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Effect of Soil-Weed Interaction on Cassava (Manihot esculenta Crantz) Production: A Review

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Abstract— *Cassava (Manihot esculenta Crantz) is a vital staple crop for over 800 million people globally, yet its early growth stages are highly vulnerable to weed infestation due to slow canopy development and low initial nutrient uptake. Soil-weed interactions play a central role in determining cassava growth and yield, as soil physical, chemical, and biological properties influence weed emergence, growth, and competitiveness. Climate change further complicates weed management by accelerating weed phenology and favouring drought-adapted species, potentially reducing cassava yields by up to 59% under unmitigated scenarios. Key soil factors include texture, moisture, bulk density, pH, nutrient availability, and microbiome composition, which affect both crop performance and herbicide efficiency. Dominant cassava weeds such as Cyperus rotundus, Imperata cylindrica, and Commelina benghalensis exhibit specific soil affinities. Mechanisms of interference include asymmetric nutrient competition, allelopathic effects mediated by soil microbes, and serving as pathogen reservoirs. Their aggressive growth can reduce cassava yields by 30–80% if unmanaged. Integrated soil–weed–cassava management strategies — including soil texture-specific herbicide application, cover crops, mulching, conservation agriculture, and decision support tools — enhance crop competitiveness while improving soil health. Future research priorities include microbiome-mediated allelopathy, precision herbicide application, seed bank modelling under variable tillage, soil health indices predictive of weed pressure, and climate-smart cover crop mixtures. Advancing these integrated and site-specific approaches is essential to sustainably mitigate weed impacts, improve cassava productivity, and enhance agro-ecosystem resilience under changing environmental conditions.*

Keywords— Allelopathy, weed competitiveness, soil properties, herbicide–soil dynamics, integrated weed management, cassava.

I. INTRODUCTION

Understanding soil-weed interactions is crucial for developing resilient, site-specific weed management strategies that go beyond the prescriptive approach of simply keeping the field productive (Behera, 2024; Monteiro and Santos, 2022; Korres, 2023). Integrated strategies that manage soil physical, chemical, and biological properties are necessary for improving crop productivity, given the increasing pressures of climate change and resource limitations (Ikeh et al., 2012; Van Chuong et al., 2025; Ghafoor, 2025).

Cassava (Manihot esculenta Crantz) is an important food crop that serves as a primary source of calories for over 800 million people. It is the third most important staple food (after maize and rice), consumed by hundreds of millions, and supports the livelihoods of smallholder farmers across regions from Nigeria in West Africa to parts of South America (Otekunrin, 2024; Adebayo, 2023; FAO, 2021). Despite its global economic importance, cassava is highly susceptible to weed competition during the early stages of growth due to its slow canopy development, wide intra-row spacing, and low initial nutrient uptake.

Several field studies have consistently identified the first 8 to 12 weeks after planting (WAP) as the most critical period of weed interference, during which uncontrolled weed infestation significantly reduces crop establishment and yield (Li et al., 2017; Silva et al., 2025; Adebayo, 2023; Ekeleme et al., 2004; Anikwe, 2018; Ramella et al., 2020). Conventional reviews have mostly focused on direct competition between crops and weeds for sunlight, water, and nutrients (Nath et al., 2024; Sultana et al., 2024). However, recent research emphasizes the role of soil as an active mediator in crop-weed interactions (Rojas-Sánchez, 2025; Sahoo, 2025).

For instance, soil texture influences the sorption and mobility of herbicides (Jensen et al., 2019); organic matter content affects microbial degradation of herbicide residues (Farenhorst, 2008); bulk density affects root growth and resource uptake (Adekiya et al., 2022); and the soil microbiome can influence allelopathic interactions between cassava and competing weed species (Eslami, 2025; Massenssini et al., 2014; Revillini et al., 2023). These interactive roles necessitate investigation into the complex interactions between soils and weeds affecting cassava production.

II. DEFINITION AND KEY ELEMENTS OF SOIL–WEED INTERACTION

Soil-weed interaction refers to the dynamic relationship between soil properties (morphological, physical, chemical, and biological) and weeds, as well as other variables such as rainfall, sunshine, and human activities. This encompasses how soil characteristics influence weed seed germination, herbicide efficacy, nutrient availability, and competitive ability against crops. It also includes how this relationship affects the growth, yield, and productivity of crops (Muhammad et al., 2025; Udoh et al., 2007a; Patzold et al., 2020). The key elements of this interaction are presented in Table 1.

TABLE 1
KEY ELEMENTS OF SOIL-WEED INTERACTION

Interaction Element	Definition	Selected References
Soil as habitat for weed germination and growth	Soil characteristics such as moisture levels, pH, texture, temperature, and nutrient availability play a crucial role in the germination, emergence, and establishment of weed seeds. For example, Cyperus rotundus thrives in sandy soils, while Commelina benghalensis does well in heavy, moist soils.	Koti et al. (2010); Holm et al. (1977); Abd El-Hamid et al. (2019)
Competition for nutrients	Both crops and weeds absorb nutrients from the same soil strata. Fast-growing weed species often have more aggressive root systems, allowing them to outcompete crops like cassava, rice, and maize for key nutrients such as nitrogen (N), phosphorus (P), and potassium (K).	Liebman and Mohler (2001); O'Neil et al. (2021)
Herbicide-soil interactions	Soil properties significantly influence the performance of herbicides used for weed control. Soils rich in organic matter or clay can bind herbicides, lowering their activity, while sandy soils may increase leaching and reduce herbicide persistence.	Jensen et al. (2019); Farenhorst et al. (2008); Walpola and Hettiarachchi (2020)
Soil disturbance and weed seed bank dynamics	Tillage and land preparation practices affect how weed seeds are distributed vertically within the soil profile. Frequent soil disturbance can bring buried seeds to the surface, stimulating their germination and intensifying weed competition with crops.	Mohler (2001); Swanton et al. (2000)
Biological interactions	Soil microorganisms influence interactions between weeds and crops. Some soil microorganisms can degrade allelopathic chemicals released by weeds that could otherwise inhibit crop root growth.	Inderjit and Weston (2003); Rice (1984)
Effect on crop yield	When specific soil conditions favour weeds, their growth can be aggressive, resulting in reduced crop growth through competition for water, light, and nutrients. If weed-soil interactions are not managed effectively, yield reductions of 30% to 80% can occur, depending on crop species and weed infestation severity.	Oerke (2006); Pimentel (2007)
Integrated soil, crop, and weed management	Integrated management practices (IMP) foster soil health, productivity, and agro-ecosystem resilience. Understanding crop-weed-fertilizer-water interactions and their implications for weed management enhances soil fertility, disrupts weed life cycles, and strengthens crop competitiveness.	Liang et al. (2025); Kaur et al. (2018); Liebman and Gallandt (1997); Swanton et al. (2015); Singh (2024); McGranahan and Swanton (2015)

III. DOMINANT WEEDS IN CASSAVA AND THEIR SOIL AFFINITIES

Across several regions of Africa, certain weed species such as Ageratum conyzoides, Cyperus rotundus, Digitaria horizontalis, Rottboellia cochinchinensis, and Commelina benghalensis commonly occur at densities exceeding 800 seeds per square metre; their distribution is strongly influenced by soil properties. For example, C. rotundus thrives in coarse, well-aerated sandy soils where its tubers face little resistance during growth, while D. horizontalis is more prevalent in heavier Ultisols that are susceptible to surface sealing.

