahim Yusuf Afolabi, for his spiritual, academic, and leadership mentorship. Also, to my mother, Hajia Fatima Ibrahim, for her unconditional love, support, and training that shaped my early life. May Allah have mercy on them as they had mercy on me during my childhood.

I am sincerely grateful to the Vice Chancellor of Ahmadu Bello University, Professor Kabir Bala, management of the University, and the Director of the Division of Agricultural Colleges, Professor Bashir Ahmed. Babaji for the honour and privilege of presenting my inaugural lecture.

I extend my heartfelt thanks to my academic supervisors—Professor Aliyu Lamido, Professor B. M.

Auwalu, Professor G. N. Udom, Professor A. A. Mukhtar, Professor B. A. Babaji, and Professor I. D. Adekpe—for their guidance and support throughout my academic journey. I also appreciate the mentorship of Professor S. A. Rahman, Professor M. A. Mahadi, and Dr. H. A. Akintoye. My gratitude also goes to all the previous Provosts of Samaru College of Agriculture—Dr. Mrs. H. Omenesa, Dr. Aliyu Sai'd, Professor Abdullahi Namakka, and Professor E.M. Shaibu-Imodagbe—for their trust and support in my various leadership roles and projects.

Thank you to all my teachers, friends, and schoolmates from primary school through my PhD studies for their unwavering support. I am also grateful to my colleagues at Samaru College of Agriculture, Federal University Gashua, Longwood Gardens, and Arnold Arboretum of Harvard University for their various support. Special appriciation to Professor Idi Hamman Lakun and Dr. B. A. Mahmoud Ali for being my principal research partners. My appreciation extends to all my students, whose involvement has been a source of pride and joy.

To my siblings—Alhaji Abubakar Yusuf Afolabi, Hajia Hawawu Adenike Mohammed, Barrister Mohammed Tiamiyu Ibrahim, Lukman Ibrahim, and Yunusa Ibrahim—thank you for your varied support. I am also thankful to special family members, including Alhaji Saka Yusuf Esq. (late), Alhaji Suleiman Olohundare (SMO), Mr. Umar D. Nasir, Alhaji Toyin Mohammed Baboko, Late Hajia Zikrat Iyabo Folahan, Hafsoh Ibrahim, and Dr. Usman Oba Abdulrauf Tosho, as well as the entire Ile-

Bamidele family and my mother's family, for their support. I also appreciate all the support from my in-laws.

Most importantly, I extend my deepest gratitude to my sweetheart: Professor Fatima Badiru Ibrahim, my darling: Dr. Jamila Aliyu, and my dear children: Bilkisu, Maryam, Abdulrahman, Ibrahim, and Fatima for their patience understanding, and love.

Protocol

- The Vice-Chancellor
- The Deputy Vice - Chancellors
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- The Chairman Agriculture and Veterinary Complex
- My Director - Director of the Division of Agricultural Colleges
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- Other Deans and Directors
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- Distinguished Professors and other members of the Senate
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- The staff of the Division of Agricultural Colleges
- Staff and Students of the Department of Agronomy and the Faculty of Agriculture
- Members of the Horticultural Society of Nigeria
- Members, Agricultural Society of Nigeria
- Members, Weed Science Society of Nigeria
- Alumni of the Longwood Fellows
- International Exchange Alumni Network, US Department of State
- Member, Agriculture, Nutrition and Health Academy, United Kingdom
- My Supervisors
- My Family and Friends
- Gentlemen of the Press
- Other Distinguished Guests
- Ladies and Gentlemen

Preamble

In the Name of Allah, the Beneficent, the Merciful. I am deeply grateful to my Lord for His guidance throughout my journey. My passion for crop production began as early as primary school, where agriculture was my favorite hobby. At the age of 10 years old, I started a farm in New Bussa, cultivating crops like onion and maize. I served as the Science Laboratory Prefect, overseeing the agriculture lab and school farm. My academic achievements in agriculture, geography, and Islamic studies in the West African Examination (WAEC) foreshadowed my future as a professor in agriculture, an international scholar, and a student of Islamic knowledge.

Though I initially applied to study medicine at Ahmadu Bello University, I received two admissions—one for biochemistry and the other for agriculture after the school of general remedial studies (SGRS) program. After much reflection, prayer (*istikhara*), and consultation with family and friends, I chose agriculture, in accordance with the teachings of our noble Prophet (SAW).

I graduated from Ahmadu Bello University in 2001 and completed my National Youth Service Corps (NYSC) as a lecturer at the College of Agriculture, Jalingo, Taraba State. There, under the mentorship of Dr. Richard Adeola, I developed a crop guide titled "Modern Crop Production Practices: A Guide for Small- and Large-Scale Farmers in Taraba State", earning me a special award from the Ardokola Local Government. After my NYSC program, His Royal Highness, the Emir of Muri, Alhaji Abass

Tafida, offered me a position as the farm manager of Muri Emirate Council. This opportunity allowed me to gain invaluable practical experience in crop production.

My professional journey took me to Premier Seeds Nigeria Limited, where I worked as a marketing officer, establishing demonstrations and training farmers on various crops. At Saro AgroSciences, I expanded my knowledge in pest control, weed management, and disease prevention in major Nigerian crops.

In 2011, a decade after my graduation, I joined the Division of Agricultural Colleges, Ahmadu Bello University, as a lecturer. This decision puzzled many, as I left a well-paid job for academics. However, I owe thanks to Professor Shehu Abdul Rahman, who encouraged me to take the position.

Today's lecture is unique in its relevance to agriculture and food, essential for humanity's survival and progress. Allah (SWT) emphasizes the importance of agriculture in the Qur'an, as seen in verses such as Chapter 80:24-32, where He describes the creation of food for humans and animals. These verses remind us of the divine wisdom in cultivating the earth and producing sustenance.

With humility, I attribute my accomplishments to Allah (SWT), who has endowed me with virtues such as excellence, hard work, honesty, dedication, and transparency. Among my many notable honors are being elected as the President-in-Council and receiving the Fellow of the Horticultural Society of Nigeria (FHSN). I

was the first Nigerian to participate in the Longwood Fellows Program for Horticulturists. Additionally, Additionally, I have served in numerous leadership roles at Samaru College of Agriculture, including Head of Agronomy, Head of Horticulture, and Head of Irrigation Agronomy, and Linkages Coordinator for the Division of Agricultural Colleges.

My research aims to advance the understanding of nutritious crop production while ensuring the health and safety of farmers and other actors in the food value chain. Using a cross-cutting and interdisciplinary approach, I have collaborated with students and researchers, ensuring my research remains accessible to students while maintaining high scientific standards.

Over the past 13 years, I have taught and supervised students at various levels—National Diploma, Higher National Diploma, Bachelor's, Master's, and PhD. My work includes 65 peer-reviewed journal articles, 25 publications in conference proceedings, and 51 presentations at local and international conferences. I also published a book titled: Horticultural Crop Production.

In addition to research on Good Agricultural Practices (GAPs), I have engaged in community service by training farmers and conducting programs aimed at improving agricultural practices. Among my contributions:

1. Collaborating with East-West Seed Nigeria Ltd (2023): As Head of Horticulture at Samaru College, I led the project to cultivate 45 vegetable varieties. This initiative aimed at boosting

farmers' income and transforming agriculture into a profitable business. It included capacity building for students and extension officers, with an international field day attended by 701 participants from seven countries.

2. Green Innovation Center Maize Project (2016-2023): I participated in this collaborative project with GIZ to train farmers in contract farming, Good Agricultural Practices, and cooperative business schools. We also co-authored a book titled "Contract Farming in Nigeria."
3. Federal Government Maize Doubling Project (2005-2009): Working with Premier Seeds Nigeria Limited, I conducted trials and trained farmers on maize production across Bauchi, Plateau, and Gombe states.
4. Federal Ministry of Agriculture Training (2014): Under the Agricultural Transformation Agenda Program, I trained farmers on GAP for crops like sugarcane, soybean, groundnut, and horticultural crops.
5. Saro AgroSciences Collaborations (2009-2011): I coordinated partnerships with Agricultural Development Projects (ADPs) and IITA to train farmers on rational pesticide use and Good Agricultural Practices in southwestern states and Kwara.

