

Review Article

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Enhancing Sweet Potato Yield: An Overview of Strategies for High-Yield and Sustainable Production

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Abstract Sweet potato (*Ipomoea batatas* L.), the third most important root crop globally, offers significant nutritional value and high yield potential, making it a critical crop for food security, particularly in developing regions. However, its production is influenced by various factors. As the global population grows and dietary demands shift toward more sustainable and nutritious food sources, there is an increasing need to enhance the productivity of sweet potato cultivation. This review provides a comprehensive overview of strategies to improve sweet potato yield, with a focus on practical agricultural approaches. Key aspects such as the selection of high-yield, disease-resistant varieties are emphasized. Soil management practices, including optimal soil conditions, preparation techniques, and nutrient management, are demonstrated. Planting techniques, including optimal timing, plant density, and propagation methods, are also highlighted. Effective irrigation and water management strategies for different growth stages are crucial and addressed in detail. Pest and disease management is addressed through integrated approaches, while weed control strategies emphasize sustainable practices. Nutrient management and fertilization are addressed, comparing organic and synthetic options. Finally, the review offers guidelines on harvesting handling to reduce losses and maximize yield. In summary, integrating genetic improvement with effective agricultural practices can significantly enhance sweet potato production. However, future research should prioritize developing new varieties with higher yield potential and greater tolerance, ultimately improving the marketability and economic viability of sweet potato farming.

Keywords Sweet potato; Yield; Genetic traits; Agriculture practice; Growth

1 Introduction

Sweet potato (*Ipomoea batatas* L.) is the third most important root and tuber crop globally, following potato (*Solanum tuberosum* L.) and cassava (*Manihot esculenta* Crantz). It is a valuable source of both nutrition and energy (Marques et al., 2022). The storage roots of sweet potato are rich in macronutrients and micronutrients, including carbohydrates, dietary fiber, minerals, carotenoids, and vitamins (Kourouma et al., 2019). Due to its high nutritional value and substantial yield potential, sweet potato has become a staple food worldwide, particularly in developing regions (Steffler et al., 2022; Ahmed et al., 2024). Additionally, the crop's resilience and ability to thrive in marginal soils further emphasize its significance in sustaining agricultural productivity and supporting the livelihoods of smallholder farmers (Mukhongo et al., 2017; Fan et al., 2018; Steffler et al., 2022).

Globally, sweet potato production plays a crucial role in agriculture, particularly in regions such as sub-Saharan Africa, Asia, and Latin America. In sub-Saharan Africa, sweet potato yields are crucial for smallholder farmers, with potential yields reaching up to 45 t/ha under optimal conditions (Mukhongo et al., 2017). In Asia, countries such as China and Bangladesh have made significant strides in improving cultivation techniques, which have not only increased yields but also led to greater adoption of high-yielding sweet potato varieties (Fan et al., 2018; Mahmud et al., 2021). According to recent statistics, China remains the world's largest annual producer of sweet potato, accounting for more than 50% of global production (He et al., 2023).

The yield of sweet potatoes is influenced by a variety of factors, including genetic potential, environmental conditions, and management strategies (Figure 1) (Liang et al., 2023; Sapakhova et al., 2023). As the global

population continues to grow and dietary demands increasingly shift toward more sustainable and nutritious food sources, there is a growing need to enhance both the productivity and quality of sweet potato cultivation. This need is particularly urgent in light of climate change, which presents new challenges to agricultural productivity and stability.

This review aims to provide a comprehensive overview of the practical approaches to improving sweet potato yield. It will cover key aspects such as variety selection, soil management practices, planting techniques, water management strategies, pest and disease management, weed control strategies, Nutrient management and fertilization, as well as harvesting handling. The review will offer practical guidelines and recommendations that have the potential to significantly improve sweet potato yields, with the promise of positively impacting food security and the agricultural economy. By adopting these strategies, farmers can enhance productivity, leading to increased income and fostering sustainable development in the sweet potato industry.