TABLE 2
TYPES OF WEEDS AND THEIR SOIL AFFINITIES IN CASSAVA PRODUCTION

Weed Species	Soil Affinity	Selected References
Imperata cylindrica (spear grass)	Thrives in poor, acidic, well-drained sandy or lateritic soils; aggressive in degraded land	Udensi and Chikoye (2013); Chikoye et al. (2006)
Chromolaena odorata (Siam weed)	Prefers fertile, moist, well-drained loamy soils, often colonizing fallows	Ojeniyi et al. (2012); Tiamiyu and Okunlade (2020)
Cyperus rotundus (purple nutsedge)	Common in sandy, well-aerated soils with moderate moisture; tolerates low fertility	Akobundu (1987)
Euphorbia heterophylla (wild poinsettia)	Prefers light, sandy-loam soils with moderate fertility; thrives under warm climates	Rocha et al. (2016); Santos et al. (2015)
Aspilia africana (wild sunflower)	Grows well in sandy to loamy soils, especially in well-drained uplands	Okezie and Okeke (2013)
Panicum maximum (Guinea grass)	Thrives in fertile, moist, well-drained soils but tolerates a range from sandy to clay loam	Chikoye et al. (2001)
Rottboellia cochinchinensis (itchgrass)	Grows in fertile, well-drained soils, especially sandy loams with high organic matter	Anusontpornperm et al. (2009); Bolfrey-Arku (2011)
Sida acuta (wireweed)	Colonizes poor, acidic sandy soils with low fertility; drought-tolerant	Akobundu (1987)
Ageratum conyzoides (goat weed)	Prefers moist, fertile loamy soils rich in nitrogen; common in disturbed fields	Ekeleme et al. (2003)
Amaranthus spinosus (spiny amaranth)	Thrives in nitrogen-rich, loose loamy soils; indicator of fertile land	Holm et al. (1977)
Commelina benghalensis (Benghal dayflower)	Favours moist, clay-loam soils with good organic matter; persists in humid zones	Walker and Evenson (1985)
Mimosa pudica (sensitive plant)	Thrives in acidic, sandy-loam soils; tolerates low fertility and degraded land	Jayasinghe (2001)
Tridax procumbens (coat button)	Grows in sandy or gravelly soils of low fertility; drought-tolerant	Okezie and Okeke (2013); Amutha et al. (2019); Chauhan and Johnson (2008)
Digitaria horizontalis (crabgrass)	Thrives in sandy soils with moderate fertility; germinates well in disturbed topsoil	Chikoye and Ekeleme (2001)
Pennisetum polystachion (mission grass)	Grows best in sandy-loam soils of moderate fertility and good drainage	Holm et al. (1977)
Eleusine indica (goosegrass)	Prefers compacted, sandy to clay soils; thrives in disturbed and well-drained conditions	Glaspie et al. (2021); Hooda and Chauhan (2023)
Boerhavia diffusa (hogweed)	Common in sandy, dry soils with low fertility; drought-adapted	Tropical Plant Database (2025)
Parthenium hysterophorus (parthenium weed)	Prefers light, sandy loams with low fertility; invades degraded soils	Kaur et al. (2014)
Calopogonium mucunoides (calopo)	Thrives in fertile, moist, loamy soils; sometimes beneficial as green manure	IITA (1997)
Ipomoea triloba (morning glory)	Favours sandy-loam soils with good drainage; thrives in moist conditions	Webster and MacDonald (2001)

Imperata cylindrica (speargrass), which is difficult to eradicate due to its rhizomatous root system, performs well in sandy or loamy soils with low organic matter, where it competes aggressively for water and nutrients (MacDonald, 2024; Akobundu, 1987). *Chromolaena odorata* (Siam weed) grows well in loamy, well-drained soils with high nitrogen content.

FIGURE 1: Soil-weed interaction (AB)

FIGURE 2: Soil-cassava interaction (AC)

FIGURE 3: Soil-weed-cassava interaction (ABC)

FIGURE 4: Soil-weed-type-cassava interaction (ADC)

The dominant weeds in cassava and their soil affinities, as reflected in Figures 1 to 4, can adversely affect cassava production if not properly managed. In Figure 1, the role soil plays in cassava production is equal to the role soil plays in weed growth. In Figure 2, the effect on soil is greater on cassava due to proper weed management, which brings about productivity. However, Figure 3 shows weed dominance leading to poor growth and yield of cassava, while Figure 4 shows the effect of dominant weed type on cassava. Under constant conditions, weeds should be managed to avoid low crop growth and yield loss.

Weeds hinder crop growth through allelopathy and can dominate young cassava fields if not controlled effectively (Ekeleme et al., 2016; Ivens, 1989), as seen in Figure 3. *Bidens pilosa* (blackjack) is common on well-aerated, moderately fertile loamy and sandy-loam soils. It is an annual weed with rapid growth that competes strongly for nutrients and light (Esilaba et al., 2021; Akobundu and Agyakwa, 1998). *Amaranthus spinosus* (spiny amaranth) is prolific in nitrogen-rich, fertile soils where it exhibits rapid growth and high seed production (Holm et al., 1977). *Commelina benghalensis* (Benghal dayflower) thrives on moist, fertile clay loams. It grows aggressively in humid environments and is difficult to control because of its rapid vegetative propagation and deep root system (Balliu et al., 2021; Awotedu et al., 2021). *Aspilia africana* is adapted to acidic, low-fertility soils, where it competes with cassava seedlings in early growth stages (Syauswa, 2020; Akobundu, 1987). Soil-weed interactions also affect disease risk, as broadleaf weeds can host pathogens such as *Xanthomonas phaseoli* pv. *manihotis* (Sulley et al., 2021).

IV. SOIL PHYSICAL PROPERTIES INFLUENCING WEED EMERGENCE AND COMPETITIVENESS

4.1 Soil Moisture Regimes:

Soil moisture affects weed seed germination and seedling establishment. Wet or poorly drained soils encourage species such as *Echinochloa crus-galli* and *Cyperus esculentus* (Khadka, 2021; Ameena et al., 2024; Alama et al., 2023), while dry soils favour drought-resistant weeds like *Portulaca oleracea* (Zhao et al., 2025; Chauhan et al., 2006). Waterlogged soils can reduce crop vigour, providing weeds with a competitive advantage (Kongsil et al., 2025; Anikwe and Ikenganyia, 2018; Ponnamperuma, 1984) under fluctuating soil moisture conditions.

4.2 Bulk Density and Penetration Resistance

Cassava tolerates moderate compaction, but germinating seedlings of some weed species are more sensitive. Soil resistance exceeding 2 MPa (megapascal) can reduce the emergence of *Amaranthus* spp. by up to 50%. Globally, conservation agriculture (CA) practices have led to a 0.11 Mg m^{-3} reduction in soil bulk density compared to conventional systems (Galindo et al., 2022; Alama et al., 2022; Arévalo-Gardini, 2015). CA also increased earthworm numbers by 83% and soil moisture by 5%. These soil improvements promoted early cassava root establishment and concurrently suppressed shallow-rooted annual weeds (Dettweiler, 2024; Sultana, 2024). This suggests that good soil structure promotes better crop establishment and reduces weed competitiveness. However, weeds such as *Cynodon dactylon* can thrive in compacted conditions due to their aggressive rhizome systems (Ameena et al., 2024; Rana and Rana, 2016).

4.3 Temperature and Thermal Amplitude in the Soil Profile

In West Java Ultisols, experiments using *Arachis pintoi* biomulch lowered soil surface temperatures by 3.8°C, which delayed the peak emergence of thermophilic weeds by up to 12 days (Chozin, 2018). The combination of the resulting cooler microclimate with reduced day-night temperature fluctuations allowed cassava cuttings to develop carbohydrate-producing leaves before facing weed competition (Suwitono et al., 2023).

V. SOIL CHEMICAL PROPERTIES INFLUENCING NUTRIENT COMPETITION BETWEEN WEEDS AND CASSAVA

5.1 Macronutrient Dynamics

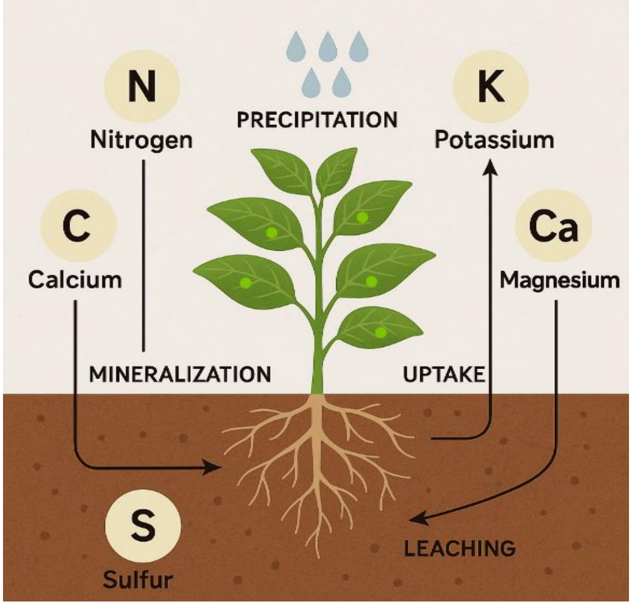

FIGURE 5: Soil-weed nutrient interaction — conceptual diagram showing weeds exploiting nutrient-rich zones more efficiently than crops

FIGURE 6: Soil-weed-cassava nutrient interaction — conceptual diagram showing competitive dynamics for nutrients among all three components

Weeds often exploit nutrient-rich zones in the soil more efficiently than crops (Figure 5). Species like *Chenopodium album* have high nutrient use efficiency, allowing them to outcompete crops for nitrogen, phosphorus, and potassium (Namatsheve et al., 2024; Liebman et al., 2001). In Paraná, Brazil, weed infestation resulted in reductions of up to 85% in cassava leaf nitrogen and phosphorus uptake under both no-till and conventional farming, corresponding with a 15% decline in root dry weight (Soares et al., 2022; Ramella et al., 2020). This nutrient loss is primarily due to the dense, shallow root systems of weeds, which dominate the surface (15 cm) soil horizons — the zone where surface-applied fertilizers tend to accumulate.

