

**IMPACT OF MULCHING ON THE MORPHOLOGY OF BBT BROWN VARIETY
OF COWPEA (*Vigna unguiculata* (L.) WALP.)**



BY

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DEPARTMENT OF PLANT BIOLOGY AND BIOTECHNOLOGY

FACULTY OF LIFE SCIENCES

UNIVERSITY OF BENIN

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**A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF
PLANT BIOLOGY AND BIOTECHNOLOGY, FACULTY OF LIFE
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FOR THE UNIVERSITY OF BENIN, BENIN CITY, AWARD OF
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CERTIFICATION

This is to certify that this project work was carried out by Osadebamwen Destiny EMUMWEN (Miss) of the Department of Plant Biology and Biotechnology. Faculty of life sciences. University of Benin, Benin city.

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Date

Prof. B. Ikhajiagbe
(Head of Department)

Date

DEDICATION

This project work is dedication to the Almighty God for this grace and mercies and to everyone that has showed their support and love throughout my period of study.

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ABSTRACT

This study examines the impact of mulching on the MORPHOLOGY OF BBT BROWN VARIETY OF COWPEA (*Vigna unguiculata* (L.) Walp.) it was conducted in the university of Benin's Department of Plant Biology and Biotechnology botanic garden, the experiment aim to expose the impact of various mulched types on the cowpea.

This research investigated the morphological responses of cowpea to eight distinct soil covers (mulch) comprising four inorganic mulch (Polythene Black(PO), Polythene White (PW), Polythene Transparent (PT), Polythene Blue (PB)) and five organic residual (Sawdust, Banana Leaves, Bamboo Leaves, Spent Substrate), against a non-mulched control. The primary objectives were to delineate the influence of each material on stand establishment, vegetative morphology, resource partitioning via the Root Mass Ratio (RMR), and the resulting economic yield components. The experiment evaluated critical parameters across the growth cycle, including Emergence Percentage, Shoot weight, leaf weight, Avg no of leaves, root collar Root Nodules count, RMR(Root Mass Ratio), and key yield components (Avg No of Pods, Avg No of Seeds/Pod, and Avg Pod Length, Avg pedicule length). The analysis revealed significant variation in morphology parameters and impact, it reveals that polythene Black (PO) treatment established itself as the leading practice for highest mean numbers of pods, this findings translated to an increase in pod output compared to the control(non- mulched).The outcome of the analysis also show that inorganic polythene white mulch influenced the cowpea plant as observed in the yield quality metrics having recorded the highest no of pods per seed and the longest Avg pod length, leading to a notable increase during harvest as compared to the control. It also showed that a certain mulch type (OS) influenced the cowpea plant to adopt a root prioritizing strategy giving that it recorded the highest no of nodules. This findings definitively confirms that mulching is essential for optimizing cowpea productivity, but the choice of material must align with the specific productions goals (Either for commercial yield maximization or it utility for long term soil biological sustainability).

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

Cowpea (*Vigna unguiculata* (L.) Walp) is a staple grain-legume of major socioeconomic importance across West Africa and Nigeria in particular. It is grown for human consumption, animal feed, and soil improvement through biological nitrogen fixation, and contributes substantially to food security and livelihoods for smallholder farmers in humid and savannah agro-ecologies (Osipitan, 2021). Cowpea's adaptability to poor soils and its role in crop rotations make it a focus crop for sustainable intensification and climate-smart farming interventions in Nigeria.

The "BBT" series of cultivars (e.g., ARTPEA/BBT/72/B - Remilekun and ARTPEA/BBT/22/W — Boluyo) were developed and released for humid ecologies of Nigeria to address yield-limiting biotic stresses such as brown blotch disease and to offer farmer-preferred traits like earliness and acceptable seed quality. According to Akinyosoye et al. (registration report), cowpea varieties such as Bbt brown have been characterized and registered for production. The registration and characterization literature for these cultivars document their agronomic adaptation and disease-tolerance traits under Nigerian conditions. Local germplasm descriptions and recently published varietal characterization (including pollen and other morphological studies) also list BBT Brown among commonly studied varieties in Nigerian research institutions. These cultivar-specific descriptions are important because varietal response to cultural practices such as mulching can be genotype-specific.

Morphology, the external form and structure of plants, in cowpea typically refers to traits such as plant height, number of branches, leaf area, stem thickness, root system architecture, pod number and length, seed size and colour, and phenological stages (vegetative vs

reproductive). These traits are influenced by genotype (variety), environment (soil, moisture, temperature) and management (planting density, fertilization, tillage, mulching). Morphological traits are routinely used as indicators of growth vigor, resource capture (light, water), and ultimately yield potential (Okpefa, 2010).