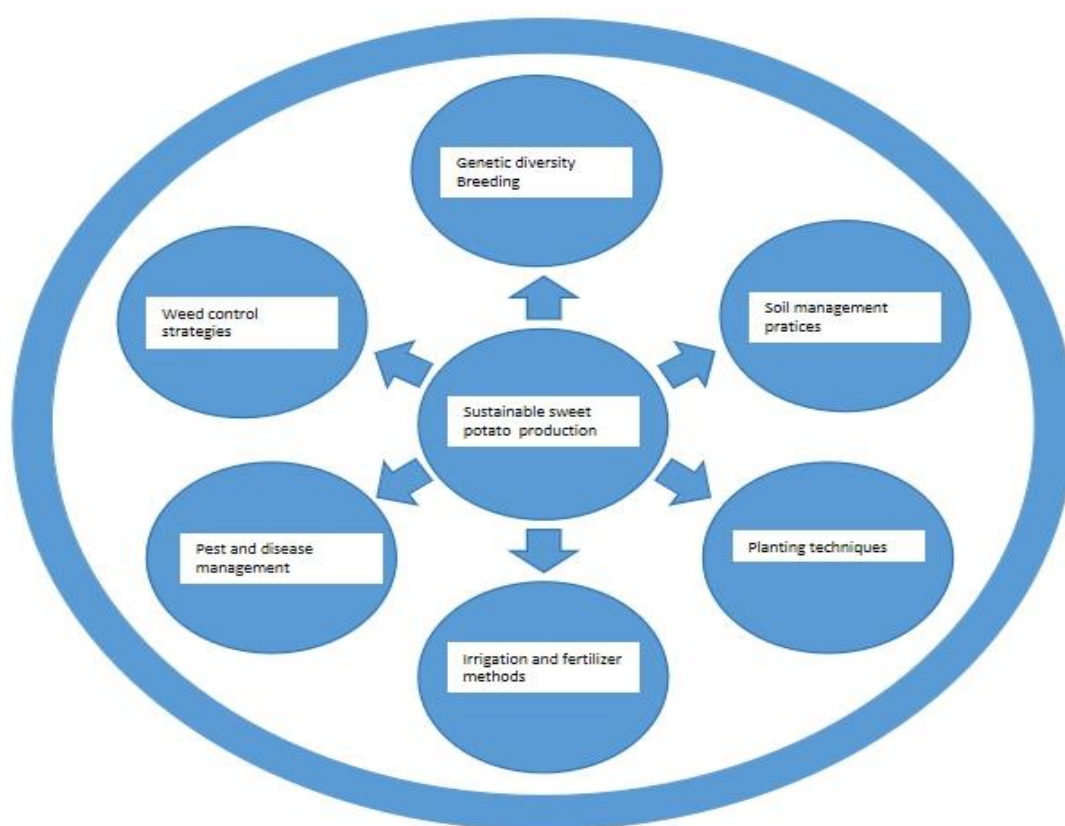


Figure 1 Factors influencing sweet potato industry

2 Variety Selection

2.1 Importance of choosing high-yield varieties

Selecting high-yield varieties is crucial for enhancing sweet potato production, especially in regions facing food security challenges. In the main sweet potato production areas in Benin, A survey conducted among 480 farmers from the primary sweet potato production areas in Benin highlighted the key criteria used by farmers in selecting sweet potato varieties (Ahoudou et al., 2023). The analysis revealed that high root yield is considered the most important factor in variety selection. This preference for high-yielding varieties is consistent with findings from other studies, which confirm that yield is a primary concern for farmers (Zawedde et al., 2014; Adeola et al., 2019). Research has shown that genetic variability within sweet potato populations provides a significant opportunity for selecting superior genotypes with desirable traits, such as high yield, quality, and stress resistance (Otoboni et al., 2020; Vargas et al., 2020; Mahmud et al., 2021). The selection of genotypes such as CERAT31-01, CERAT21-02, and CERAT51-30 has demonstrated promising results in terms of yield improvement (Otoboni et al., 2020). In the face of climate change, developing and selecting high-yielding varieties that can adapt to specific

and challenging climatic conditions is essential. For instance (Hanume et al., 2024), found that the drought tolerant genotypes including Dhenkanal local-2, 84×14, SB21/57, Howrah, S-783 and 84×1 exhibited low yield reduction ratio, which guide breeding programs aimed at improving yield under drought conditions. In a word, high-yield varieties not only ensure better productivity, even under stressful conditions, but also contribute to the economic stability of farmers.