Management practices such as split fertilizer applications or deep band placement can redirect nutrients to deeper layers, thereby enhancing cassava root access to available nutrients (Onasanya, 2020; Gonzales et al., 2020; Soares et al., 2022). Soil-weed interaction is unavoidable because the crop is an integral part of the plant community alongside weeds, and both depend on nutrient availability according to crop requirements (Figure 3). Soil-weed interaction is thus a product of farm management quality.

5.2 Soil pH and Herbicide Ionization

Soil pH influences herbicide effectiveness. Weak acids such as atrazine bind more strongly in acidic soils, which reduces their bioavailability. Field trials indicate that atrazine efficacy is reduced in acidic soils but can be significantly improved by lime amendments that increase soil pH (Meng et al., 2025; Aladesanwa and Akinbobola, 2008). Similarly, soil pH affects the behaviour of herbicides such as sulfentrazone and flumioxazin commonly used in cassava cultivation. In clay-rich soils with high organic matter content, pH buffering and increased adsorption capacity allow for the use of higher application rates without crop injury. Sandy Lixisols increase the risks of leaching and phytotoxicity (Maciejewska et al., 2024; Li et al., 2021; Obiazi, 2024b).

Soil pH also influences nutrient solubility and soil microbial activity, both of which affect weed prevalence. Some weed species exhibit preference for acidic or alkaline soils. For example, many *Rumex* species are common in acidic soils, while *Conyza bonariensis* thrives in neutral to alkaline soils (Rao, 2000). Changes in soil pH can alter weed flora and enhance crop competitiveness (Liebman and Davis, 2000).

5.3 Cation Exchange Capacity (CEC) and Weed Nutrient Uptake

Cation Exchange Capacity (CEC) is an important soil property that affects the availability and uptake of nutrients by both crops and weeds (Khadim et al., 2024; Ćirić et al., 2023; Alama et al., 2025). Although cassava can produce appreciable yields even in marginal soils, it ultimately thrives and gives better yields in balanced soils with optimum nutrient conditions (Ossai et al., 2024; Alama et al., 2022). CEC influences nutrient retention and availability to cassava and competing weeds.

In low CEC soils, nutrients remain near the soil surface, where weeds can outcompete cassava. High CEC soils retain nutrients better (Emmanuel et al., 2025; Alama et al., 2023), especially when combined with mulching or deep fertilizer placement, which gives cassava a competitive advantage due to its deeper root system. Strategies such as using cover crops and organic amendments can improve CEC, thereby enhancing cassava nutrient uptake while reducing weed infestation (Soares et al., 2022; Adekiya et al., 2023). Experiments showed that *Brachiaria ruziziensis* mulch increased levels of exchangeable potassium and calcium by 12–18%. Cassava was reported to absorb a higher proportion of these nutrients compared to weeds (Soares et al., 2022). This suggests that the timing of nutrient release from mulches can be aligned with cassava uptake patterns, thereby improving its ability to compete with weeds (Ravi et al., 2021; Lubis et al., 2023).

VI. SEED BANK ECOLOGY AND SOIL DISTURBANCE

Weed seed banks in the soil are the primary sources of weed emergence, and their composition is influenced by land management practices (Ahmad, 2025; Hossain and Begum, 2015). A six-year seed bank study in southwestern Nigeria reported that viable weed seed densities were reduced by 86% under *Acacia auriculiformis* fallows compared to continuously cultivated plots. Mounding further suppressed seed density by 47–66% by burying seeds too deep to germinate. Minimum tillage preserved more diverse weed seed banks but may also contribute to increased weed persistence (Choudhary, 2023; Akobundu and Ekeleme, 2005). Redundancy analysis showed that interactions between soil disturbance and soil cover shifted weed communities from grass-dominated to broadleaf-dominated types (Ren et al., 2024; She et al., 2024). This is an important consideration when selecting appropriate herbicide formulations.

VII. MECHANISMS AND PATHWAYS OF SOIL–WEED–CASSAVA INTERACTION

7.1 Resource-Based Competition

One of the primary pathways through which weeds interfere with cassava development is asymmetric competition for soil nutrients, particularly nitrogen (Garcia-Barrios, 2003; Rocha et al., 2016). Results from isotopic ^{15}N tracing studies showed that weeds rapidly absorb early nitrate flushes, while cassava nitrogen demand intensifies around 60 days after planting (DAP), corresponding with its physiological shift from fibrous root proliferation to the initiation of tuberous storage roots. This early nutrient depletion by weeds extends the critical weed-free period of cassava (CWFP) by approximately 20 days, depending on soil fertility and weed infestation (Phaphenit and Poonpaiboonpipat, 2023). Field study reports also indicate that an additional manual weeding cycle may be required to maintain cassava productivity under such conditions, especially in nutrient-poor Alfisols (Obiazi et al., 2024a; Obiazi et al., 2024b; Eni and Alama, 2025; Alama et al., 2023).

7.2 Allelopathy and Soil Microbial Mediation

An important mechanism in soil-weed interactions involves allelopathy. Some weeds, such as *Cyperus rotundus*, release root exudates containing phenolic compounds that can inhibit cassava enzyme activity, specifically cassava root peroxidase activity (Singh et al., 2003; Kostina-Bednarz et al., 2023). Suppression of these enzymes hinders cassava growth. However, this allelopathic suppression is not uniform across all soil types. Soils rich in phenol-degrading microorganisms show reduced allelopathic effects (Han et al., 2025). Inoculating soils with lignin-degrading fungi, such as those isolated from *Mucuna* cover crop rhizospheres, can detoxify these allelochemicals and mitigate their negative impact on cassava (Wang et al., 2024). This represents a biocontrol strategy with strong potential that is currently under-researched.

7.3 Pathogen Reservoir Dynamics

In addition to competing with cassava for resources, weeds also serve as alternative hosts for pathogens that spread diseases in cassava fields. Weed species such as *Ageratum conyzoides*, *Bidens pilosa*, and *Commelina benghalensis* have been reported to act as alternative hosts for *Xanthomonas phaseoli* pv. *manihotis*, the pathogen responsible for cassava bacterial blight (Yameogo et al., 2023). These weeds sustain the pathogen during off-seasons, leading to higher disease incidence in subsequent cropping cycles. Soil surface moisture levels exceeding 60% field capacity promote pathogen survival on weed root surfaces, suggesting that improved drainage can simultaneously suppress weed populations and soil-borne pathogen survival (Yan and Nelson, 2022; Yameogo et al., 2023).

VIII. QUANTIFYING YIELD LOSSES: FROM OBSERVATION TO PREDICTION

A review of several field studies showed that yield losses due to season-long weed infestation range from 30% to 80%, with an average loss of approximately 52%, contingent on weed species present and management practices (Akobundu, 1987; Chikoye et al., 2001). The level of loss differs based on soil type, ranging from approximately 30% in fertile Vertisols to as high as 80% in degraded Oxisols. This emphasizes the effect of soil properties on weed-crop competition (Kumar, 2016).

To support more predictive agronomic decisions, dose–response models were calibrated with field data from Nigeria (Sileshi, 2022; Tovihoudji et al., 2019). Results from field-tested models suggest that integrating pre-emergence applications of indaziflam and isoxaflutole, followed by a single post-emergence glyphosate spray, can increase cassava root yields by 11–14 t ha^{-1} compared to conventional farmer practices, which typically involve late or incomplete weeding. The efficiency of this herbicide regime depends on a minimum soil organic matter content of 1.5%, which is essential to maintain adequate herbicide persistence and efficacy (Nosratti et al., 2023).

IX. SOIL–WEED INTERFACE MANAGEMENT STRATEGIES

9.1 Herbicide Optimisation by Soil Texture

The efficacy and safety of soil-applied herbicides are strongly influenced by soil texture. For example, flumioxazin applied at rates above 75 g ha^{-1} in both clay and sandy soils resulted in a minimum of 70% weed control but caused significantly lower phytotoxicity in clay soils (Glaspie et al., 2021). In contrast, sulfentrazone, another commonly used pre-emergence herbicide, exhibited a narrower safety margin in sandy soils. Application rates higher than 250 g ha^{-1} in these lighter soils caused cassava root yield losses of up to 30%, likely due to increased herbicide mobility and root absorption. These findings emphasize the importance of calibrating herbicide rates based on soil texture analysis. This approach allows for more site-specific and environmentally safe recommendations, reducing the risk of crop injury while maintaining effective weed suppression (Costa et al., 2023).