Mulching refers to the practice of covering the soil surface with organic or inorganic materials

(Crop residues, straw, cocoa pod husk, empty fruit bunches, plastic sheets, or living mulches).

In the humid and sub-humid tropics, smallholder farmers commonly use organic mulches (crop residues, husks, grass) because they are low-cost, locally available and provide multiple benefits : reduction of soil moisture evaporation, moderation of soil temperature, weed suppression, reduced erosion, improved soil organic matter, and as a source of nutrients upon decomposition(Maurya et al., n.d.; Etukudoh et al., 2019). In West Africa, both surface mulching with residues and "mulch planting" (planting into a layer of mulch) are known practices for

cowpea and other legumes. The physical and biochemical effects of mulches translate into measurable changes in plant morphology:

- Soil moisture and microclimate: Surface mulches reduce evaporative losses and moderate diurnal soil temperature fluctuations, supporting sustained vegetative growth and prolonged leaf area expansion, which often increases plant height and branch number in water-limited environments (Masete et al., 2022; Ogban, 2008).
- Soil physical properties and root environment: Mulches reduce surface crusting and compaction, maintain higher infiltration rates and improve soil structure over time, which can encourage below-ground development (root length, root mass) and improved nutrient uptake

affecting above-ground morphological traits. Studies in Southeastern Nigeria reported improved root growth and better early-season vigor under mulched plots compared with bare soil (Ogban, 2008).

- Nutrient dynamics and nodulation: Organic mulches contribute to soil organic carbon and may influence nitrogen cycling. For legumes like cowpea, mulching may affect biological nitrogen fixation (BNF) and nodulation; some studies show that low C:N organic mulches can reduce BNF proportionally by altering mineral N availability, while other organic mulches improve overall plant N status indirectly through improved soil moisture and temperature (Masete et al., 2022). Changes in nodulation and plant N status can alter morphological allocation between vegetative growth and reproductive organs (pods and seeds).

- Weed suppression and competition: By suppressing weeds, mulches can reduce interspecific competition for light and nutrients, allowing cowpea plants to allocate more resources to branching and pod set; conversely, dense or heavy mulches may impede seedling emergence in some crops, though cowpea's relatively large seed often allows emergence through surface residue (Osipitan, 2021).

Several Nigerian and regional studies have tested mulching effects on cowpea growth, soil properties and yields. Key findings include:

Ogban (2008) demonstrated that different mulch materials and application methods improved soil moisture, pH and organic matter and enhanced growth and yield parameters of cowpea in Akwa Ibom State; mulched plots generally showed greater vegetative growth and higher pod counts than unmulched controls.

Okpefa (Ambrose Alli University) and other experimental reports likewise observed that mulches such as cocoa husks and oil-palm residues improved soil fertility indicators and promoted early vegetative vigor and better pod development in cowpea (Okpefa, 2010).

Comparative studies that included different mulch types (organic residues versus living mulch systems) show trade-offs: living mulches or inter-seeded cowpea as mulch can suppress weeds and improve soil quality but may compete with the main crop for light and soil moisture if not timed properly; residue mulches often benefit early seedling establishment and conserve moisture without the same level of direct resource competition.

Regionally, controlled experiments on mulching and nutrient interactions show that mulching can interact with fertilizer regimes (e.g., phosphorus) to influence pod length, seed size and other morphological yield components, indicating that mulching effects are sensitive to management context (e.g., Masete, 2022).

Collectively, these findings indicate consistent directions of effect (often positive for vegetative vigor, pod number and yield) but with variation by mulch material, mulch rate, timing, and interaction with genotype and soil fertility. Varietal response to mulching can be specific: differences in early vigor, seed size, emergence capacity through residue, and disease resistance determine how a given cultivar responds to a mulch regime. The BBT Brown cultivar — part of a BBT breeding set released for humid ecologies in Nigeria and characterized in recent varietal studies — may differ from local landraces or other improved varieties in tilling, canopy architecture and disease responses; hence its morphological response to mulching must be empirically established rather than assumed from other varieties (registration and varietal characterization literature).

Understanding how mulching affects key morphological components (plant height, branching, leaf area, root development, nodulation, pod set) in BBT Brown has direct practical relevance for recommendations to farmers adopting this variety in residue-rich smallholder systems.