I am a recipient of numerous national and international grants, including the prestigious Longwood Fellows grant worth over $120,000. Additionally, I have been awarded 12 travel grants to participate in academic conferences

and training programs across South Africa, Malawi, the UK, the USA, Ghana, Ethiopia, and the Czech Republic.

I take immense pride in seeing my students now leading in the agricultural industry, contributing to Nigeria's agricultural growth and development. Furthermore, the farmers and agro-dealers I have trained have become food-secure and economically empowered.

My journey culminates in the title of this presentation: "Exploring the Fundamental Principles of Good Agronomical Practices (GAgrPs) for Sustainable Crop Production, Human Nutrition, Health, and Environmental Preservation."

In line with university tradition, this lecture marks the inauguration of a new professor. My account today is not just a personal achievement but a testament to the role of academia in supporting society's agricultural and environmental needs.

Content

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INTRODUCTION

Good Agricultural Practices (GAPs)

Good Agricultural Practices (GAPs) are principles aimed at improving farm production and post-production processes. These practices are designed to ensure the production of safe and healthy food and non-food agricultural products, while also considering economic, social, and environmental sustainability (FAO, 2019). The primary goals of GAPs are to enhance the safety, quality, and quantity of farm produce, protect the environment, and safeguard worker health and safety (FAO, 2019).

In the context of crop production, GAPs are specifically referred to as Good Agronomic Practices (GAgrPs). These practices are essential as they encompass responsible farming methods, from site selection and land preparation to harvesting and handling. GAgrPs apply available knowledge to promote environmental, economic, and social sustainability, resulting in safer and healthier crop production (FAO, 2019). By adopting GAgrPs, farmers can improve yield and profitability, benefiting both the local economy and national development.

Nigeria, with the largest population in Africa, estimated at 218 million in 2022 and projected to double by 2050 (FAO, 2023), faces significant opportunities and challenges in crop production. Crop production is a critical area for improving nutrition and has the potential

to employ around 50 % of the youth in various agricultural enterprises. The country's diverse crop varieties offer opportunities for international market exports. However, current crop production levels fall short of meeting local market demand and export needs. Supporting smallholder farmers to adopt GAgrPs is crucial for increasing production to meet both local and international demands.

GAgrPs can enhance yield from the same area of land while mitigating negative environmental impacts associated with crop production. Bruinsma (2009) notes that 80 % of the required increase in crop production can be achieved through improved varieties and GAgrPs, with only 20 % relying on expanding arable land. Improved varieties can reach their full potential only when GAgrPs are applied. Therefore, addressing factors that limit production by implementing GAgrPs is essential for increasing crop productivity and yields.

Fundamental Principles of Good Agronomic Practices (GAgrPs)

Good agronomic practices encompass eleven key principles that collectively enhance the safety, quantity, and quality of crop production while protecting the environment and ensuring worker safety. According to Auwalu (2006), these principles form an eleven-step algorithm for managing crops. The fundamental practices are:

1. Site Selection
2. Land Clearing
3. Land Preparation
7. Weed Control
8. Pest Control
9. Harvesting

4. Selection of a Suitable Variety
5. Seed Sowing
6. Fertilization
10. Processing
11. Storage

Numerous studies have been conducted to improve crop management across these eleven areas. For this presentation, I will focus on the areas where I have made contributions and include aspects related to workers' health and safety.

Linkages Between Crop Production and Nutrition

Nutrition is fundamentally about consuming a diet that provides essential macronutrients and micronutrients necessary for maintaining normal body functions, growth, and tissue repair (Harvard Health, n.d). Adequate, safe, high-quality food and nutrition are crucial for human well-being. Crop production is intimately connected to the factors that influence nutrition and is a key component of nutrition-sensitive programming. Nutrition-sensitive programs is aim to enhance nutrition outcomes by addressing the underlying determinants of nutrition. By integrating nutrition-sensitive approaches like improved crop production, significant strides can be made in advancing nutrition and health.

Sustainable diets are characterized by their low environmental impact, contributing to food and nutrition security while ensuring a healthy life for current and future generations. These diets are nutritionally adequate, safe, and healthy, and they optimize the use of natural and human resources (GBD, 2024). Conversely, non-

nutritious or unsafe diets are a leading risk factor in the Global Burden of Disease, with dietary risk factors including insufficient calories, vitamins, and minerals, or excessive intake of calories, saturated fats, salt, and sugar, leading to various forms of malnutrition (GBD, 2024).

Malnutrition, as defined by Black *et al.* (2013), affects approximately one-third of the global population, predominantly in Southern Asia and sub-Saharan Africa (Herforth *et al.*,2020). It includes both deficiencies and excesses in food and nutrient intake, resulting in underweight, overweight, obesity, and diet-related non-communicable diseases such as anemia and diabetes (WHO, 2023). Addressing malnutrition is a pressing global health issue, highlighting the importance of linking crop production to nutritional outcomes.

Pathways by which Agriculture Can Improve Nutrition

According to Kadiyala *et al.* (2014), agriculture can improve nutrition through three main pathways:

1. **Food Production:** Enhancing crop production increases the availability and quality of food, directly impacting the types, quantities, and seasonal availability of food in households. Improved crop yields can also affect local food markets, influencing food prices and accessibility.

2. **Income from Crop Production:** Increased income from agriculture enables families to spend more on food and other essential needs. Higher

agricultural incomes can reduce poverty, support small farming businesses, and provide the means for families to afford a healthier diet.

3. **Women's Empowerment:** Empowering women through agricultural initiatives can boost their income, enhance their caregiving capabilities, and improve household nutrition. Women's empowerment impacts the nutritional status of both mothers and children, contributing to overall better health outcomes.

Crop Production, Climate Change, and Environmental Sustainability

Climate change, characterized by rising temperatures and more extreme rainfall patterns, affects the dynamics between crops, pests, pathogens, and weeds. It also exacerbates environmental issues like pollinator declines, water scarcity, and increased ground-level ozone concentrations. These changes impact crop yields and food security, with significant implications for nutrition (IPCC, 2019).

The International Panel on Climate Change (IPCC) projects that climate change could lead to a 29% increase in cereal prices by 2050 and place an additional 183 million people at risk of hunger compared to scenarios without climate change. Low-income consumers will be particularly vulnerable, with an estimated 24 million children at risk of undernutrition (IPCC, 2019). The relationship between crop production and environmental

sustainability is complex; merely increasing crop output is insufficient. Sustainable practices are needed to protect and enhance the natural resources on which agriculture depends.

With the global population expected to reach 10 billion by 2050, crop production must rise to meet this demand. However, increased production will likely lead to higher greenhouse gas emissions. Different crops also contribute to varying environmental stresses, such as high-water usage for certain horticultural crops in water-scarce regions.

Crop production systems are highly sensitive to environmental changes. Climate change can alter crop yields by affecting temperature and CO_2 levels. For instance, a 3°C increase in temperature could significantly impact crop yields, with some regions experiencing improved yields while others suffer reductions, particularly in low- and middle-income countries (IPCC, 2019). Springmann *et al*. (2016) project that climate-related changes in diets could result in an additional 500,000 deaths by 2050 due to decreased food intake and reduced consumption of vegetables and fruits. Increased atmospheric CO_2 is also expected to lower the nutritional quality of staple crops and reduce the yield of fruits and vegetables, which are essential for good nutrition (IPCC, 2019).

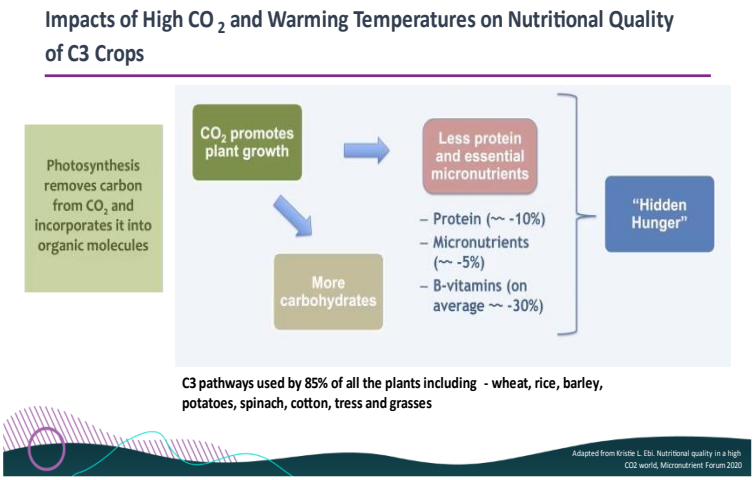

Figure 1: Impact of High CO_2 and Warming Temperature on Nutritional Quality of C3 Crop.