9.2 Cover Crops, Biomulches, and Live Mulches

Cover crops and live mulches are biological strategies for weed suppression (Nath et al., 2024). These methods are increasingly recognized for their beneficial roles in weed management and soil health. For instance, planting *Arachis pintoi* eight weeks before cassava reduced weed dry matter by 47%. Their decomposition contributed significantly to soil organic matter buildup, increasing organic carbon (7.6%) and total nitrogen up to 0.41%. This improved soil fertility and structure in ways that herbicides alone cannot achieve (Suwisono et al., 2023). Intercropping cassava with *Mucuna pruriens* in central Nigeria also produced the lowest weed densities among five tested legumes, though it slightly reduced tuber yields due to short-term competition for assimilates (Gbanguba et al., 2020).

9.3 Mulch and Weed Mat Technologies

Mulching strategies are promising alternatives to recurrent herbicide applications (Nath et al., 2024). Weed control ground cover (WCGC) mats, though relatively expensive, resulted in similar performance to four manual weedings in terms of root yield. They also improved soil microbial activity and organic carbon content compared to glyphosate-treated plots (Shah et al., 2025; Nedunchezhiyan et al., 2017). Organic mulches, such as rice straw, cassava peel, or maize stover, can provide similar benefits but break down quickly in humid tropical conditions. Incorporating high-lignin biomass, such as sugarcane trash, has been shown to significantly suppress weeds throughout the crop life cycle (Bassey et al., 2021).

9.4 Tillage and Soil Structure Management

Techniques such as conservation agriculture (CA), especially reduced tillage combined with ridging and mulching, have exhibited positive effects on cassava physiology by improving the physicochemical properties of soils (Emmanuel et al., 2025; Raimondi, 2024). These practices were reported to improve physiological traits such as leaf area index and stomatal conductance, particularly under drought. These physiological improvements were accompanied by reduced weed infestation due to improved canopy closure and moisture conservation (Ocaña-Reyes et al., 2024). However, long-term CA practices can eventually lead to the build-up of perennial weeds, necessitating rotational tillage or strategic use of cover crops to disrupt weed seed banks (Basch et al., 2020; Raimondi, 2024).

9.5 Decision Support Tools

Digital tools are now aiding site-specific weed management. The "Six Steps to Cassava Weed Management" app developed by IITA provides decision support on site selection, herbicide options, crop spacing, and timing of post-emergence sprays, and has been associated with cassava yield increases of 15–50% across smallholder fields in Nigeria (IITA, 2024). Incorporating rapid soil tests — such as pH, organic matter levels, and texture-dependent herbicide behaviour — into such toolkits could make herbicide and management recommendations more precise (Fohrafellner et al., 2024).

X. CLIMATE CHANGE AND FUTURE SCENARIOS

Projected increases in mean global temperatures of 1.5 to 2°C by 2050 (Lee et al., 2014; Rogelj et al., 2018; Li et al., 2022) are anticipated to accelerate weed phenological development, reduce the cassava crop weed-free period (CWFP) (Phaphenit and Poonpaiboonpipat, 2023; Peressin and da Costa, 2024), and lead to a compositional shift in weed communities toward drought-adapted C4 grass species (Lee et al., 2014). Simulation models indicate that, in the absence of adaptive management interventions, cassava root yields could decline by approximately 9–59% (Srivastava et al., 2022). These projected yield losses may be effectively reduced through the combination of drought-resilient cassava genotypes with conservation agriculture practices, including the application of mulch (Srivastava et al., 2023). Such integrated management approaches improve soil moisture retention and suppress heat-induced weed flushes, thereby sustaining cassava productivity under projected climate change impacts (Ekeleme et al., 2003; Anikwe, 2018; Suwitono et al., 2023).

XI. CURRENT RESEARCH GAPS AND FUTURE PROSPECTS

11.1 Soil Microbiome-Mediated Allelopathy

Allelochemicals — biochemicals released by plants (roots, leaves, residues) that impact the germination, growth, or survival of nearby plants — are influenced by the soil microbial community (bacteria, fungi, archaea, and other microorganisms) that regulates their production, transformation, and activity (Fadiji et al., 2025; Bhattacharyya and Furtak, 2022). Soil microbiome-mediated allelopathy is a promising but under-researched field requiring advanced systems biology tools such as metagenomics and metabolomics to study how soil microbes influence weed-produced allelochemicals. Understanding these interactions could lead to microbiome-based biocontrol methods that reduce synthetic herbicide use (Thakur et al., 2023; Compant et al., 2025).

11.2 Precision Herbicide Placement

Soil texture mapping and band spraying are recent advancements in precision herbicide application technology that can reduce chemical use and environmental impact (Huang et al., 2025). Further research is required to increase sensor precision, strengthen assessments of soil variability, and develop trustworthy decision-support systems that efficiently translate soil data into practical herbicide application plans (Aarif et al., 2025).

11.3 Seed Bank Modelling Under Variable Tillage

Seed bank modelling in the context of varying tillage practices represents a significant area for further investigation (Santín-Montanyá et al., 2016; Mahé et al., 2021). Tillage redistributes weed seeds in the soil, affecting germination and emergence. Improved seed bank models need to be adapted for tropical soils to better predict seed behaviour and design tillage systems that disrupt weed cycles (Norsworthy et al., 2012).

11.4 Soil Health Indices Predictive of Weed Pressure

Developing soil health indicators that predict weed risk could help target weed control efforts. This requires integrating CEC, active carbon, and microbial respiration, and calls for interdisciplinary research (Goel and Kumar, 2024; Obiazi et al., 2024b).

11.5 Climate-Smart Cover Crop Mixtures

Tailored cover crop blends can suppress weeds and improve soil health, especially when adapted to specific soil conditions and climate variability. Further research is needed on species choice, planting strategies, and timing. Addressing these research gaps will greatly enhance sustainable weed management strategies amid growing environmental and climate-related challenges (Melis, 2025).

XII. CONCLUSIONS

Soil-weed interactions have a significant and complex impact on cassava cultivation. The physical characteristics of the soil determine the specific conditions under which weeds can sprout, while chemical properties affect competition for nutrients and herbicide efficacy. Additionally, the biological characteristics of the soil influence both weed competition and disease prevalence.

The evidence presented in this review indicates that integrated approaches — such as applying herbicides suited to soil texture, using cover crops to enhance soil fertility, and implementing conservation tillage strategies — often achieve better results than single-method approaches. These combined strategies can increase cassava tuber yield by up to 14 tons per hectare while improving soil health.

Future research and extension services should focus on developing decision-making tools that combine rapid soil testing, climate predictions, and adaptive weed management strategies to ensure that cassava production remains productive and sustainable under increasing environmental and climate pressures.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] Adekiya, A. O., Agbede, T. M., & Kolawole, V. O. (2022). Improving soil physical properties and cassava productivity through organic manures management in southern Cameroon. *Scientific Reports*, *12*, Article 4834. https://doi.org/10.1038/s41598-022-08834-9

[2] Adekiya, A. O., Alori, E. T., Ogunbode, T. O., Sangoyomi, T., & Oriade, O. A. (2023). Enhancing organic carbon content in tropical soils: Strategies for sustainable agriculture and climate change mitigation. *The Open Agriculture Journal*, *17*(1). https://doi.org/10.2174/0118743315282476231124074206

[3] Ahmad, I., Abbas, R. N., Aslam, Z., & Anwar-Ul-Haq, M. (2025). Ecological insights into weed seed bank dynamics: Management strategies through tillage and mulching interventions in maize (*Zea mays* L.) fields. *Journal of Ecological Engineering*, *26*(10). https://doi.org/10.12911/22998993/205713

[4] Akobundu, I. O. (1987). *Weed science in the tropics: Principles and practices*. John Wiley & Sons.

[5] Akobundu, I. O., & Agyakwa, C. W. (1998). *A handbook of West African weeds* (2nd ed.). International Institute of Tropical Agriculture.

[6] Akobundu, I. O., & Ekeleme, F. (2005). Weed seedbank response to planted fallow and tillage in southwest Nigeria. *Agroforestry Systems*, *63*, 299-306. https://doi.org/10.1007/s10457-005-5747-0

[7] Aladesanwa, R. D., & Akinbobola, T. N. (2008). Effects of lime on the herbicidal efficacy of atrazine and yield response of maize (*Zea mays* L.) under field conditions in southwestern Nigeria. *Crop Protection*, *27*(6), 926-931. https://doi.org/10.1016/j.cropro.2007.10.012

[8] Alama, S. I., Onyibe, C. E., Nwachukwu, E. F., Emuh, F. N., Egbuchua, C., & Akparobi, S. O. (2022). Physical properties of three geomorphological swampland soils in Delta State, Nigeria. *Journal of Biodiversity and Environmental Sciences*, *21*(1), 126-133.