2.2 Genetic variation and breeding strategies

Genetic variation within a species is the foundation of plant breeding because it allows breeders to select and combine different traits to create new varieties. In sweet potatoes, this variation can be found in traits such as yield, root size, shape, color, taste, nutritional content, and resistance to abiotic stresses and diseases (Vargas et al., 2020; Mahmud et al., 2021). To maximize genetic yield potential, breeders often focus on combining high yield with other desirable traits such as disease resistance, drought tolerance, and quality attributes (Otoboni et al., 2020; Rahmawati et al., 2021). This requires a deep understanding of the genetic basis of yield and how it interacts with environmental factors. Various techniques, such as quantitative trait locus (QTL) mapping and genomic selection have been used to identify the genes and alleles associated with high yield. using a mapping population consisting of 202 individuals derived from a cross between Xushu18 (a high yield cultivar) and Xu781 (a low yield line) (Li et al., 2014) mapped nine major QTLs for storage root yield of sweet potato. starch content, which is negatively correlated with fresh yield, is contributed by gene *IbPMA1*. Overexpression of *IbPMA1* in sweet potato results in significantly increased starch and sucrose contents, while its knockdown exhibits an opposing effect (Jiang et al., 2024).

The use of selection indexes, such as the one proposed by Mulamba & Mock, has been instrumental in achieving genetic gains in sweet potato breeding (Vargas et al., 2020). Moreover, breeding efforts have incorporated advanced techniques like marker-assisted selection and genetic engineering to enhance the efficiency of developing high-yield varieties (Ngailo et al., 2013). For example, the CropInd tool has been utilized to estimate agronomic performance and stability of sweet potato genotypes, aiding in the selection of superior varieties like 0113-672COR for specific regions (Rosero et al., 2023). Additionally, reciprocal crosses and the study of maternal effects have provided insights into the inheritance of yield and quality traits, further improving breeding strategies (Lin et al., 2007). Several studies highlight the successful adoption of high-yield sweet potato varieties across different regions. In Bangladesh, the evaluation of four popular varieties ('BARI Mistialu-8', 'BARI Mistialu-12', 'BARI Mistialu-14', and 'BARI Mistialu-15') across multiple environments demonstrated significant yield improvements. 'BARI Mistialu-12' emerged as the highest yielder, followed by 'BARI Mistialu-8' and 'BARI Mistialu-14', showing 57.89%, 61.50%, and 44.30% higher yields than the local check cultivar, respectively (Mahmud et al., 2021). Similarly, in Indonesia, the stability and yield potential of Orange-Fleshed Sweet Potato (OFSP) genotypes were assessed using AMMI and GGE biplot models. Genotypes F1-038 and F1-069 were identified as the most stable and high-yielding, making them suitable for recommendation as superior varieties for West Java (Karuniawan et al., 2021). These studies underscore the effectiveness of breeding programs and the importance of selecting high-yield varieties tailored to specific environmental conditions.

3 Soil Management Practices

3.1 Ideal soil conditions for sweet potato growth

Sweet potatoes produce best in well-drained, light, sandy loam or silt loam soil with a pH range of 5.5 to 6.6 (Kihurani, 2008). These conditions facilitate root development and nutrient uptake, both of which are essential for high yields (Kennedy, 2022). Controlled experiments have demonstrated that soil pH level can significantly affect the quality of sweet potatoes, with certain pH ranges being more conducive to higher dry matter content. Therefore, managing soil pH through appropriate amendments and practices can enhance nutrient availability, promote healthy root development, and support beneficial microbial activity, all of which are crucial for high crop yields and maintaining soil health over the long term (Navarro et al., 2020; Agbede and Oyewumi, 2022). Additionally, maintaining soil moisture through practices like straw mulching can improve soil humidity, decrease transpiration, and cool the soil, which is especially beneficial in dry and hot regions (Waheed et al., 2023).