Pathways for Carbon Fixation in Plants

Plants utilize several pathways to remove carbon dioxide (CO_2) from the atmosphere through photosynthesis and incorporate it into organic molecules. The primary pathways are:
C3 Pathway (Calvin Cycle): Many plants use the C3 pathway, also known as the Calvin cycle. In this process, CO_2 is fixed into a three-carbon compound called 3-phosphoglyceric acid (PGA). About 85% of all plants, including wheat, rice, barley, potatoes, spinach, cotton, trees, and grasses, use the C3 pathway.

C4 Pathway: Some plants have evolved a different form of photosynthesis known as C4 photosynthesis, which is

particularly effective in hot and dry environments. In this pathway, a four-carbon compound is produced, and unique leaf anatomy allows CO_2 to be concentrated in 'bundle sheath' cells around the enzyme Rubisco. This adaptation helps reduce losses due to photorespiration. C4 plants include corn, sugarcane, millet, sorghum, and pineapple.

Impact of Increased CO_2 on C_3 and C_4 Plants

The rising CO_2 levels in the atmosphere have different effects on C3 and C4 plants. For C3 plants, higher CO_2 concentrations lead to increased carbohydrate production but reduced nutritional quality. Studies show that under elevated CO_2, C3 plants experience about a 10% reduction in protein content, a 5% reduction in micronutrients, and a 30% reduction in B vitamins (Kristie, 2020). On the other hand, C4 plants are less affected by increased CO_2 levels and maintain their nutritional quality better. As countries develop, dietary patterns may shift. However, in places like Nigeria, where a significant portion of calories still comes from rice and maize, the nutritional impacts of increased CO_2 could be more pronounced. Modeling estimates suggest that declines in nutritional density due to higher CO_2 will affect hundreds of millions of people, especially in low- and middle-income countries that rely heavily on these staple crops.

Addressing Climate Change and Environmental Impacts

Addressing climate change requires a comprehensive approach to the food system. The following key approaches have been identified as the main strategies for addressing climate change.

Mitigation: Mitigation involves reducing the severity of climate change impacts by preventing or lowering greenhouse gas (GHG) emissions. This can be achieved through measures such as increasing forest cover and reducing carbon emissions. Essentially, mitigation involves human interventions to reduce GHG sources.

Adaptation: Adaptation focuses on anticipating and minimizing the adverse effects of climate change. Examples include adjusting agricultural practices, such as planting crop varieties that are resilient to changing weather conditions. Adaptation is about adjusting to both current and anticipated climate impacts.

Strategies for Mitigation and Adaptation

Rosenzweig *et al.* (2020) provide a range of strategies for mitigating and adapting to climate change impacts on food systems. These strategies are evaluated for their potential effectiveness and co-benefits beyond their primary goals.

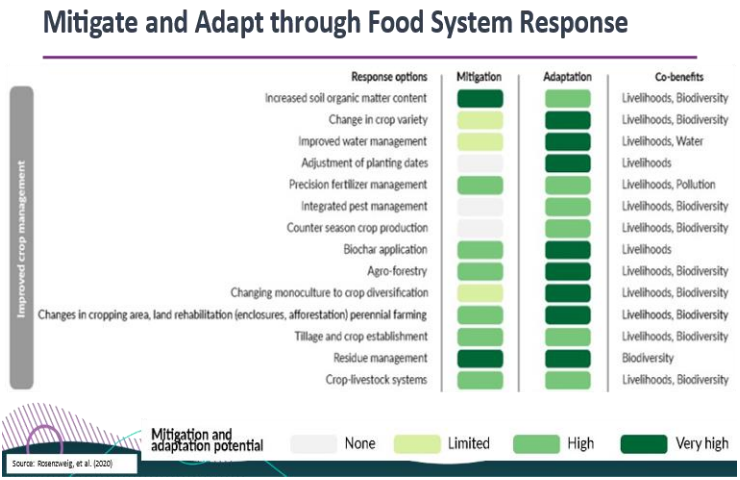

Figure 2: Mitigation and Adaptation Methods through Food System Response

MY CONTRIBUTIONS

RESEARCH RELATED TO IMPROVED CROP PRODUCTION

Cowpea (*Vigna unguiculata* L. Walp.)

Cowpea is a vital crop for food nutrition and environmental sustainability, utilized for food, vegetables, fodder, green manure, and cover cropping (Horn *et al.,* 2022). It provides a cost-effective source of dietary protein and is a staple in markets across Nigeria. Nigeria is the world's leading producer of cowpea, with a total production of 3.6 million tons in 2021 (FAO, 2021). Despite this, the demand for cowpea exceeds its supply due to the country's large population and low productivity (Osipitan *et al.,* 2021). Current productivity stands at about 900 kg per hectare, whereas the potential yield is approximately 2,000 kg (NAERLS and FDAE, 2023). This productivity gap is often attributed to inadequate agronomical practices during cultivation (Chibuzo *et al.,* 2024). Thus, exploring Good Agronomical Practices (GAgrPs) is essential for achieving sustainable cowpea production for improved human nutrition and health.

Research 1: Impact of Defoliation on Cowpea Growth and Yield

Cowpea plants offer various benefits, including use as human and animal feed and green manure. The effect of leaf removal for livestock consumption on grain yield has been a focus of research to optimize yields of both leaves

and grain. I conducted a study on the impact of defoliation stages and intensities on cowpea growth and yield, initially as an undergraduate project in 2021 and later expanded for my M.Sc. thesis in 2002 and 2003.

The objective was to assess how defoliation at different growth stages and intensities affects cowpea yield and profitability in Nigeria's savannah zone. The field experiments were conducted over multiple years (2002, 2003, 2006, and 2007) at the Institute for Agricultural Research, Ahmadu Bello University, Samaru, Zaria. The experimental design was a randomized complete block design with three replications, featuring a factorial combination of three growth stages (vegetative, flowering, and podding) and five defoliation intensities (0, 25, 50, 75, and 100%).

Results indicated that defoliation at early stages significantly reduced both growth and developmental characteristics of cowpea. Early defoliation led to substantial decreases in yield and yield components, with more severe reductions as defoliation intensity increased. The interaction between the defoliation stage and intensity was significant, showing that defoliating up to 50% during the vegetative stage was particularly detrimental to pod yield. These findings underscore the negative impact of leaf removal on cowpea yield and profitability (Rahman *et al*., 2008; Ibrahim *et al.,* 2010).

Research 2: Weed Control in Cowpea

Cowpea cultivation in the rainy season often faces challenges from weed infestations, which compete with the crop for resources and can significantly reduce yields (Patel *et al*., 2003). Weeds also lower input efficiency, harbor pests and pathogens, and contaminate harvests. Traditional weed control methods, such as hand pulling and hoeing, are labor-intensive and costly. Herbicides offer a more feasible option for large-scale production.

The research aimed to determine the effectiveness of different herbicides in controlling weeds, enhancing cowpea performance, and improving profitability. The field experiments were carried out in 2011 and 2012 at the Institute for Agricultural Research, Ahmadu Bello University, Zaria, within the Northern Guinea Savannah Ecological Zone.

Herbicides tested included S-metolachlor 960 EC, pendimethalin 33% (w/v) EC, and Butachlor E.C., all applied at a rate of 3.5 L ha^{-1}. The results showed that pendimethalin, combined with hoe weeding at 6 weeks after sowing (WAS), achieved the best weed control, growth, and yield. The average yield from this treatment was 3.2 t ha^{-1}. Additionally, pendimethalin application resulted in the highest gross margin and cost-benefit analysis. The study concluded that pre-emergence herbicides, particularly pendimethalin, should be adopted to improve cowpea yield and profitability (Ibrahim, 2013a; Ayinde and Ibrahim, 2012)

Effect of Post-Emergence Herbicides on Cowpea: Weed Control, Yield, and Profitability

Post-emergence herbicides are not widely used by farmers in the study area, likely due to limited knowledge about their effectiveness, crop safety, and economic benefits. Furthermore, the optimal timing for post-emergence weed control often coincides with peak workload periods. To address these issues, a field experiment was conducted at the Samaru College of Agriculture Student Demonstration Farm during the 2011 rainy season. The study aimed to evaluate the performance of various post-emergence herbicides and provide recommendations for effective weed control methods beyond traditional hoe weeding.