[9] Alama, S. I., Uwabor, C. S., Ossai, C. O., Egbuchua, C., & Onyibe, C. E. (2023). Effects of flooding on physicochemical properties of hydromorphic soils of Bayelsa, South-South, Nigeria. *Journal of Agriculture and Food Environment*, *1*(10), 1-13.

[10] Ameena, M., Deb, A., Sethulakshmi, V. S., Sekhar, L., Susha, V. S., Kalyani, M. S. R., & Umkhulzum, F. (2024). Weed ecology: Insights for successful management strategies: A review. *Agricultural Reviews*.

[11] Amutha, R., Sudha, A., & Pandiselvi, P. (2019). *Tridax procumbens* (coat buttons): A gift of nature: An overview. In *Pharmacological benefits of natural products* (pp. 193-212).

[12] Anikwe, M. A. N. (2018). Ecophysiology and production principles of cassava (*Manihot* species) in Southeastern Nigeria. In *Cassava*. IntechOpen. https://doi.org/10.5772/intechopen.70828

[13] Anusontpornperm, S., Nortcliff, S., & Kheoruenromne, I. (2009). Interpretability comparison between soil taxonomic and fertility capability classification units: A case of some major cassava soils in northeast Thailand. *Agriculture and Natural Resources*, *43*(5), 9-18.

[14] Arévalo-Gardini, E., Canto, M., Alegre, J., Loli, O., Julca, A., & Baligar, V. (2015). Changes in soil physical and chemical properties in long term improved natural and traditional agroforestry management systems of cacao genotypes in Peruvian Amazon. *PLoS One*, *10*(7), e0132147. https://doi.org/10.1371/journal.pone.0132147

[15] Awotedu, B. F., Omolola, T. O., Akala, A. O., Awotedu, O. L., & Olaoti-Laaro, S. O. (2021). Vegetative propagation: A unique technique of improving plants growth. *World News of Natural Sciences*, *35*, 83-101.

[16] Bassey, M. S., Kolo, M. G. M., Daniya, E., & Odofin, A. J. (2021). Trash mulch and weed management practice impact on some soil properties, weed dynamics and sugarcane (*Saccharum officinarum* L.) genotypes plant crop productivity. *Sugar Tech*, *23*(2), 395-406. https://doi.org/10.1007/s12355-020-00899-8

[17] Basch, G., Teixeira, F., & Duiker, S. W. (2020). Weed management practices and benefits in conservation agriculture systems. In *Advances in conservation agriculture* (pp. 105-142). Burleigh Dodds Science Publishing.

[18] Behera, P., Das, N., & Karan, N. (2024). Sustainable weed management strategies for crop production. In *Comprehensive insights into environmental science* (p. 159).

[19] Bhattacharyya, S. S., & Furtak, K. (2022). Soil–plant–microbe interactions determine soil biological fertility by altering rhizospheric nutrient cycling and biocrust formation. *Sustainability*, *15*(1), 625. https://doi.org/10.3390/su15010625

[20] Bolfrey-Arku, G. E., Chauhan, B. S., & Johnson, D. E. (2011). Seed germination ecology of itchgrass (*Rottboellia cochinchinensis*). *Weed Science*, *59*(2), 182-187. https://doi.org/10.1614/WS-D-10-00095.1

[21] Chauhan, B. S., & Johnson, D. E. (2008). Germination ecology of two troublesome Asteraceae species of rainfed rice: Siam weed (*Chromolaena odorata*) and coat buttons (*Tridax procumbens*). *Weed Science*, *56*(4), 567-573. https://doi.org/10.1614/WS-07.200.1

[22] Chikoye, D., & Ekeleme, F. (2001). Weed management in cassava. *Weed Technology*, *15*(4), 836-841.

[23] Chikoye, D., Ekeleme, F., & Udensi, U. E. (2001). Cogongrass suppression by intercropping cover crops in corn/cassava systems. *Weed Science*, *49*, 658-667.

[24] Choudhary, V. K. (2023). Weed suppression, weed seed bank and crop productivity influenced under tillage and mulches in maize-rapeseed cropping system. *Crop Protection*, *172*, Article 106333. https://doi.org/10.1016/j.cropro.2023.106333

[25] Compant, S., Cassan, F., Kostić, T., Johnson, L., Brader, G., Trognitz, F., & Sessitsch, A. (2025). Harnessing the plant microbiome for sustainable crop production. *Nature Reviews Microbiology*, *23*(1), 9-23.

[26] Costa, N. V. D., Takahashi, M., Costa, A. C. P. R. D., Ferreira, S. D., Brustolin, D. B., & Vasconcelos, E. S. D. (2023). Selectivity and efficacy of PROTOX inhibitors in cassava varieties cultivated in clayey and sandy soils. *Acta Scientiarum: Agronomy*, *45*, Article e57135. https://doi.org/10.4025/actasciagron.v45i1.57135

[27] Ćirić, V., Prekop, N., Šeremešić, S., Vojnov, B., Pejić, B., Radovanović, D., & Marinković, D. (2023). The implication of cation exchange capacity (CEC) assessment for soil quality management and improvement. *Agriculture & Forestry*, *69*(4). https://doi.org/10.17707/AgricultForest.69.4.08

[28] Ekeleme, F., Akobundu, I. O., Isichei, A. O., & Chikoye, D. (2003). Cover crops reduce weed seedbanks in maize–cassava systems in southwestern Nigeria. *Weed Science*, *51*(5), 774-780. https://doi.org/10.1614/0043-1745(2003)051[0774:CCRWSI]2.0.CO;2

[29] Ekeleme, F., Chikoye, D., & Akobundu, I. O. (2004). Changes in size and composition of weed communities during planted and natural fallows. *Basic and Applied Ecology*, *5*(1), 25-33.

[30] Ekeleme, F., Hauser, S., Atser, G., Dixon, A., Weller, S., Olorunmaiye, P., ... & Chikoye, D. (2016). Weed management in cassava in Africa: Challenges and opportunities. *Outlooks on Pest Management*, *27*(5), 208. https://doi.org/10.1564/v27_oct_04

[31] Emmanuel, C. P., Alama, I. S., Okon, U., Uwabor, S. C., Onwudiwe, N., Offeoritse, F. O., Otite, O. F., Enor, E., & Okonjo, E. (2025). Effects of tillage types on soil chemical properties, growth and yield of groundnut (*Arachis hypogaea* L.). *International Journal of Agriculture and Rural Development*, *28*(1), 7380-7385.

[32] Eni, E. I., Falade, A. A., Osunleti, S. O., & Alama, S. I. (2025). Evaluating the effects of weed control methods on the growth and yield of jackbean (*Canavalia ensiformis* L.) in South West Nigeria. *NOUN Journal of Agricultural Research and Development*, *1*(2), 106-111. https://journal.agric.nou.edu.ng

[33] Esilaba, A. O., Miriti, J., Gitari, J., Mangale, N., Kathuku-Gitonga, A. N., Njiru, E., & Mwangi, H. (2021). *KCEP-CRAL integrated soil fertility and water management extension manual*. Kenya Agricultural and Livestock Research Organization.

[34] Fadiji, A. E., Adeniji, A., Lanrewaju, A. A., & Babalola, O. O. (2025). Dynamics of soil microbiome and allelochemical interactions: An overview of current knowledge and prospects. *Annals of Microbiology*, *75*(1), Article 21. https://doi.org/10.1186/s13213-025-01812-y

[35] Farenhorst, A., Papiernik, S. K., Saiyed, I., Messing, P., Stephens, K. D., Schumacher, J. A., ... & Schumacher, T. E. (2008). Herbicide sorption coefficients in relation to soil properties and terrain attributes on a cultivated prairie. *Journal of Environmental Quality*, *37*(3), 1201-1208.

[36] Fohrafellner, J., Keiblinger, K. M., Zechmeister-Boltenstern, S., Murugan, R., Spiegel, H., & Valkama, E. (2024). Cover crops affect pool specific soil organic carbon in cropland: A meta-analysis. *European Journal of Soil Science*, *75*(2), e13472. https://doi.org/10.1111/ejss.13472

[37] Food and Agriculture Organization of the United Nations. (2021). *Save and grow: Cassava – A guide to sustainable production intensification*. https://www.fao.org/3/ca6902en/ca6902en.pdf

[38] Galindo, V., Giraldo, C., Lavelle, P., Armbrecht, I., & Fonte, S. J. (2022). Land use conversion to agriculture impacts biodiversity, erosion control, and key soil properties in an Andean watershed. *Ecosphere*, *13*(3), e3979. https://doi.org/10.1002/ecs2.3979

[39] Garcia-Barrios, L. (2003). Plant-plant interactions in tropical agriculture. In *Tropical agroecosystems* (pp. 11-58).