3.2 Soil preparation techniques for enhanced yield

Proper soil preparation is fundamental to achieving high yields in sweet potato cultivation. This process begins with thorough land preparation, which is essential for creating an optimal environment for sweet potato growth. The establishment of well-structured planting beds is recommended to ensure proper drainage and aeration, both of which are vital for root development. To cultivate robust seedlings, the application of base fertilizers, particularly phosphorus and potassium, plays a critical role in soil preparation. These nutrients are essential for the development of a strong root system and overall plant vigor (Fan et al., 2018). In sandy soils, the application of phosphorus at appropriate levels can significantly boost tuber yield and starch concentration, particularly in areas with low initial soil phosphorus levels (Cordeiro et al., 2023).

Furthermore, integrating organic amendments, such as compost and green manure, into the soil can substantially improve both soil structure and fertility. These amendments not only enrich the soil with essential nutrients but also enhance its organic matter content, which in turn improves water retention, soil aggregation, and microbial activity (Larkin et al., 2021; Agbede and Oyewumi, 2022). Collectively, these factors contribute to enhanced crop growth and higher yield.

3.3 Nutrient management and soil health maintenance

Nutrient management is a critical component of soil health maintenance and sweet potato productivity. Sweet potatoes have a high demand for nutrients, particularly nitrogen, phosphorus, and potassium. The combined application of biofertilizers and inorganic nutrients has been demonstrated to significantly enhance sweet potato yields. For instance, the use of arbuscular mycorrhizal fungi (AMF) in combination with nitrogen and potassium fertilizers can significantly increase both tuber yield and overall biomass (Mukhongo et al., 2017). Additionally, the incorporation of green manure crops, such as *Mucuna aterrima*, enriches soil nutrients and promotes sweet potato growth, thereby reducing the need for high doses of mineral nitrogen fertilizers (Fernandes et al., 2020). This approach not only optimizes nutrient uptake but also contributes to a more sustainable and efficient agricultural system.

4 Planting Techniques

4.1 Optimal planting time and density

Optimal planting time and density are indeed crucial for maximizing sweet potato yields, and recent research has provided valuable insights into these agronomic practices. An appropriate planting density can balance shoot and root development, promoting storage root formation and increasing storage root number (Shao et al., 2018; Liang et al., 2023). Research on the 'Longshu 13' variety revealed that early planting, combined with a density of 49 995 plants per hectare, resulted in higher yields (Zi-lon, 2015), highlighting the importance of both timing and density. Similarly, the 'Wanshu 34' variety achieved high yields when planted in the last ten days of May with a density of 4 500~5 000 plants per 667 m² (Wenhui et al., 2006). Experiments conducted using "Hungary" demonstrated that a row spacing of 0.75 meters was more favorable than 1.0 meters, leading to higher marketable tuber yields (Pepó, 2018; 2020). These indicate that row spacing is another critical factor in optimizing land use and improving yields of sweet potato.

4.2 Use of cuttings vs. seed propagation

The method of propagation, whether through vine cuttings or seed propagation, also affects sweet potato yield. The most common method for propagating sweet potatoes is through the use of vine cuttings. This involves taking 25~30 centimeter-long cuttings from healthy, insect- and disease-free plants (Essilfie et al., 2016). Studies have shown that using vine cuttings, particularly the top vines, can significantly enhance yield (Zi-lon, 2015; Sarkodie-addo et al., 2017). In some colder climates where vines do not develop well, farmers may plant storage roots, which could be considered a form of seed propagation. This method requires cultivar with strong early vigor to compete with weeds effectively. Genotypes like 'Kyushu No.198' have shown promising results in terms of early vigor and shoot dry matter yield (Sakaigaichi et al., 2020). However, the use of secondary transplants from shoots has been found to yield higher results on ridges compared to primary transplants from tubers (Szarvas et al., 2018).

4.3 Influence of planting depth on yield

The performance of sweet potato seedlings is significantly affected by the transplantation posture, which is determined by the planting depth. Therefore planting depth is another critical factor influencing sweet potato yield. Independently refined by Jinhua Academy of Agricultural Sciences, this automated sweet potato transplanter adapts to local pedo-geomorphic conditions while enhancing planting efficiency and yield. Furthermore, its precision technology regulates planting depth and seedling orientation, supplements optimal moisture, adjusts ridge height, and compacts the ridge surface. These functions ensure all seedlings attain ideal planting depth, contributing to uniform transplanting quality across heterogeneous soils and elevated survival rates (typically >95% in field trials) (Figure 2).