The field trial tested three post-emergence herbicides at two different application rates each:

- Fluazifop-p-butyl**:** 300 g ha^{-1} and 450 g ha^{-1}
- Haloxyfop-R-methyl: 108 g ha^{-1} and 162 g ha^{-1}
- Benzothiadiazone: 96 g ha^{-1} and 144 g ha^{-1}

These herbicides were applied at 4 weeks after sowing (WAS). Comparisons were made with traditional hoe weeding at 4 WAS, 6 WAS, and both 4 and 6 WAS, as well as an unweeded control. The results show that the application of 96 g ha^{-1} Benzothiadiazone gave the highest weed control index, gross margins, and cost-benefit ratio among all methods tested. In contrast, uncontrolled plots suffered significant weed loss, approximately 80%, highlighting the importance of effective weed management. The use of 96 g ha^{-1} Benzothiadiazone at 4 WAS resulted in the highest yield, averaging 3684 kg ha^{-}

[1]. This herbicide can effectively replace hoe weeding, especially in areas where labor is scarce during peak periods of the season (Ibrahim *et al.,* 2013a).

Groundnut (*Arachis hypogaea* L.)

Groundnut has significantly contributed to the Nigerian economy. Between 1956 and 1967, groundnut products, including cake and oil, accounted for about 70% of Nigeria's total export earnings, surpassing other cash crops like cotton, oil palm, cocoa, and rubber (Harkness *et al.,* 1976). Until 1969, Nigeria was the world's third-largest groundnut exporter, after India and China. Today, groundnut remains an important source of income through the sale of seeds, cakes, oil, and haulms.

In Nigeria's northern Guinea and Sudan savanna zones, groundnuts are consumed whole or processed into various products such as groundnut paste, cake (*kuli kuli*), salted groundnuts (*gyada mai gishiri),* millet porridge with groundnuts (*kunun gyada*), groundnut candy (*kantun gyada*), and groundnut soup (*miyar gyada*). Groundnut haulms, particularly in the Sudano-Sahelian region, are equally valuable as the pods, providing significant cash income for smallholder farmers. Groundnut shells are often used as fuel or spread on fields as a soil amendment.

Research 1: Profitability and resource use efficiency in groundnut

Research on the profitability and resource use efficiency in groundnut production reveals that groundnut pod yield

from farmers' fields under rainfed conditions is less than 1,000 kg ha^{-1} (NAERLS and FDAE, 2023), far below the potential yield of 3,000 kg ha^{-1}. A survey by Ibrahim *et al.* (2013b) conducted in Sabon-gari local government concluded that groundnut yield and profitability in the area are low, and inputs are not being used efficiently.

The study identified several key constraints limiting groundnut production. These include the unavailability of improved seed varieties suited to specific ecologies, poor soil fertility, and inappropriate crop management practices. Additional challenges such as high labor demands, lack of mechanization, and market constraints further contribute to low yields. These factors discourage farmers from cultivating groundnut, leading them to favor other food crops like maize, particularly in Nigeria.

Research 2: Influence of poultry manure and weed control methods on the performance of groundnut (Arachis hypogaea L.) Varieties under rainfed and irrigated conditions.

As part of my PhD research, aimed at addressing challenges in groundnut production, I focused on optimizing crop performance through nutrient and weed management strategies. The study investigates the impact of poultry manure and various weed control methods on the performance of groundnut (*Arachis hypogaea* L.) under rainfed and irrigated conditions.

With the rising costs and environmental concerns of chemical fertilizers, poultry manure has gained popularity

due to its rich nutrient content, including nitrogen, phosphorus, and potassium. It also improves soil quality by enhancing structure, nutrient retention, and water infiltration (Mitchell and Donald, 2012). However, determining the optimal poultry manure application rate is essential for maximizing groundnut yields.

Weed control is crucial for profitable groundnut production. Weeds can account for 30-40% of potential yield losses (Akobundu, 1987). Hoe weeding, the predominant method in the tropics, is labor-intensive, costly, and can damage pegs and roots, reducing yields. Evaluating post-emergence herbicides offers potential to reduce labor and costs while avoiding crop damage.

Adopting improved groundnut varieties is key to increasing yields. Farmers using these varieties have seen yield gains of 23%, 43%, and 31% in Mali, Niger, and Nigeria, respectively (ICRISAT, 2011). Determining suitable varieties for specific ecological zones is crucial, as is the expansion of irrigation farming to supplement rainfed production, particularly in areas like the Sudan Savanna where climatic unpredictability hampers crop growth.

In response to these challenges, field trials were conducted in 2012 and 2013 at Samaru (rainfed) and Kadawa (irrigated). The study evaluated three levels of poultry manure (0, 1.5 and 3 tonnes ha-1), five weed control methods, which included three rates of post-emergence herbicide (0.054 kg a.i.ha-1 , 0.108 kg a.i ha-1 and 0.162 kg a.i ha-1 of Haloxyfop-R-methyl ester),

weedy check, and hoe weeding at 3 and 6 weeks after sowing (WAS) and three varieties of groundnut (SAMNUT 11, SAMNUT 22 and SAMNUT 23).

The objectives were to evaluate:

- The effect of poultry manure on groundnut performance under rainfed and irrigated conditions.
- The impact of different weed control methods on weed infestation and groundnut yield.
- The most adaptable and highest-yielding groundnut varieties.
- The profitability of poultry manure and weed control methods on three groundnut varieties.

Key findings:

- Application of 1.5 tonnes ha^{-1} of poultry manure yielded the highest pod output, while 3 tonnes ha^{-1} produced the highest haulm yield.
- Hoe weeding at 3 and 6 weeks after sowing (WAS) provided the best weed control and highest pod and haulm yields, followed by 0.162 kg a.i. ha^{-1} of Haloxyfop-R-methyl ester.
- SAMNUT 11 performed better in terms of weed control, pod, and haulm yield compared to SAMNUT 22 and SAMNUT 23.
- Significant growth and yield traits, such as pod weight, 100-kernel weight, and number of pods, contributed to higher pod yield and are important for breeding high-yielding varieties.
- The combination of 1.5 tonnes ha^{-1} poultry manure, two hoe weedings, and SAMNUT 11

produced the highest net farm income. Average yields were 2,270 kg and 2,489 kg at Samaru and Kadawa, respectively.

Innovations:

1. Manure Calculation Model: Developed a model to calculate poultry manure requirements based on inorganic fertilizer recommendations.
2. Weed Species Quantification: Utilized Relative Frequency (RF) to quantify weed species in the study area.
3. Profitability Analysis Model: Created a model combining regression and profitability analysis to determine the most profitable groundnut production strategies.

These findings provide valuable insights for optimizing groundnut production through improved nutrient and weed management, increasing yields and profitability under both rainfed and irrigated conditions (Ibrahim *et al*., 2016 a; Ibrahim *et al*., 2016 b; Ibrahim *et al.,* 2015 a; Ibrahim *et al.,* 2015 b; Ibrahim *et al.,* 2014a; Ibrahim *et al.,* 2014 b; Ibrahim *et al.,* 2013 c).

Onion production (*Allium cepa*)

Onion production (*Allium cepa*) is widespread across the savanna zones of Nigeria, especially in Gombe, Sokoto, Kaduna, Kano, Plateau, and Borno States. Onions are valued for their medicinal and nutritional properties, being rich in proteins, carbohydrates, minerals, and vitamins. They also serve as a viable industry that

employs large numbers of people, with onions traded domestically and internationally. Despite being the second most important vegetable in Nigeria, current onion production levels do not meet the demand due to improper agronomic practices that result in low yields.