[40] Gbanguba, A. U., Daniya, E., Kolo, M. G. M., Ibrahim, P. A., Ismaila, U., & Umar, A. (2020). Effects of pre rice cassava/legume intercrops and weed management practices on weed dynamics and yield of low land rice in Badeggi, Nigeria.

[41] Ghafoor, I., Naz, T., Nawaz, S., Iqbal, M. M., Ambreen, U., Hameed, S., ... & Umair, M. (2025). The climate challenge: Sustaining soil health and crop resilience. In *Soils and sustainable agriculture: Interplay of soil, plant, water and environmental systems for sustainable agriculture* (pp. 337-379). Springer. https://doi.org/10.1007/978-3-031-91114-9_14

[42] Glaspie, C. F., Jones, E. A., Penner, D., Pawlak, J. A., & Everman, W. J. (2021). Effect of clay, soil organic matter, and soil pH on initial and residual weed control with flumioxazin. *Agronomy*, *11*(7), Article 1326. https://doi.org/10.3390/agronomy11071326

[43] Goel, V., & Kumar, A. (2024). Advances in soil health assessment: Integrating technologies for sustainable agriculture. *Plant Archives*, *24*(2). https://doi.org/10.51470/plantarchives.2024.v24.no.2.089

[44] Han, J., Li, Y., Li, H., Yang, H., Luo, S., Man, H., & Shi, G. (2025). Phenolic acids alleviated consecutive replant problems in lily by regulating its allelopathy on rhizosphere microorganism under chemical fertilizer reduction with microbial agents in conjunction with organic fertilizer application. *Applied Soil Ecology*, *205*, Article 105780. https://doi.org/10.1016/j.apsoil.2024.105780

[45] Holm, L. G. (1977). *The world's worst weeds: Distribution and biology* (pp. 353-357). University Press of Hawaii.

[46] Holm, L. G., Plucknett, D. L., Pancho, J. V., & Herberger, J. P. (1991). *The world's worst weeds: Distribution and biology* (pp. 8-24, 125-133). Krieger Publishing.

[47] Hooda, V. S., & Chauhan, B. S. (2023). Herbicide response and germination behavior of two goosegrass (*Eleusine indica*) populations in the Australian environment. *Weed Science*, *71*(6), 584-593. https://doi.org/10.1017/wsc.2023.51

[48] Hossain, M. M., & Begum, M. (2015). Soil weed seed bank: Importance and management for sustainable crop production: A review. *Journal of the Bangladesh Agricultural University*, *13*(2), 221-228.

[49] Huang, Y., Sun, X., Rai, N., Yao, H., Reddy, K. N., & Jenkins, J. (2025). Remote sensing for precision weed management. *Pest Management Science*. https://doi.org/10.1002/ps.8833

[50] Ifeakachukwu, S. A., Onyibe, C. E., Nwachukwu, E. F., Emuh, F. N., Egbuchua, C., & Akparobi, S. O. (2022). Physical properties of three geomorphological swampland soils in Delta State, Nigeria. *Journal of Biodiversity and Environmental Sciences*, *21*(1), 126-133.

[51] IITA (International Institute of Tropical Agriculture). (1997). *Cassava production in Africa*. IITA.

[52] Ikeh, A. O., Ndaeyo, N. U., & Ikeh, C. E. (2023). Effects of integrated fertilization on soil sustainability and cassava (*Manihot esculenta* Crantz) yield in an ultisol. *Journal of Current Opinion in Crop Science*, *4*(2), 89-102. https://doi.org/10.62773/jcocs.v4i2.197

[53] Inderjit, & Weston, L. A. (2003). Root exudates: An overview. In H. de Kroon & E. J. W. Visser (Eds.), *Root ecology* (pp. 235-255). Springer. https://doi.org/10.1007/978-3-642-64739-7_10

[54] Ivens, G. W. (1989). *East African weeds and their control*. Oxford University Press.

[55] Jayasinghe, U. (2001). Invasive nature of *Mimosa pudica*. *Tropical Grasslands*, *35*(2), 119-125.

[56] Jensen, R. E., Enkegaard, A., & Steenberg, T. (2019). Increased fecundity of *Aphis fabae* on *Vicia faba* plants following seed or leaf inoculation with the entomopathogenic fungus *Beauveria bassiana*. *PLoS One*, *14*(10), e0223616. https://doi.org/10.1371/journal.pone.0223616

[57] Jensen, L. C., Neira Albornoz, A., & Escudey, M. (2019). Herbicides mechanisms involved in the sorption kinetic of ionisable and non ionisable herbicides: Impact of physical/chemical properties of soils and experimental conditions. In *Kinetic modeling for environmental systems*. IntechOpen. https://doi.org/10.5772/intechopen.84906

[58] Kaur, M., Aggarwal, N. K., Kumar, V., & Dhiman, R. (2014). Effects and management of *Parthenium hysterophorus*: A weed of global significance. *International Scholarly Research Notices*, *2014*, Article 368647, 1-12. https://doi.org/10.1155/2014/368647

[59] Kaur, S., Kaur, R., & Chauhan, B. S. (2018). Understanding crop-weed-fertilizer-water interactions and their implications for weed management in agricultural systems. *Crop Protection*, *103*, 65-72. https://doi.org/10.1016/j.cropro.2017.09.011

[60] Khadka, R. B. (2021). *Application of Nepalese Trichoderma spp. with anaerobic soil disinfestation (ASD) to control soil-borne diseases and effect of ASD on weeds* [Doctoral dissertation, The Ohio State University].

[61] Khadim, M. D., Wesal, A. B., & Peezhand, A. W. (2024). Overview of the impact of compost on bulk density, aggregate consistency and cation exchange capacity of soils and its consequential effect on crop productivity. *Cognizance Journal of Multidisciplinary Studies*, *4*(6), 344-359. https://doi.org/10.47760/cognizance.2024.v04i06.021

[62] Kongsil, P., Ceballos, H., Siriwan, W., Vuttipongchaikij, S., Kittipadakul, P., Phumichai, C., ... & Rojanaridpiched, C. (2024). Cassava breeding and cultivation challenges in Thailand: Past, present, and future perspectives. *Plants*, *13*(14), Article 1899. https://doi.org/10.3390/plants13141899

[63] Korres, N. E., Travlos, I. S., & Gitsopoulos, T. K. (Eds.). (2023). *Ecologically based weed management: Concepts, challenges, and limitations*. John Wiley & Sons.

[64] Kostina-Bednarz, M., Płonka, J., & Barchanska, H. (2023). Allelopathy as a source of bioherbicides: Challenges and prospects for sustainable agriculture. *Reviews in Environmental Science and Bio/Technology*, *22*(2), 471-504. https://doi.org/10.1007/s11157-023-09656-1

[65] Koti, S., Anil, K. M., & Ramachandrappa, B. K. (2010). Growth, tuber formation and spread of *Cyperus rotundus* L. from single tubers. *Karnataka Journal of Agricultural Sciences*, *23*(3), 495-496.

[66] Kumar, A. (2016). *Impact of conservation agriculture on nutrient dynamics in dominant cropping systems in a black soil of central India* [Doctoral dissertation, Indira Gandhi Krishi Vishwavidyalaya].

[67] Lee, M. A., Manning, P., Walker, C. S., & Power, S. A. (2014). Plant and arthropod community sensitivity to rainfall manipulation but not nitrogen enrichment in a successional grassland ecosystem. *Oecologia*, *176*(4), 1173-1185. https://doi.org/10.1007/s00442-014-3077-5

[68] Li, K., Pan, J., Xiong, W., Xie, W., & Ali, T. (2022). The impact of 1.5°C and 2.0°C global warming on global maize production and trade. *Scientific Reports*, *12*(1), Article 17268. https://doi.org/10.1038/s41598-022-22228-7

[69] Li, Y., Cui, Y., Zhou, Z., Luo, J., Liu, M., & Zhao, J. (2017). The industrial applications of cassava: Current status, opportunities and prospects. *Journal of the Science of Food and Agriculture*, *97*(8), 2282-2290. https://doi.org/10.1002/jsfa.8287

[70] Liang, X., Yu, S., Ju, Y., Wang, Y., & Yin, D. (2025). Integrated management practices foster soil health, productivity, and agroecosystem resilience. *Agronomy*, *15*(8), 1816. https://doi.org/10.3390/agronomy15081816

[71] Liebman, M., & Davis, A. S. (2000). Integration of soil, crop, and weed management in low-input farming systems. *Weed Research*, *40*(1), 27-47.

[72] Liebman, M., Staver, C. P., & Mohler, C. L. (2001). Crop diversification for weed management. In *Ecological management of agricultural weeds* (pp. 322-374).