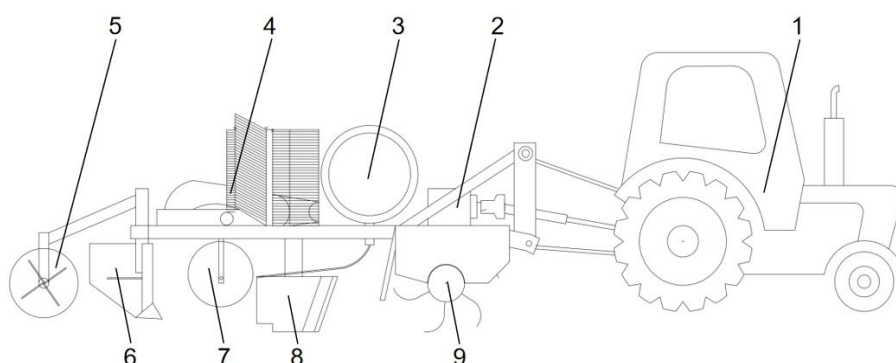


Figure 2 Simplified mechanical diagram of automated sweet potato transplanter. 1-main control device; 2-power transmission device; 3-water supply device; 4-transplanting device; 5-compacting device; 6-refill device; 7-furrow device; 8-ridging device; 9-Rotary tillage device

Optimizing the structure of transplanting equipment, such as the self-covering soil opener, can improve the quality of transplanting by ensuring the correct planting depth and posture (Wu et al., 2023). Field experiments have shown that different transplanting configurations, such as the use of finger-clip type transplanters on mulched raised beds, can lead to higher yields by maintaining optimal planting depth and soil temperature (Li et al., 2023). Additionally, flat planting has been found to produce higher yields compared to ridge planting under certain soil conditions (Pepó, 2018; 2020).

5 Irrigation and Water Management

5.1 Water requirements at different growth stages

Sweet potatoes are generally considered drought-tolerant plants, but they still require a consistent supply of water to thrive. Sweet potatoes have different water requirements at various growth stages, which significantly influence their growth and yield. At the vine growth stage, regular watering is essential to support vigorous growth. During the late-season growth phase, moderate irrigation (75% of crop evapotranspiration, ET_c) has been shown to enhance the source-sink balance, increase photosynthetic rates, and promote the allocation of photosynthates to storage roots, thereby improving yield and water use efficiency (WUE) (Zhou et al., 2023). Excessive or insufficient irrigation during this period can negatively impact the transfer and allocation of photosynthetic products, leading to suboptimal yields.

5.2 Efficient irrigation methods for sweet potatoes

Efficient irrigation methods are crucial for optimizing sweet potato yield and water productivity. Drip irrigation, particularly when combined with bed planting, has been found to be superior in terms of water saving and productivity compared to traditional furrow irrigation methods (Waqas et al., 2020). Drip irrigation allows for precise water application, reducing water wastage and enhancing water use efficiency. Additionally, regulated deficit irrigation (RDI) strategies, where water supply is reduced during less critical growth stages, can maintain high yields while conserving water. For instance, applying mild water deficits during the seedling stage can result in high yields and improved water use efficiency (Li et al., 2021).

5.3 Impact of drought and waterlogging on yield

Drought and waterlogging are two critical abiotic stresses that can severely affect sweet potato yield. Drought stress, particularly during the late-season growth phase, can reduce photosynthetic rates and hinder the accumulation of biomass in storage roots, leading to lower yields (Zhou et al., 2023). Conversely, waterlogging can cause root hypoxia, reducing nutrient uptake and leading to poor plant growth and tuber quality. Efficient water management practices, such as the use of drip irrigation and appropriate irrigation scheduling, are essential to mitigate the adverse effects of both drought and waterlogging (Waqas et al., 2020; Li et al., 2021).