Research 1: Growth and Yield of Onion as Influenced by Planting Dates and Mulching Types in Samaru

Planting time is critical for onion bulb formation, and proper timing ensures high yield and profitability. Soil moisture is another key factor, as onions extract water mainly from the upper 30 cm of the soil. Mulching helps conserve moisture, improving plant growth. This trial, conducted at the Teaching and Research Farm of Ahmadu Bello University, evaluated different planting dates (15th October, 30th October, 14th November, and 29th November) and mulching types (white polythene, black polythene, water hyacinth, and control). The results showed that planting on 15th October and using white polythene mulch provided the highest growth and yield (Hamma *et al.*, 2012).

Research 2: Productivity of Onion as Influenced by Nitrogen Fertilizer Rates and Plant Population Under Irrigation in the Nigerian Savanna

Onions require adequate nitrogen for optimal growth, but excess nitrogen can reduce quality and cause nitrate leaching. Plant population also plays a crucial role in determining yield. This study, conducted in Samaru and Kadawa during the 2019/2020 dry season, aimed to find

the optimal nitrogen rate and plant population for maximum yield. Five nitrogen rates (0, 40, 80, 120, and 160 kg N ha^{-1}) and four plant population levels (160,000 to 1,000,000 plants ha^{-1}) were evaluated. The results indicated that 750,000 plants ha^{-1} was optimal at Samaru, while 666,666 plants ha^{-1} was best at Kadawa, with 114.08 kg N ha^{-1} yielding 14.71 t ha^{-1} at Samaru and 150.5 kg N ha^{-1} yielding 19.46 t ha^{-1} at Kadawa (Issa *et al.*, 2022).

Research 3: Effect of Poultry Manure Levels and Weeding Regimes on Onion Performance in Samaru

Poultry manure is a valuable resource for crop growth due to its nutrient content, but its application must match the crop's needs to avoid wastage. Weed control is essential for successful onion production, as onions do not compete well with weeds. This research, conducted during the 2010 and 2011 cropping seasons, assessed four poultry manure levels (0, 5, 10, and 15 t ha-1) and eight weeding regimes. The results showed that applying 15 t ha^{-1} of poultry manure and weeding at 4, 8, and 12 weeks after transplanting (WAT) produced the highest onion growth and yield (Ibrahim *et al*., 2011a).

Research 4: Effect of Post-Emergence Weed Control on Onion Performance, Yield, and Profitability

Post-emergence herbicides are marginally selective for broadleaf weeds, and timing is critical to avoid crop injury while controlling weeds effectively. In Nigeria, onion production has stagnated partly due to weed-related yield

losses. A study conducted during the 2009 and 2010 dry seasons in Gombe and Ibadan evaluated two onion varieties (Red Creole and Early Texas Yellow) and five weed control methods, including herbicides and hoe weeding. The results showed that herbicides significantly reduced labor requirements, with oxyfluorfen providing the highest gross margin, outperforming hoe weeding by 3% in profitability. The study concluded that oxyfluorfen is the most cost-effective post-emergent herbicide for onion production (Ibrahim *et al.*, 2012; Ibrahim *et al.*, 2013d; Hamma *et al.*, 2011).

These studies underscore the importance of proper agronomic practices—such as timely planting, appropriate fertilization, weed management, and the use of organic manure—in boosting onion yields and profitability in Nigeria.

Rice (*Oryza sativa* L.)

Rice (Oryza sativa L.) is widely cultivated in Nigeria, particularly in the Northern Guinea Savannah agroecological zone. Rice importation in Nigeria increased dramatically from less than 500,000 metric tonnes in 1994 to 2.1 million metric tonnes in 2011. Between 2008 and 2011, Nigeria spent an average of US$ 2.5 billion annually on rice imports (Anon., 2010). This high level of importation has raised concerns about sustainability, prompting the Nigerian government to refocus on stimulating domestic rice production. One strategy has been the establishment of rice processing factories in Kano, Kwara, Ogun, and Benue States with a

combined installed capacity of 730,000 metric tonnes per annum (Anon., 2010). Boosting local paddy rice production is vital to maximizing these processing capacities, creating employment, increasing incomes, and reducing poverty.

Research 1: Evaluation of Herbicides on Weed Infestation, Yield, and Profitability of Rice in the Northern Guinea Savannah of Nigeria

Weed control is critical for profitable rice production, as weeds compete with rice for moisture, nutrients, and light, which can lead to significant yield reductions. Weeds can also interfere with harvesting and drying operations, lower the quality of rice grains through contamination, and reduce the crop's market value. In rice production worldwide, weed-related yield losses vary depending on weed species and farmers' control methods. In Nigeria, yield losses in upland rice due to weeds can range from 40% to 100% (Akobundu, 1987).

The traditional method of weed control in the region is hoe weeding, but this method is labor-intensive, costly, and unreliable, especially during peak seasons when labor is scarce. Furthermore, hoe weeding can cause crop injury and loss, and some grass weeds, which closely resemble rice, may escape detection during hand weeding.

To explore more efficient alternatives, herbicides have been evaluated as a promising method of weed control in rice production. When applied at the recommended rates, herbicides can offer effective weed suppression and

improve rice yields. Previous studies, such as that by Mahadi *et al.* (2006), reported that pre-emergence herbicide applications produced rice grain yields comparable to those from two rounds of hoe weeding.

However, the adoption of herbicides among Nigerian farmers has been limited due to concerns over crop injury, efficacy, and the cost of herbicide treatments. To address these concerns, a field experiment was conducted during the 2009, 2010, and 2015 wet seasons in Lafiagi, Kwara State, Nigeria, to evaluate the yield and profitability of rice production under various weed control treatments.

The study aimed to identify selective herbicides that could effectively control weeds in rice fields while reducing labor requirements and enhancing rice production. This would ultimately support efforts to reduce Nigeria's reliance on imported rice and save valuable foreign exchange reserves.

The research concluded that early weed control in rice production using pre-emergence herbicides, particularly Topstar (Oxadiargyl 400g/l) at 0.8 liters per hectare, in combination with any of the following post-emergence herbicides—Solito (300g Pretilachlor + 20g pyribenzoxim) at 1.5 liters per hectare, Orizo Plus (360g Propanil + 200g 2,4-D) at 10 liters per hectare, Nominee Gold (Bisbyribac sodium 100 S.C.) at 0.4 liters per hectare, and Profit (170g Pretilachlor + 330g Propanil) at 6 liters per hectare, applied at six weeks after sowing (WAS)—resulted in significantly higher rice yields and

gross margins compared to the control and other treatments tested.

The study found that the use of pre-emergence herbicide Topstar alone at planting provided the highest cost-benefit return of N7.1, representing a 122% increase over the control. The combination of Topstar as a pre-emergence herbicide with Nominee Gold applied at 6 WAS showed an 80% increase in returns (N5.8), and the combination of Topstar with hoe weeding at 6 WAS resulted in a 75% higher return (N5.6) compared to the control.

In terms of labor requirements, the use of Topstar alone as a pre-emergence herbicide required the least labor (1 man-day), while combining pre-emergence herbicide application with hoe weeding required 5 man-days. Using both pre-emergence and post-emergence herbicides reduced labor demand to 2 man-days.

The research concluded that herbicide application not only increased rice yield and profitability but also reduced labor requirements. Therefore, it is recommended that for successful rice production in the study area, farmers should adopt Topstar as a pre-emergence herbicide and Nominee Gold as a post-emergence herbicide (Ibrahim *et al.,* 2011b; Ibrahim & Namakka, 2019).

Research 2: Response of Improved Rice Varieties to Different Rates of Nitrogen Fertilizer under Irrigation

Nutrient deficiency, particularly nitrogen (N), is a major constraint to rice production in West Africa, including

Gashua. Efficient fertilizer management involves determining the right rate, source, timing, and application method. Rice varieties differ in their nitrogen uptake and utilization efficiency (Fageria, 2007), and genetic variation among rice varieties leads to varying responses to nitrogen.

In dryland rice production, a common challenge is farmers' reluctance to adopt high-yielding, medium to late-maturing rice varieties, favoring early-maturing, low-yielding local varieties instead. High-yielding improved varieties, which cannot thrive under rainfed conditions, combined with the use of chemical fertilizers in irrigated settings, offer a potential strategy to boost rice yields.

In a study conducted by Ibrahim *et al.* (2017), researchers evaluated the response of various improved rice varieties to different nitrogen fertilizer rates under irrigation in Gashua's Sahelian agro-ecological zone. The objectives of the study were to assess yield response, agronomic efficiency, partial factor productivity of applied nitrogen, and grain harvest index, with the goal of developing alternative fertilizer recommendations for the varieties.