[73] Lubis, H. A., Zuraida, R., & Ginting, A. M. (2023). Biomulch treatment effects on weed control and soil properties in cassava plantation. *Journal of Tropical Crop Science*, *10*(2), 55-62.

[74] MacDonald, G. E. (2004). Cogongrass (*Imperata cylindrica*): Biology, ecology, and management. *Critical Reviews in Plant Sciences*, *23*(5), 367-380. https://doi.org/10.1080/07352680490505114

[75] Mahé, I., Cordeau, S., Bohan, D. A., Derrouch, D., Dessaint, F., Millot, D., & Chauvel, B. (2021). Soil seedbank: Old methods for new challenges in agroecology? *Annals of Applied Biology*, *178*(1), 23-38. https://doi.org/10.1111/aab.12619

[76] McGranahan, N., & Swanton, C. (2015). Biological and therapeutic impact of intratumor heterogeneity in cancer evolution. *Cancer Cell*, *27*(1), 15-26.

[77] Melis Çerçioğlu, Udawatta, R. P., & Anderson, S. H. (2025). Use of cover crops for sustainable management of soil condition and health: A review. *Soil Security*, *18*, Article 100177. https://doi.org/10.1016/j.soisec.2025.100177

[78] Meng, F., Wang, Y., & Wei, Y. (2025). Advancements in biochar for soil remediation of heavy metals and/or organic pollutants. *Materials*, *18*(7), Article 1524. https://doi.org/10.3390/ma18071524

[79] Monteiro, A., & Santos, S. (2022). Sustainable approach to weed management: The role of precision weed management. *Agronomy*, *12*(1), Article 118. https://doi.org/10.3390/agronomy12010118

[80] Muhammad, M., Wahab, A., Waheed, A., Hakeem, K. R., Mohamed, H. I., Basit, A., ... & Li, W. J. (2025). Navigating climate change: Exploring the dynamics between plant–soil microbiomes and their impact on plant growth and productivity. *Global Change Biology*, *31*(2), e70057. https://doi.org/10.1111/gcb.70057

[81] Namatsheve, T., Cardinael, R., Chikowo, R., Corbeels, M., Rugare, J. T., Mabasa, S., & Ripoche, A. (2024). Do intercropping and mineral nitrogen fertilizer affect weed community structures in low-input maize-based cropping systems? *Crop Protection*, *176*, Article 106486. https://doi.org/10.1016/j.cropro.2023.106486

[82] Nath, C. P., Singh, R. G., Choudhary, V. K., Datta, D., Nandan, R., & Singh, S. S. (2024). Challenges and alternatives of herbicide-based weed management. *Agronomy*, *14*(1), Article 126. https://doi.org/10.3390/agronomy14010126

[83] Nedunchezhiyan, M., Ravi, V., George, J., & Veena, S. S. (2017). Effect of weed control methods on the yield and starch content of storage root of cassava (*Manihot esculenta*) and soil health.

[84] Norsworthy, J. K., Ward, S. M., Shaw, D. R., Llewellyn, R. S., Nichols, R. L., Webster, T. M., ... & Barrett, M. (2012). Reducing the risks of herbicide resistance: Best management practices and recommendations. *Weed Science*, *60*(SP1), 31-62. https://doi.org/10.1614/WS-D-11-00155.1

[85] Nosratti, I., Korres, N. E., & Cordeau, S. (2023). Knowledge of cover crop seed traits and treatments to enhance weed suppression: A narrative review. *Agronomy*, *13*(7). https://doi.org/10.3390/agronomy13071683

[86] Obiazi, C. C., Alama, I. S., Onwudiwe, N., & Oghenekaro, K. E. (2024a). Chemical weed control in eggplant with pendimethalin. *Chemistry Research Journal*, *9*(2), 95-102.

[87] Obiazi, C. C., Chukwuma, S. U., Alama, S. I., Onwudiwe, N., Erute, O. K., & Onwudiwe, N. (2024b). Assessment of weed control potentials of butachlor in garden egg. *Chemistry Research Journal*, *9*(1), 176-183.

[88] Ocaña Reyes, J. A., Paredes Espinosa, R., Quispe Tomas, A., Díaz Chuquizuta, H., Ore Aquino, Z. L., Agurto Piñarreta, A. I., ... & Lao Olivares, C. P. (2024). Tillage systems modify soil properties and cassava physiology during drought. *Agronomy*, *14*(12), Article 3041. https://doi.org/10.3390/agronomy14123041

[89] Ojeniyi, S. O., Odedina, S. A., & Agbede, T. M. (2012). Soil productivity improving attributes of Mexican sunflower (*Tithonia diversifolia*) and siam weed (*Chromolaena odorata*). *Emirates Journal of Food & Agriculture*, *24*(3).

[90] Okezie, A. K., & Okeke, C. U. (2013). Weed flora of cassava farms. *Journal of Agriculture and Biodiversity Research*, *2*(3), 54-61. https://doi.org/10.4314/acsj.v24i1.16S

[91] O'Neil, C. M., Tiemann, L. K., & Miesel, J. R. (2021). Mycorrhizal symbioses enhance competitive weed growth in biochar and nutrient amended soils. *Frontiers in Agronomy*, *3*. https://doi.org/10.3389/fagro.2021.731184

[92] Onasanya, O. O. (2020). *Evaluation of agronomic practices on growth, yield of cassava and some physical properties of soils in southwestern Nigeria* [Unpublished doctoral dissertation]. ETH Zurich.

[93] Ossai, C. O., Ojobor, S. A., Ogwuche, T. O., Akpeji, S. C., Alama, I. S., & Diebiru-Ojo, E. M. (2025). Performance of four newly released cassava varieties in a fallowed land over two cropping seasons. *PLoS One*, *20*(5), e0317477. https://doi.org/10.1371/journal.pone.0317477

[94] Peressin, V. A., & da Costa, N. V. (2024). Integrated weed management in cassava fields. In *Sustainable cassava* (pp. 99-116). Academic Press.

[95] Phaphenit, K., & Poonpaiboonpipat, T. (2023). The critical period of weed control for cassava planted during the rainy season of Thailand. *International Journal of Agricultural Technology*, *19*(3), 1179-1190.

[96] Pimentel, D. (2007). Environmental and economic costs of vertebrate species invasions into the United States.

[97] Pätzold, S., Hbirkou, C., Dicke, D., Gerhards, R., & Welp, G. (2020). Linking weed patterns with soil properties: A long term case study. *Precision Agriculture*, *21*(3), 569-588. https://doi.org/10.1007/s11119-019-09682-6

[98] Raimondi, G. (2024). *Crop response, N and C dynamics after cover crop introduction*.

[99] Ramella, J. R. P., Barbosa, J. D. A., Ferreira, S. D., Fey, E., & Costa, N. V. D. (2020). Weed interference on nutrient accumulation in the leaves of cassava under no-tillage or conventional tillage. *Pesquisa Agropecuária Brasileira*, *55*, e01750. https://doi.org/10.1590/S1678-3921.pab2020.v55.01750

[100] Rana, S. S., & Rana, M. C. (2016). *Principles and practices of weed management*. Department of Agronomy, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya.

[101] Ravi, V., Suja, G., Saravanan, R., & More, S. J. (2021). Advances in cassava based multiple cropping systems. *Horticultural Reviews*, *48*, 153-232. https://doi.org/10.1002/9781119750802.ch3

[102] Ren, Z., Gibson, D. J., Gage, K. L., Matthews, J. L., Owen, M. D., Jordan, D. L., ... & Young, B. G. (2024). Exploring the effect of region on diversity and composition of weed seedbanks in herbicide-resistant crop systems in the United States. *Pest Management Science*, *80*(3), 1446-1453. https://doi.org/10.1002/ps.7875

[103] Revillini, D., Morran, S., & Schultz, C. J. (2023). Allelopathy selected microbiomes mitigate chemical inhibition of plant performance. *New Phytologist*, *242*(5), 2157-2169. https://doi.org/10.1111/nph.19249

[104] Rice, E. L. (1984). *Allelopathy* (2nd ed.). Academic Press.

[105] Robá, M., Neto, A. C. A., Rebouá, A., da Silva Lima, R., de Souza Moreira, E., Prado, T. R., ... & Moreira, G. L. P. (2016). Effect of weeds on yield loss of cassava plants in response to NPK fertilization. *African Journal of Agricultural Research*, *11*(5), 356-370. https://doi.org/10.5897/AJAR2015.10551

[106] Rogelj, J., Popp, A., Calvin, K. V., Luderer, G., Emmerling, J., Gernaat, D., ... & Tavoni, M. (2018). Scenarios towards limiting global mean temperature increase below 1.5°C. *Nature Climate Change*, *8*(4), 325-332.