6 Pest and Disease Management

6.1 Common pests and their control measures

Sweet potato cultivation faces numerous challenges, particularly from pests such as the sweet potato weevil (*Cylas formicarius*), which is among the most detrimental. Effective management strategies for this pest include the use of pest-free planting material, which can reduce the risk of introducing pests into new areas. Disinfecting planting materials with insecticides has also proven to be a crucial measure. Field trials have shown that these methods can significantly reduce weevil damage and increase economic yield (Rahman and Sultana, 2005). Furthermore, the deployment of sex pheromone traps has emerged as an innovative approach to monitor and manage sweet potato weevil populations. Another common pest, the sweet potato whitefly (*Bemisia tabaci*), also poses significant threat to sweet potato health. Management of this pest can be effectively achieved through the use of insect exclusion netting (IEN) and UV-reflective mulch. These managements have been shown to reduce whitefly populations and lower virus incidence under both greenhouse and field conditions (LaTora et al., 2022).

6.2 Disease prevention and management strategies

Diseases caused by bacteria, fungi, and viruses can impact sweet potato growth and development. Utilizing disease-free planting material is a fundamental approach to preventing the spread of diseases (Vinayaka and Misra, 2012). In general, bacterial diseases do not impact sweet potato production. However, fungal diseases, such as black rot (*Ceratocystis fimbriata*), Fusarium wilt (*Fusarium oxysporum* f. sp. *batatas*), foot rot (*Plenodomus destruens*), Fusarium root rot and stem canker and surface rot (*Fusarium oxysporum*, *Fusarium solani*) that occur in field production, severely influence the quality and yield of sweet potato. The most challenging diseases of sweet potato are those caused by viruses (Table 1). The use of disease-free planting material is a fundamental approach to preventing the spread of diseases. For instance, the use of cisgenically modified potato varieties resistant to late blight has been shown to reduce the need for fungicide applications by 80%~90%, demonstrating the potential for similar strategies in sweet potato cultivation (Kessel et al., 2018). Additionally, cultural practices such as crop rotation and the destruction of infested crop residues are crucial in managing disease spread (Rahman and Sultana, 2005).

Table 1 High yield sweet potato disease prevention and control plan

Disease type	Pathogen	Key symptoms	Management strategies
Fungal Diseases			
Black rot	<i>Ceratocystis fimbriata</i>	Dark circular lesions on tubers, vine wilting	Use disease-free slips; crop rotation
Fusarium wilt	<i>Fusarium oxysporum</i> f. sp. <i>batatas</i>	Yellowing leaves, vascular discoloration	Resistant varieties; soil fumigation
Foot rot	<i>Plenodomus destruens</i>	Stem base rot, plant collapse	Remove infected plants; avoid waterlogging
Fusarium root rot	<i>Fusarium solani</i>	Root decay, stunted growth	Improve soil drainage; fungicide application
Viral Diseases	Sweet Potato Feathery Mottle Virus (SPFMV)	Leaf mottling, stunting	Virus-free planting material; vector control
	Sweet Potato Chlorotic Stunt Virus (SPCSV)	Yellowing, reduced tuber size	Roguing infected plants; resistant cultivars

6.3 Integrated pest management (IPM) approaches

Integrated Pest Management (IPM) is a holistic approach that combines multiple control strategies to manage pests and diseases sustainably. IPM for sweet potato includes the use of cultural practices, biological control, and judicious use of chemical pesticides. For example, combining row covers, UV-reflective mulch, and selective insecticides has been effective in managing whitefly populations and associated virus symptoms in squash, suggesting similar benefits for sweet potato (LaTora et al., 2022). Moreover, IPM strategies that incorporate evolutionary principles can delay resistance development in pests and optimize the effectiveness of each control measure (Green et al., 2020). Farmer Field Schools (FFS) have also been successful in disseminating IPM knowledge and practices, leading to significant increases in productivity and income for farmers (Ortiz et al., 2019).