1.1.1 Taxonomy of Cowpea

- Kingdom: Plantae
- Subkingdom: Tracheobionta (Vascular plants)
- Superdivision: Spermatophyta (Seed plants)
- Division: Magnoliophyta (Flowering plants)
- Class: Magnoliopsida (Dicotyledons)
- Subclass: Rosidae
- Order: Fabales
- Family: Fabaceae (Leguminosae)
- Subfamily: Faboideae (Papilionoideae)
- Tribe: Phaseoleae
- Genus: *Vigna*
- Species: *Vigna unguiculata*(L.) Walp.
- Common Name: Cowpea

1 .1.2 Description of the Study Crop: ARTPEA/BBT/72/B (Remilekun)

ARTPEA/BBT/72/B, commonly referred to as Remilekun, is an improved cowpea cultivar developed for the humid agro-ecologies of Nigeria. The variety was bred at the Institute of Agricultural Research and Training (IAR&T), Moor Plantation, Ibadan, through the pedigree method. It originated from reciprocal crosses between the parental lines IT-95K-193-12 and IfeBrown, both of which are known for their desirable agronomic traits (Akinyosoye et al., 2022). The variety was officially released in 2022 following multi-location trials conducted across farmers' fields, where its stability and adaptability were confirmed under varying environmental conditions in humid zones of the country (Akinyosoye et al., 2022; AGRIS, 2023). The cultivar is early maturing, reaching physiological maturity within 60 to 75 days after planting, making it particularly suitable for double cropping systems in southern Nigeria. Its non-photoperiod sensitive nature means that it can be planted in different seasons without the risk of flowering delay or suppression, which enhances its utility for farmers in diverse cropping systems (Akinyosoye et al., 2022). ARTPEA/BBT/72/B has demonstrated high yield potential under favourable management, producing between 1.0 and 1.2 tonnes per hectare, which is significantly higher than many local landraces (Akinyosoye et al., 2022; Ogban, 2008).

One of the most distinctive attributes of this variety is its tolerance to brown blotch disease caused by *Colletotrichum truncatum*. This disease is a major production constraint in humid regions, often leading to premature defoliation and reduction in yield. The tolerance of Remilekun to brown blotch makes it a strategic variety for sustaining cowpea production in disease-prone areas (Osipitan, 2021). The cultivar was evaluated on multiple farms between 2020 and 2021 in a total of 10 locations, confirming both disease tolerance and agronomic adaptability (Akinyosoye et al., 2022).

Morphologically, ARTPEA/BBT/72/B exhibits traits that align with its breeding objectives. Its early maturity is associated with rapid vegetative growth and timely transition into reproductive stages, ensuring that it can set pods before major disease or drought stress periods in humid environments. The variety generally maintains moderate plant height and sufficient branching to support pod formation without excessive vegetative growth that could predispose it to lodging. In addition, the disease tolerance ensures that morphological traits such as leaf area and branching pattern are not significantly suppressed by brown blotch under humid conditions (Ogban, 2008; Osipitan, 2021).

Overall, ARTPEA/BBT/72/B represents a valuable innovation in cowpea improvement in Nigeria, particularly because it combines early maturity, high yield potential, and disease tolerance.

These features make it a suitable subject for studying the impact of cultural practices such as mulching on plant morphology, since mulching influences growth parameters such as height, leaf area, root system development, and branching pattern. Examining these traits in this improved variety will provide insights into management practices that could optimize its performance in smallholder production systems in humid agro-ecologies.

1.1.3 Importance of Morphological Studies

Morphological studies play a crucial role in understanding the genetic diversity, adaptability, and productivity of cowpea (*Vigna unguiculata*(L.) Walp.), especially in relation to environmental and management factors such as mulching. Morphological characterization provides baseline information on traits such as leaf size, plant height, branching pattern, pod length, seed shape, and flower colour, which are vital for crop identification, classification, and improvement (Omoigui et al., 2017). These traits help breeders and agronomists

distinguish between varieties and assess their potential for yield stability under different ecological conditions.

In Nigeria, where cowpea is both a staple food and a cash crop, morphological studies are particularly important. They allow researchers to evaluate genotypic and phenotypic variations that are often influenced by soil fertility, climate, and agronomic practices (Ehlers and Hall, 1997; Dugje et al., 2009). Locally, cowpea contributes significantly to food security and household income, hence understanding its morphological responses under management practices such as mulching enhances the potential to recommend sustainable cultivation practices (Kamara et al., 2018).