[107] Santín-Montanyá, M. I., Martin-Lammerding, D., Zambrana, E., & Tenorio, J. L. (2016). Management of weed emergence and weed seed bank in response to different tillage, cropping systems and selected soil properties. *Soil and Tillage Research*, *161*, 38-46. https://doi.org/10.1016/j.still.2016.03.007

[108] Santos, E. A., Correia, N. M., Silva, J. R. M., Velini, E. D., Passos, A. B. R. J., & Durigan, J. C. (2015). Herbicide detection in groundwater in Córrego Rico-SP watershed. *Planta Daninha*, *33*(1), 147-155.

[109] Shah, A. M., Zhang, H., Shahid, M., Ghazal, H., Shah, A. R., Niaz, M., ... & Zhao, H. (2025). The vital roles of agricultural crop residues and agro-industrial by-products to support sustainable livestock productivity in subtropical regions. *Animals*, *15*(8), Article 1184. https://doi.org/10.3390/ani15081184

[110] She, Y., Li, X., Zhang, J., & Zhou, H. (2024). Effects of soil characteristics on grassland productivity in long term artificial grassland establishment.

[111] Sileshi, G. W. (2022). Dose-response models to guide site-specific nutrient management and lessons for fertiliser trial design in sub-Saharan Africa. *Experimental Agriculture*, *58*, e2. https://doi.org/10.1017/S0014479721000193

[112] Silva, R. B., Santos Neto, A. L. D., Santos, W. M. D., Teodoro, I., Barros, A. C., Santos, V. R. D., ... & Silva, D. M. (2025). Cassava growth and productive performance at different planting times in the Agreste of Alagoas, Northeastern Brazil. *Revista Brasileira de Engenharia Agrícola e Ambiental*, *29*(6), e285686. https://doi.org/10.1590/1807-1929/agriambi.v29n6e285686

[113] Singh, H. P., Batish, D. R., & Kohli, R. K. (2003). Allelopathic interactions and allelochemicals: New possibilities for sustainable weed management. *Critical Reviews in Plant Sciences*, *22*(3-4), 239-311. https://doi.org/10.1080/713610858

[114] Singh, N. K., Sachan, K., Bp, M., Panotra, N., & Katiyar, D. (2024). Building soil health and fertility through organic amendments and practices: A review. *Asian Journal of Soil Science and Plant Nutrition*, *10*(1), 175-197. https://doi.org/10.9734/AJSSPN/2024/v10i1224

[115] Soares, D. O., Pinto, K. G., Bhowmik, P. C., & Albertino, S. M. (2022). Chemical properties of soil and cassava yield as a function of weed management by cover crops in the Amazon ecosystem. *Sustainability*, *14*(3), Article 1886. https://doi.org/10.3390/su14031886

[116] Srivastava, A. K., Ewert, F., Akinwumiju, A. S., Zeng, W., Ceglar, A., Ezui, K. S., ... & Gaiser, T. (2023). Cassava yield gap: A model-based assessment in Nigeria. *Frontiers in Sustainable Food Systems*, *6*, Article 1058775. https://doi.org/10.3389/fsufs.2022.1058775

[117] Srivastava, A. K., Gaiser, T., Akinwumiju, A. S., Zeng, W., Ceglar, A., Ezui, K. S., ... & Rahimi, J. (2022). Simulating regional cassava yield gap in Nigeria.

[118] Sulley, S., Hind, S. R., & Babadoost, M. (2021). Survival of *Xanthomonas cucurbitae* in different crop rotations, plant debris, and weeds in pumpkin fields. *Plant Health Progress*, *22*(4), 529-535. https://doi.org/10.1094/PHP-03-21-0069-RS

[119] Sultana, S. N., Zubayer, M., Islam, M. S., Ashab, K. R., Shanta, S. H., & Kayesh, E. (2024). Sustainable and ecofriendly approach to weed management. In *Weed management: Global strategies* (p. 83). IntechOpen.

[120] Suwitono, B., Chozin, M. A., Guntoro, D., & Suwarto, S. (2023). Biomulch treatment effects on weed control and soil properties in cassava plantation. *Journal of Tropical Crop Science*, *10*(2), 111-123. https://doi.org/10.29244/jtcs.10.02.111-123

[121] Swanton, C. J., Anderson, R. L., & Harper, J. J. (2000). Tillage systems and the vertical distribution of weed seedbanks. *Weed Technology*, *14*(2), 511-517.

[122] Thakur, N., Nigam, M., Mann, N. A., Gupta, S., Hussain, C. M., Shukla, S. K., ... & Khan, S. A. (2023). Host-mediated gene engineering and microbiome-based technology optimization for sustainable agriculture and environment. *Functional & Integrative Genomics*, *23*(1), Article 57. https://doi.org/10.1007/s10142-023-00982-9

[123] Tovihoudji, P. G., Akponikpè, P. I., Agbossou, E. K., & Bielders, C. L. (2019). Using the DSSAT model to support decision making regarding fertilizer microdosing for maize production in the sub-humid region of Benin. *Frontiers in Environmental Science*, *7*, Article 13. https://doi.org/10.3389/fenvs.2019.00013

[124] Tropical Plants Database. (2025). *Boerhavia diffusa*. Ken Fern. tropical.theferns.info/viewtropical.php?id=Boerhavia+diffusa

[125] Udensi, U. E., & Chikoye, D. (2013). Effect of relative proportion and density on competition between speargrass (*Imperata cylindrica* (L.) Raeuschel) and maize (*Zea mays* L.) in a moist savannah of Southwestern Nigeria. *Journal of Animal and Plant Sciences*, *18*, 2761-2774.

[126] Udoh, B. T., Ogunkunle, A. O., & Ndaeyo, N. U. (2007). Influence of soil series and physico-chemical properties on weed flora distribution at moor plantation Ibadan, southwestern Nigeria. *Journal of Agriculture and Social Sciences*, *3*(2), 55-58.

[127] Udoh, J. P., Chikoye, D., & Swanton, C. J. (2007). Influence of physicochemical soil properties on the distribution of *Tridax procumbens* and *Cyperus rotundus* in sugarcane fields. *Pesquisa Agropecuária Brasileira*, *42*(4), 537-543.

[128] Van Chuong, N., Tri, T. L. K., Trang, N. N. P., Liem, T. T., & Dang, P. T. H. (2025). Synergistic effect of *Leclercia adecarboxylata* CIP 82.92 and rice husk biochar on yield enhancement and cadmium reduction in mung bean. https://doi.org/10.21203/rs.3.rs-7316646/v1

[129] Walker, S. R., & Evenson, J. P. (1985). Biology of *Commelina benghalensis*. *Weed Research*, *25*(5), 239-246. https://doi.org/10.1111/j.1365-3180.1985.tb00640.x

[130] Walpola, B. C., & Hettiarachchi, R. H. A. N. (2020). Organic manure amended with phosphate solubilizing bacteria on soil phosphorous availability. *Journal of Agricultural Sciences – Sri Lanka*, *15*(2).

[131] Wang, X., Gao, J., Ning, G., Zhang, H., Duan, Y., Li, J., Wu, Y., Qi, M., Huang, Y., & Yang, Z. (2024). Effects of inoculation of thermotolerant *Bacillus* strains on lignocellulose degradation. *Agriculture*, *14*(11), Article 2044. https://doi.org/10.3390/agriculture14112044

[132] Webster, T. M., & MacDonald, G. E. (2001). Biology and control of *Ipomoea triloba*. *Weed Technology*, *15*(4), 835-839.

[133] Yameogo, F., Wonni, I., Sanou, A., Sere, I., Somda, I., Szurek, B., & Gagnevin, L. (2023). Evaluation of weeds as alternative hosts of *Xanthomonas phaseoli* pv. *manihotis*, the causal agent of cassava bacterial blight in Burkina Faso. *PhytoFrontiers*™, *3*(2), 420-429. https://doi.org/10.1094/PHYTOFR-10-22-0118-R

[134] Yan, H., & Nelson Jr., B. (2022). Effects of soil type, temperature, and moisture on development of Fusarium root rot of soybean by *Fusarium solani* (FSSC 11) and *Fusarium tricinctum*. *Plant Disease*, *106*(11), 2974-2983. https://doi.org/10.1094/PDIS-12-21-2738-RE

[135] Zhao, X., Liang, L., Qi, S., Fang, J., Li, P., Xu, M., & Yan, J. (2025). Integrated analysis of 16S endophytic bacteria and non-targeted metabolomics reveals the drought response mechanisms of *Portulaca oleracea* L. *BMC Plant Biology*, *25*(1), Article 1139. https://doi.org/10.1186/s12870-025-07181-7.