7 Weed Control Strategies

7.1 Sanitation practices

Weeds are a significant challenge in sweet potato cultivation, competing for nutrients, water, and light, which can drastically reduce crop yields. Common weeds include broad leaf species and grasses, which can vary depending on the region and specific field conditions. For instance, *Sorghum halepense* is a dominant weed in some areas, significantly impacting sweet potato growth if not managed properly (Singh et al., 2017). Implementing strict sanitation practices is the first step towards effective weed management. This includes using clean machinery and implements that prevent the spread of weed seeds or propagules from one area to another, removing weeds near irrigation ditches, fence rows, before they reach the reproductive stage helps to prevent the spread of weeds into cultivated areas (Anup, 2016). Proper composting involves reaching and maintaining temperatures high enough to kill weed seeds.

7.2 Mechanical and chemical weed control methods

Mechanical and chemical methods are widely used for weed control in sweet potato cultivation. Mechanical methods, such as hand weeding and the use of mulches, are traditional approaches that can be effective but are labor-intensive. Hand weeding, for example, has been shown to significantly reduce weed biomass and improve sweet potato yields (Laurie et al., 2015). Chemical control involves the use of herbicides, which can be highly effective but come with concerns such as environmental pollution and potential crop phytotoxicity. Herbicides like metribuzin, clomazone, and linuron have been tested for their efficacy in sweet potato fields. Metribuzin, when applied pre-emergence, can control a wide range of weeds but may reduce in effectiveness over time (Shafiq and Kaur, 2021). Post-emergence applications of herbicides like clodinafop combined with metribuzin have shown to be more effective, providing higher tuber yields and better economic returns (Shafiq and Kaur, 2021). Additionally, the combination of pendimethalin followed by quizalofop-p-ethyl has been found to be particularly effective in controlling narrow-leaved weeds and improving sweet potato yields (Singh et al., 2017).

7.3 Sustainable weed management practices

Sustainable weed management practices aim to reduce reliance on chemical herbicides and promote environmentally friendly approaches. Integrated Weed Management (IWM) combines various methods to optimize weed control while minimizing negative impacts. This includes the use of living mulches, organic mulches, and intercropping. Living mulches, such as white mustard, common vetch, and Persian clover, can reduce weed biomass and improve soil health, although they may not be as effective as chemical methods alone (Kołodziejczyk, 2015). Organic mulches like compost and grass straw can also be used, but their effectiveness varies. For instance, newspaper mulch has been found to be a viable option for smallholder farmers, providing effective weed control and comparable yields to hand weeding (Laurie et al., 2015). Intercropping is another sustainable practice that can enhance weed control. For example, intercropping sweet potato with maize or peanut has been shown to reduce weed density and improve crop yields (Weerarathne et al., 2017). Selecting compatible intercrop combinations is crucial for maximizing the benefits of this approach.

8 Nutrient Management and Fertilization

8.1 Essential nutrients for optimal sweet potato yield

Sweet potato (*Ipomoea batatas* L.) requires a balanced supply of essential nutrients to achieve optimal yield. Key macronutrients include nitrogen (N), phosphorus (P), and potassium (K), which play critical roles in plant growth and development. Nitrogen is vital for vegetative growth, phosphorus is essential for energy transfer and root development, and potassium is crucial for water regulation and enzyme activation (Koch et al., 2019; Fernandes and Ribeiro, 2020). Additionally, secondary nutrients such as calcium (Ca), magnesium (Mg), and sulfur (S) are important for various physiological functions and overall plant health (Koch et al., 2019). Micronutrients, though required in smaller quantities, are also essential for maximizing yield and quality (Fernandes and Ribeiro, 2020).

8.2 Organic vs. synthetic fertilizers

The choice between organic and synthetic fertilizers can significantly impact sweet potato yield and soil health. Organic fertilizers, such as poultry and bovine manure, improve soil chemical attributes and enhance the production and quality of sweet potatoes (Nunes et al., 2020). They also contribute to long-term soil fertility by increasing organic matter content (Karkee and Bishwokarma, 2023). On the other hand, synthetic fertilizers provide a more immediate nutrient supply, which can lead to higher yields in the short term (Yadav et al., 2017). However, the integration of both organic and synthetic fertilizers has been shown to be more effective. For instance, combining 75% of the recommended dose of synthetic fertilizers with 25% of nitrogen from farmyard manure (FYM) resulted in higher productivity and better soil health (Yadav et al., 2017; Shabitha and Rajeswari, 2021). This integrated approach leverages the benefits of both fertilizer types, ensuring sustainable production.