The results showed that:

- 45 kg N/ha application gave the highest agronomic efficiency, partial factor productivity, and grain harvest index.
- 135 kg N/ha application resulted in the highest grain yield.

- FARO 61 had the highest grain, partial factor productivity of applied nitrogen, and grain harvest index.
- FARO 60 exhibited the highest agronomic efficiency.
- All varieties, except FARO 44, outperformed the local variety in yield and productivity.

Based on these findings, farmers in Gashua are advised to grow FARO 52, FARO 60, FARO 61, and the local variety Jamila under irrigation during the dry season. The recommended fertilizer application is 50 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} during land preparation, followed by 135 kg N/ha, split into two applications (two weeks and six weeks after transplanting) to maximize rice yield. A profitability analysis using regression results indicated that applying 126 kg N/ha provided the highest economic returns (Ibrahim *et al.,* 2018).

RESEARCH RELATED TO THE SAFETY, WELFARE, AND HEALTH OF FARMERS AND OTHER ACTORS IN THE CROP VALUE CHAIN

The concept of One Health recognizes the interconnectedness of human, plant, and animal health, emphasizing that biodiversity is essential to maintain healthy ecosystems and the services they provide. One Health is an integrated, unifying approach that seeks to balance and optimize the health of people, plants, animals, and ecosystems. It provides a framework for understanding complex systems and implementing strategies to prevent harm and promote sustainability across various sectors.

In the past decade, other integrated health approaches, such as EcoHealth and Planetary Health, have emerged to build on the human-centered focus of Global Health. EcoHealth emphasizes the health of ecosystems and highlights the importance of socio-ecological drivers of health, while Planetary Health focuses on the relationship between human health and the Earth's natural systems.

Recent advancements in One Health (2021/2022) include the formation of the One Health High-Level Expert Panel, the recognition of Indigenous and pastoral knowledge systems as essential components, and the establishment of the Quadripartite Agreement, which includes key international organizations such as the World Health Organization (WHO), Food and Agricultural Organization (FAO), World Association for Animal

Health (WAOH), and the United Nations Environment Program (UNEP).

One Health promotes harmonized and coordinated efforts across sectors, countries, and cultures, involving various stakeholders, including government departments, NGOs, foundations, Indigenous groups, trade unions, private companies, and more. These efforts aim to safeguard the health, welfare, and safety of farmers and others involved in the crop value chain by addressing the challenges and risks they face through a holistic, ecosystem-based perspective.

Occupational Safety and Pesticides Hazard Among Agro-Chemical Input Dealers

Recognizing the critical role of agro-dealers in accelerating smallholders' access to quality inputs, agro-dealers not only sell products but also serve as advisors to farmers on the safe use of pesticides. These dealers are in direct contact with both chemicals and farmers, which poses certain occupational hazards. In this context, Ibrahim *et al*. (2011c) conducted a study on Occupational Safety and Pesticides Hazard Among Agro-Chemical Input Dealers.

The objectives of the research were to evaluate the knowledge, location, and safety provisions of agrochemical dealers, assess how well they understand the products they sell, and determine the safety and health measures in place. Additionally, the study aimed to

evaluate the effectiveness of regulatory oversight and the existence of formal training programs for these dealers.

A sample size of 320 agrochemical dealers in Oyo State was used. The results revealed that 91% of the dealers had not undergone any formal training, although they were aware of the hazards associated with their work. Many dealers operated without a separate office space for storing chemicals, which exposed them to chemical hazards for approximately 10 hours per day. Their technical knowledge was limited, particularly in critical areas such as hazard classification, first aid treatment, usage directions, warning precautions, symptoms of poisoning, first aid instructions, and toxicology hazards. These are crucial aspects for the safe handling of chemicals.

The findings were presented to the Oyo State Agro Input Dealers Association (OSAIDA), highlighting that training is essential in pesticide handling. It was recommended that only individuals who had undergone proper training should be licensed to sell and handle pesticides.

In response to these recommendations, a coordinated training effort was initiated by OSAIDA, IFDC (International Fertilizer Development Center), and CropLife. The training was spearheaded by Saro Agro Sciences, in collaboration with the International Fertilizer Development Center, for all OSAIDA members. The training, which took place from 2009 to 2010, focused on the safe handling and sale of pesticides. Additionally, Saro Agro Sciences, in response to its corporate social

responsibility, sponsored training programs for farmers on Good Agricultural Practices (GAP) and Rational Pesticide Usage, in collaboration with the Agricultural Development Programs (ADP) of Oyo, Ondo, Osun, Ekiti, Ogun, and Kwara States.

Effect of Snake and Scorpion Bites on Farming Activities

Exposure to snake and scorpion bites is a significant occupational hazard faced by farmers, rural dwellers, herdsmen, and hunters. To further research on the safety, welfare, and health of farmers, Ibrahim *et al.* (2016c) conducted a study on the effects of snake and scorpion bites on farming activities in selected Local Government Areas (LGAs) in northern Nigeria.

The study areas included farmers from Soba, Zaria, Sabon-Gari, Kudan, and Ikara LGAs in Kaduna State, Kiru, Karaye, and Gwarzo LGAs in Kano State, and Malumfashi and Sabuwa LGAs in Katsina State. Data were collected through structured questionnaires randomly distributed in the selected LGAs. Additionally, focus group discussions and key interviews were conducted with community members and personnel from major hospitals and clinics in the study areas.

The results revealed that snake and scorpion bites were prevalent across all the study areas. The effects of these bites were found to increase production costs and, in some cases, reduce the amount of land farmers could cultivate. These hazards contribute to reduced productivity and

increased health and financial burdens on the farming communities.

Occupational and Environmental Safety in a Seed Company

With the rise in seed companies and the increase in the number of workers in the seed industry, ensuring the health and wellbeing of employees has become crucial. The success of any organization depends significantly on its commitment to safety and environmental conditions, which are essential for sustainable seed production and worker satisfaction. Common occupational hazards in this industry include noise pollution, electrical shocks, heat stress, exposure to seed dressing chemicals, and dust, which can lead to lung and skin diseases or physical injuries.

In May 2008, given the limited documented studies on occupational safety in the seed industry in Nigeria, we conducted research to assess these issues. The study aimed to evaluate the extent to which seed companies have implemented health measures and effectively supervised their workforce to ensure compliance with safety regulations. It also examined the availability and effectiveness of training programs designed to promote a positive safety attitude among workers. The research recommended periodic training for all staff, the placement of appropriate safety guides in each section of the factory, and regular medical checkups for employees exposed to dust and chemicals. These measures are intended to enhance occupational safety and ensure the health and

wellbeing of workers in the seed industry (Ibrahim *et al.,* 2014c).

Assessment and Management of used Pesticides Containers from Farmlands

The fast-growing demand in agricultural produce and increasing utilization of pesticides on farmlands has introduced management problems of used pesticides containers in Nigeria. Pesticides application has become an important component of crop production and unfortunately there are reports of improper disposal of pesticides which could lead to environmental pollution. In view of this Ibrahim, *et al., 2016d* carried out an Assessment and management of used pesticides containers from farmlands in Kaduna State of Nigeria. The SWOT Analysis of the current management of Used Pesticides Containers in Kaduna State is given below:

Strengths

- Fairly accurate data records on imported products can be obtained from pesticides dealers / distributors.
- Existence of Agricultural agencies that can train farmers on proper disposal methods for pesticides containers and the risks of improper disposal to the environment.
- Existence of pesticides dealers/distributors that could link up directly with manufacturers for possible return of used pesticides containers for reuse for packaging of the product.

Weakness

- Non-existence of environmental regulations and legislation which supports used pesticides container management.
- Lack of disposal facilities for pesticides containers.
- Lack of public awareness on the potential risks of improperly disposed pesticides containers to the environment and human health.
- Lack of infrastructure for formal collection and recycling pesticides containers
- Improper disposal methods such as burning and burying could lead to environmental pollution as well as pose risk to human health.

Opportunities

- Establishment of formal plastics recycling activities is viable since there is high potential for its generation.
- Employment and income generation through the used pesticides container management processes (collection, cleaning, and transportation)

Threat

The improper reuse and disposal methods presently practiced in Nigeria may expose millions of people to toxins if proper management programmes are not put in place as soon as possible.