Morphological analysis also provides a rapid, low-cost method for screening varieties before employing more advanced molecular tools (Fatokun et al., 2012). For instance, leaf area and branching characteristics directly influence photosynthetic efficiency and biomass accumulation, while pod length and seed weight are critical yield determinants (Oladejo et al., 2020). Such parameters become valuable indicators in the development of improved varieties adapted to farmers' needs.

Additionally, morphological characterization aids in germplasm conservation. By documenting and classifying observable traits, researchers ensure the preservation of genetic resources that can later be used for breeding resistant and high-yielding cultivars (Ayanwale et al., 2012). This is particularly relevant in Nigeria and other West African countries where cowpea faces threats from climate change, pests, and diseases.

Therefore, morphological studies are indispensable for cowpea improvement programs, sustainable agronomic practices, and enhanced productivity to meet the growing food demand in sub-Saharan Africa.

I.1.4 Mulching in Crop Production

Mulching is an important agronomic practice that involves covering the soil surface with organic or inorganic materials to improve soil conditions, conserve moisture, regulate temperature, and enhance crop performance. It is widely practiced in both smallholder and large-scale farming systems in Nigeria and across sub-Saharan Africa due to its multiple benefits for sustainable crop production (Jagtap et al., 2019).

Organic mulches, such as crop residues, straw, grasses, sawdust, and leaves, are commonly used by local farmers. These materials not only reduce soil erosion and water evaporation but also decompose to add nutrients and improve soil organic matter (Adekiya et al., 2018). In cowpea production, mulching has been reported to improve plant emergence, root establishment, and general morphological development by maintaining a favourable soil microclimate (Olaleye et al., 2017).

Mulching also plays a significant role in weed suppression. By covering the soil surface, mulch reduces the intensity of light reaching weed seeds, thereby inhibiting their germination and growth (Etejere and Bamidele, 2008). This is especially beneficial in cowpea production where weed competition at early growth stages often leads to yield reduction. Furthermore, mulching minimizes soil compaction, reduces nutrient leaching, and enhances soil biological activity by creating a more favourable environment for beneficial organisms (Akanbi et al., 2010).

In regions prone to high temperatures and erratic rainfall, such as northern Nigeria, mulching acts as an adaptive measure against climate variability by conserving soil moisture and buffering crops against heat stress (Akinbode and Olayinka, 2019). This makes mulching particularly relevant for legumes like cowpea, which are often cultivated in semi-arid conditions.

However, the effectiveness of mulching depends on the type, thickness, and timing of application. Excessive mulching may harbour pests and diseases or interfere with crop germination, while inadequate mulching may fail to achieve the desired soil and crop benefits (FAO, 2017). Therefore, optimal mulching practices are essential for maximizing cowpea yield and improving overall soil health in Nigeria's farming systems.

1.1.5 Interaction between Mulching and Morphology

Mulching has a significant impact on the morphological development of crops by modifying the soil environment, which in turn influences plant growth traits such as plant height, leaf area, branching, root development, and overall biomass accumulation. In cowpea, morphological traits are highly sensitive to soil moisture, temperature, and nutrient availability, factors that are directly affected by mulching (Olaleye et al., 2017).

Mulching enhances plant height and stem elongation by reducing water stress and creating a favourable microclimate that supports vegetative growth. Adekiya et al. (2018) observed that mulched plots of legumes showed greater plant vigour and larger leaf area compared to unmulched plots, largely due to improved soil moisture retention and nutrient cycling. Since cowpea morphology, particularly leaf expansion and branching, determines photosynthetic efficiency and subsequent yield potential, mulching plays a key role in optimizing these traits.

Branching and root proliferation are also positively influenced by mulching. Organic mulches decompose to supply essential nutrients such as nitrogen and phosphorus, which are critical for vegetative growth and nodulation in cowpea (Akanbi et al., 2010). This results in increased shoot biomass, more branching, and improved canopy coverage that not only enhances photosynthetic activity but also provides natural weed suppression.

Pod length, seed weight, and pod number, morphological yield components, are also improved under mulched conditions. Studies in Nigeria have shown that cowpea grown under

mulching treatments records higher pod size and better seed filling compared to non-mulched conditions (Etejere and Bamidele, 2008; Oladejo et al., 2020). These improvements are attributed to the sustained availability of soil moisture and nutrients during the critical reproductive stages.