8.3 Timing and application techniques for fertilizers

The timing and method of fertilizer application are crucial for maximizing sweet potato yields. Split application techniques, where fertilizers are applied at different growth stages, have been shown to significantly increase yields. For example, applying a base fertilizer before planting and supplementing with additional liquid fertilization during the growing season resulted in up to a 36% increase in yields for certain sweet potato varieties (Balázs et al., 2023). Similarly, the use of biofertilizers in combination with NPK fertilizers during specific growth stages can enhance nutrient uptake and boost yield (Mukhongo et al., 2017). The Nutrient Expert (NE) system, which optimizes fertilizer input and implements split fertilization, has also been effective in improving potato productivity and tuber quality (Sha et al., 2021). This system increased total and marketable tuber yields by 12%~15% and 16%~26%, respectively, compared to traditional farmer practices (Sha et al., 2021).

9 Harvesting Handling

9.1 Indicators of maturity and optimal harvest time

Identifying the optimal harvest time for sweet potatoes is crucial for maximizing both yield and quality. Sweet potatoes are typically harvested around 120 days after planting, but this can vary depending on the variety and growing conditions. Delaying the harvest to 150 or 180 days can enhance the content of bioactive compound and post-harvest quality, especially in varieties with orange pulp, which exhibit increased levels of β -carotene and antioxidant activity (Simões et al., 2020). It's also important to harvest in a timely manner to prevent decay losses, such as tip rot, which is exacerbated by late harvesting (Sugri et al., 2020).

9.2 Techniques for reducing harvest losses

To minimize harvest losses, several techniques can be employed. Careful handling during harvest is essential to avoid physical damage to the tubers, which can lead to microbial decay. Techniques such as root tip coppicing, hot water treatment, and honey waxing have been shown to significantly reduce post-harvest losses by preventing sprouting and microbial infection (Sugri et al., 2020). Moreover, harvesting intervals can impact yield; for example, a 20-day interval between harvests can result in higher leaf and stem dry matter yields, which is beneficial for overall plant health and productivity (An et al., 2003).

10 Conclusion Remarks

The review of high-yielding sweet potato cultivation techniques reveals several critical strategies that significantly

enhance productivity. Key techniques include selecting appropriate varieties that are market-adapted and planning planting schedules meticulously. Effective fertilization practices, particularly the application of phosphorus and potassium, are essential for optimal growth. Additionally, proper land preparation, including ridging and trenching, plays a vital role in supporting tuber development. Dense and uniform planting, combined with disease and pest management, ensures healthy crop growth. The use of plastic film covering has also been shown to improve soil conditions and increase yields. Since sweet potatoes benefit from moderate irrigation to optimize growth and yield, effective water management practices are needed to cope with climate change. When managing pest, disease and weeds, a sustainable approach is highly recommended to ensure the health of the crop and the economic viability of sweet potato farming. This involves the implementation of integrated pest management (IPM) strategies and sanitation practices. Finally, determining the optimal harvest time and employing precise harvesting techniques are crucial for minimizing losses and maximizing sweet potato yields.

Future research should focus on developing and optimizing new sweet potato varieties with higher yield potential and better resistance to diseases and pests. Investigating the long-term effects of different fertilization regimes and soil amendments, such as organic fertilizers, on sweet potato productivity and soil health is essential. Additionally, exploring advanced cultivation techniques, including precision agriculture and the use of biostimulants, could further enhance yield and efficiency. Research should also address market dynamics and develop strategies to improve the marketability and economic viability of sweet potato farming. Finally, continued emphasis on participatory research and farmer education will be vital in ensuring the successful adoption of innovative cultivation practices.

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Together, we will forge ahead, integrating our findings into practical applications to bolster the sweet potato industry's resilience and profitability. The journey ahead will undoubtedly present new challenges, but with our combined expertise and the insights gleaned from our research, we are well-equipped to navigate them. Each step we take will be aimed at fostering a more robust and sustainable sweet potato sector, ensuring food security and economic prosperity for farmers.

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Conflict of Interest Disclosure

The authors affirm that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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