The study also quantified the amount of pesticide containers generated in the area and proposed appropriate

disposal methods of these pesticide containers to promote agricultural development and keep the environment clean and safe. It was also estimated that by the year 2022 the quantity of used pesticides containers used in the state would be up to 9 million containers. The study also revealed problems faced by the farmers and suggested ways by which used pesticide containers can be effectively managed in Nigeria. The finding shows that pesticides containers are not well disposed and there was a yearly increase in the number of pesticides that is used. Based on the results of these findings, the following recommendations are proffered:

- Government should enact laws that would mandate pesticide manufacturers to offer take-back programmes for their pesticide containers from farmers for reuse in repackaging their products.
- More awareness should be given to farmers on the need to release their used pesticide containers to manufacturers when proper take-back programmes commence.
- Other avenues for recycling the used pesticide containers should be sought and implemented in the interim before take-back programmes commence.

CONTRIBUTION TO PROFESSIONAL SERVICE

Horticultural Society of Nigeria

The Horticultural Society of Nigeria (HORTSON), a member of the International Society of Horticultural Science was founded in October 1977 to cater for horticultural development in Nigeria. The Society binds all stakeholders (Scientists, Industrialists, and Farmers) working on fruits, vegetables, spices, and Ornamentals.

I was elected as the National Coordinator for Vegetables, Horticultural Society of Nigeria during the 33rd Annual Conference of Horticultural Society of Nigeria held at Agriculture Research Council of Nigeria, Research house, Mabushi, Abuja, Nigeria from 29th November-4th December 2015. I served the society in that capacity from 2015 to 2017 under the leadership and mentorship of Dr H.A. Akintoye. During this period, I was able to coordinate the hosting of the 34th Annual conference of Horticultural Society of Nigeria held at Federal University, Gashua from 24th-26th October 2016. The first time the society produced her conference proceeding before the end of the conference and participants went home with their copies.

Similarly in 2019 during the 35th Annual Conference of the Horticultural Society of Nigeria held at Kabba College of Agriculture, Division of Agricultural Colleges, Ahmadu Bello University, Zaria, Nigeria from 29th October - 3rd November 2017. I was elected as the National Vice President I. I was charge by the council to

create the position of zonal coordinator, which eventually help in increasing the membership of the society and creating more awareness in the different parts of the country.

I became the President-in-Council (PiC) of the society in 2019 during the 37th Annual Conference of the Horticultural Society of Nigeria that was held at Rufus Giwa Polytechnic, Owo, Ondo State from 18th -22nd November 2019 and I served as the PiC for two years from 2019-2021. It is pertinent to note that the election that brought me to the position in 2019 was unposed. While I was the PiC I champion the needed changes at that time. The council was able to develop a strategic plan for the society which covers from 2020-2027, when the society will be 50 years old (1977-2027). We also developed a draft document for a proposed Council for Regulation of Horticulture (CORHORT) in Nigeria. This document has been reviewed by various stakeholders. A copy of the draft document was circulated for review, corrections, and observations.

We also developed partnerships with many key organizations that include the International Society for Horticultural Science, American Society for Horticultural Science, American Public Garden Association, Agriculture to nutrition Community of Practice, Agriculture Nutrition and Health Academy, Longwood Gardens, Federal and State Ministry of Agriculture and private Agricultural companies to further enhance our ambition of horticultural and agricultural development in Nigeria. I was called to serve a second tenure but at that

time I was accepted to participate in the prestigious Longwood Fellows Leadership programme in Horticulture.

I was awarded the Fellow of Horticultural Society of Nigeria (FHSN), the highest honor of the Society which, is strictly awarded through a rigorous selection process to well-deserving individuals for their contributions towards the development of HORTSON and horticulture in Nigeria. The investiture ceremony took place during the 40th annual conference of the Society that took place at Taraba State College of Agriculture, Jalingo from 14-19th November 2020

Agriculture-Nutrition Community of Practice

I was elected as the National Coordinator, of the Agriculture-Nutrition Community of Practice, Nigerian subgroups in 2018. The Agriculture-Nutrition Community of Practice (Ag2Nut) is a global network dedicated to exploring the linkages between agriculture and nutrition. With approximately 7,500 members from 129 countries, it includes country-specific subgroups for Ethiopia, Ghana, and Nigeria. The Ag2Nut-Nigeria Subgroup was established in September 2018 during the ANH Academy Week in Ghana. Its purpose is to enhance communication and collaboration among those working at the intersection of agriculture and nutrition in Nigeria. Comprising 70 members from 13 countries, the subgroup is led by me and two assistants.

In collaboration with ANH Academy and HORTSON, Ag2Nut-Nigeria hosted a webinar titled "The Role of Horticulture during COVID-19" on August 20, 2021.

Figure 3: Invitation for the Webinar on The Role of Horticulture during COVID-19

The Longwood Fellows Program

The Longwood Fellows program is a 13-month intensive leadership development initiative designed to equip high-potential professionals for impactful roles in public horticulture and related fields. Held at Longwood Gardens in Kennett Square, PA, the program emphasizes critical skills such as communications, board relations, governance, action learning, master site planning, fundraising, crisis communications, and nonprofit finance. It comprises three phases: onboarding, coursework, and practical application, including field placements.

Participants gain hands-on experience through departmental immersions, a comprehensive research project, and two-month field placements with partner institutions. I am honored to be the first Nigerian to join this prestigious program, where I received the award for Leadership in Horticulture.

I had the opportunity to study and work alongside four other fellows from Mexico, Colorado, and Washington, DC, during the 2021–2022 Longwood Fellows cohort. Our diverse backgrounds and careers provided a rich array of perspectives on public horticulture, with experience spanning universities, governments, and nonprofit organizations.

Figure 4: The 2021–2022 Longwood Fellows Cohort.

As a Longwood Fellow, my work centered on performance evaluation, organizational culture, and leadership skills and behaviors. During the program, I had the opportunity to collaborate with 30 different Executive Directors across the United States, studying their managerial practices and various aspects of leadership. I also co-authored a book titled *Making an Impact: A Tool for Advancing Employee Development*.

Harvard University

As part of the program's objectives, fellows are required to undertake a field placement to contribute to the development of the host organization. I had the privilege of completing my field placement at the Arnold Arboretum of Harvard University in 2022, where I served as a visiting scholar. During my two-month tenure, I conducted a comprehensive analysis of the organizational structure and operations of the Arboretum during my field placement at the Arnold Arboretum of Harvard University, I also conducted a training session for the staff on the topic: “Understanding Yourself and Others.”

Figure 5: Some activities during my stay at the Arnold Arboretum of Harvard University.

In February 2022, I was a guest speaker at the Virginia State University STEAM-H seminar, where I presented on the topic: "International Partnership and Collaboration: How Do You Fit In?"

Figure 6: Presentation at Virginia State University STEAM-H seminar in February 2022

SUMMARY OF CONTRIBUTIONS

Cowpea Production

- Defoliation Impact: The study demonstrated that defoliation significantly impacts cowpea growth and development, with yield loss increasing as defoliation percentage rises. Removing up to 50% of leaves at early stages was found to be detrimental to cowpea yield and profitability.
- Weed Management: Application of 3.5 L ha^{-1} of pendimethalin one day after planting, followed by hand weeding at 6 weeks after sowing (WAS), was shown to enhance cowpea yield and profitability.
- Alternative Weed Control Methods: The use of 3.5 L ha^{-1} of pendimethalin a day after planting, combined with 96 g ha^{-1} of Benzothiadiazinone at 4 weeks after planting, was found to improve yield and profitability. This approach offers an effective alternative to hoe weeding, especially in situations where labor is limited, particularly during peak seasons.

Groundnut Production

- Resource Utilization: In Zaria, optimal use of labor, fertilizer, seed, herbicides, and insecticides in groundnut production was hindered by high costs, limited availability, and insufficient technical knowledge regarding the appropriate quantity and type of inputs required.

- Challenges: Lack of capital and extension services accounted for over 78% of the issues faced in groundnut production in the study area.
- Manure Application: Applying 1.5 tonnes ha^{-1} of poultry manure resulted in the highest pod yield, while 3.0 tonnes ha^{-1} provided the best weed control and highest haulm yield.
- Weed Control Methods: Hoe weeding at 3 and 6 weeks after sowing (WAS) offered the best weed control and resulted in the highest pod and haulm yields. Among herbicide options, the application of 0.162 kg a.i. ha^{-1} of Haloxyfop-R-methyl ester was also effective.
- Varietal Performance: SAMNUT 11 outperformed SAMNUT 22 and SAMNUT 23 in terms of weed control, pod yield, and haulm yield.
- Important Traits: Traits such as pod weight, 100-kernel weight, number of pods, number of branches, plant height, canopy spread, and number of leaves significantly contributed to pod yield and are crucial when breeding for high-yielding varieties.
- Economic Benefit: Combining 1.5 tonnes ha^{-1} of poultry manure, two hoe weddings, and SAMNUT 11 resulted in the highest net farm income.

Onion Production

- Optimal Growth and Yield: For optimal onion production in Samaru, Zaria, a combination of 15 t ha^{-1} of manure and three weeding regimes at 4,

8, and 12 weeks after transplanting (WAT) was found to yield better growth and onion yield.

- Planting and Mulch: Planting onions around October 15 in Samaru and using white polythene mulch resulted in higher growth and yield.
- Planting Density: Planting onions at a spacing of 15×15 cm produced significantly higher bulb yields in both Samaru and Kadawa.
- Nitrogen Application: Applying 114.08 kg of nitrogen in both locations resulted in the highest yield.
- Herbicide Application: The application of 240 g/ltr E.C of oxyfluorfen at 350 ml ha^{-1} as a post-emergent herbicide 4 weeks after transplanting resulted in impressive yield and economic performance. Oxyfluorfen increased onion profitability by 3% compared to three hoe weedings and reduced labor requirements by 75%. Additionally, yield loss in unweeded conditions could be as high as 80%.

Rice Production

- Weed Quantification: Relative Frequency (RF) is an effective tool for quantifying weed species in various habitats.
- Early Weed Control in Lafiagi: Early weed control using pre-emergence herbicides like Top Star (Oxadiargyl 400g ha^{-1}) at 0.8 L ha^{-1}, combined with post-emergence herbicides such as Solito (300g Pretilachlor + 20g Pyribenzoxim) at 1.5 L ha^{-1}, Orizo Plus (360g Propanil + 200g 2,4-D) at

10 L ha^{-1}, Nominee Gold (Bisbyribac sodium 100 SC) at 0.4 L ha^{-1}, and Profit (170g Pretilachlor + 330g Propanil) at 6 L ha^{-1} at 6 weeks after sowing (WAS) resulted in significantly higher yields and gross margins compared to the control and other treatments. Pre-emergence herbicide (Top Star) alone required the least labor (1 man-day), whereas pre-emergence combined with hoe weeding required 5 man-days, and the use of both pre- and post-emergence herbicides required 2 man-days.

- Nutrient Application in Gashua: Applying 135 kg N ha^{-1} resulted in the highest grain yield. FARO 52, FARO 60, FARO 61, and the local variety JAMILA can be grown under irrigation during the dry season with a basal application of 50 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} during land preparation, followed by a split application of 135 kg N ha^{-1} at two weeks and six weeks after transplanting.

Safety, Welfare, and Health of Farmers and Other Actors in the Crop Value Chain

- Training for Agricultural Input Dealers: Many agricultural input dealers require training in hazard classification, first aid treatment, directions for use, warnings and precautions, symptoms of poisoning, first aid instructions, and toxicology hazards. This training is essential as they often serve as technical counselors to farmers.
- Occupational Hazards: Snake and scorpion bites are significant occupational hazards for farmers.

These bites can increase production costs and, in some cases, reduce the area of land cultivated.

- Seed Company Staff: Staff working in seed companies should receive periodic training and regular medical checkups, especially those exposed to dust and chemicals. Proper precautionary guidelines should be established in each section of the factory.
- Pesticide Container Disposal: Pesticide containers are often not disposed of properly, leading to an annual increase in pesticide waste. Recycling these containers could generate employment opportunities, provide raw materials for plastic industries, and improve environmental cleanliness and safety.

Leadership and Professional Journey

During my leadership journey, I have learnt the importance of:

- Assessment tools for self-awareness.
- Empathy and active listening when working with people.
- Self-reflection for self-development
- Work-life balance and health living.

CONCLUSION AND RECOMMENDATION

- Low yield is a significant challenge for farmers in Nigeria, often stemming from insufficient production skills and knowledge. Smallholder farmers frequently struggle to produce affordable, nutritious, and sufficient food for a growing population due to a lack of appropriate skills in crop production. Each stage of crop production, from pre- to post-harvest, requires specific skills to optimize inputs, yield, and ensure quality and safety. Implementing Good Agricultural Practices (GAP) plays a crucial role in addressing these challenges. GAP promotes the efficient use of resources such as pesticides, fertilizers, and water, while also advancing eco-friendly agriculture. Moreover, GAP helps protect agricultural workers' health by minimizing the risks associated with improper chemical and pesticide use. Research and extension services from research institutes on GAP can significantly enhance farm productivity. By extending GAP principles to farmers, we can improve the safety, quantity, and quality of farm produce, protect the environment, and ensure the well-being of agricultural workers.
- Agriculture plays a vital role in shaping the underlying determinants of nutrition, making it a key area for nutrition-sensitive programming. Research has identified three major pathways through which improved crop production can enhance nutrition: boosting crop yields, increasing income from agricultural produce, and empowering women. To maximize these benefits, research principles in Good

Agricultural Practices (GAP) should emphasize cross-cutting, interdisciplinary approaches and foster collaboration with various stakeholders, including the private sector, throughout the crop production value chain. Building the capacity and training farmers in different GAP techniques is essential. Prioritizing these aspects will help optimize crop production, improve nutrition, and support overall agricultural development.

- Climate change, characterized by rising temperatures and more extreme rainfall, disrupts the relationships among crops, pests, pathogens, and weeds. It also worsens trends such as the decline in pollinating insects, increased water scarcity, and rising ground-level ozone concentrations. Crop production contributes approximately 27% of food-related greenhouse gas emissions, meaning changes in production practices can significantly influence environmental impacts. Adaptation and mitigation strategies, tailored to specific contexts and scales, are essential to combat these challenges. Implementing sustainable practices in crop production can help reduce emissions and build resilience against the effects of climate change.
- The safety, welfare, and health of farmers and other actors across the food value chain are vital for sustainable crop production, human nutrition, and environmental sustainability. Proper training in pesticide handling is crucial to safeguarding these stakeholders. We recommend that only individuals who have undergone formal training be licensed to sell and handle pesticides. This measure will not only

protect farmers and consumers but also promote responsible pesticide use, enhancing overall safety in agricultural practices.

- Our findings revealed that pesticide containers are not being properly disposed of, and there is a yearly increase in the number of these containers generated. It has therefore become both necessary and urgent to implement recycling programs for all pesticide containers. This initiative would not only help maintain a cleaner and safer environment but also create employment opportunities and provide raw materials for plastic industries, contributing to economic growth and environmental sustainability.
- The increase in production costs due to the effects of snake and scorpion bites has, in some cases, impacted crop production. To address this issue, the study recommended the provision of hospitals with adequate and effective anti-venom, the use of protective clothing by farmers, and the application of snake repellents as solutions to mitigate the risks posed by these hazards in the affected areas.
- To effectively extend Good Agricultural Practices (GAPs) to farmers, it is recommended that the government and research institutes strengthen extension services to facilitate the delivery of improved technologies to farmers. Additionally, farmers should be encouraged to seek loans through cooperatives, banks, and other available sources. The loan application process should be simplified to ensure easier access, enabling farmers to enhance crop production.

- After extensive research on effective leadership and building leadership capacity, I recommend that leaders focus on results and performance rather than self-interest or personal gratification. Achieving results, however, also requires investing in relationships within the organization, as collective effort is essential to accomplishing goals and strategies. Leadership is about making a positive impact within the organization, enabling it to contribute positively to the community or region it serves. Today's and future leaders should emphasize developing strong character, values, and principles. They should be visionary and courageous, with a belief in their ability to shape the future, and must act on those beliefs by leading with integrity and authenticity.

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