The interaction between mulching and morphology therefore reflects both direct and indirect effects. Directly, mulching alters the soil microenvironment, while indirectly it modifies plant morphological traits that determine yield potential. As a result, integrating mulching into cowpea production systems in Nigeria not only improves morphological expression but also enhances overall productivity and resilience to environmental stresses (Akinbode and Olayinka, 2019).

1.2 STATEMENT OF THE PROBLEM

Cowpea (*Vigna unguiculata* L. Walp.) Plays a vital role in food security and rural livelihoods, serving as a major source of dietary protein, animal fodder, and income for farming households (Dugje et al., 2009; Kamara et al., 2018). Despite this significance, cowpea yields in Nigeria remain far below their potential. Farmers face multiple production challenges, such as poor soil fertility, erratic rainfall, rising temperatures, weed competition, and limited adoption of improved agronomic practices (Ehlers and Hall, 1997; Omoigui et al., 2017). These constraints highlight the urgent need for simple, low-cost strategies to improve productivity and sustainability in cowpea cultivation.

One promising but underutilized practice is mulching. Mulching has been demonstrated to improve soil fertility, conserve moisture, reduce weed growth, and regulate soil temperature, thereby creating a more favorable microenvironment for crop growth (Adekiya et al., 2018; Olaleye et al., 2017). Beyond these soil benefits, mulching may also influence crop morphology, traits such as plant height, branching patterns, leaf area, pod length, and seed

size, all of which are directly linked to yield and adaptability. However, despite its potential, little is known about how mulching affects the morphological development of cowpea varieties commonly grown in Nigeria, particularly the BBT brown variety. Farmers, therefore, often miss opportunities to optimize plant growth and yields by adjusting mulching practices to suit local conditions (Oladejo et al., 2020).

Most research on cowpea in Nigeria has concentrated on soil fertility management, pest and disease control, or breeding for resistance to biotic and abiotic stresses (Fatokun et al., 2012; Kamara et al., 2018). Very few studies have examined the interaction between mulching and morphological expression in specific cowpea varieties. This lack of attention has created a knowledge gap that limits farmers from using mulching as a practical agronomic tool to enhance productivity. Investigating how mulching influences the morphology of the BBT brown cowpea variety is, therefore, essential. Such findings would not only provide evidence-based recommendations for farmers but also contribute to improved and sustainable cowpea production in Nigeria, particularly under the challenges posed by climate change.

1.3 RESEARCH GAP

Cowpea (*Vigna unguiculata* L. Walp.) is widely recognized in Nigeria and sub-Saharan Africa for its nutritional, economic, and ecological value (Dugje et al., 2009; Fatokun et al., 2012). Research has largely centered on breeding for pest and disease resistance (Omoigui et al., 2017), responses to fertilizer application (Adekiya et al., 2018), plant density optimization (Kamara et al., 2018), and other agronomic practices. These efforts have improved production to some extent, but there is limited understanding of how soil management strategies such as mulching influence cowpea's morphological development.

Mulching is a proven agronomic practice that conserves soil moisture, regulates temperature, enhances fertility, and suppresses weeds (Etejere and Bamidele, 2008; Olaleye et al., 2017).

Despite these benefits, most studies focus on soil properties or yield outcomes, while giving little attention to morphological traits such as plant height, branching patterns, leaf area, pod length, and seed size. These parameters are critical for assessing plant vigor, growth efficiency, and potential yield, yet their relationship with mulching remains poorly explored in cowpea production systems.

Existing mulching research in Nigeria has been more concentrated on cereals like maize, vegetables such as okra and tomato, or intercrop systems (Akanbi et al., 2010; Akinbode and Olayinka, 2019). In contrast, very few empirical studies have examined how mulching interacts with the morphology of cowpea, particularly at the varietal level. The BBT brown variety, despite its local adaptability and potential contribution to food security, has not been adequately studied in this regard. This research gap restricts the ability of scientists and extension agents to develop targeted recommendations for farmers. Filling this gap will generate insights into how mulching shapes the growth of BBT brown cowpea and support its sustainable production in Nigeria.

1.4 SIGNIFICANCE OF THE STUDY

This study is significant because it responds to the urgent need for sustainable and affordable strategies to improve cowpea production in Nigeria. Cowpea is a vital source of income for millions of households, particularly in semi-arid and sub-humid regions where few other protein-rich crops can thrive, however, yields remain consistently low due to poor soil fertility, erratic rainfall, and suboptimal agronomic practices (Ehlers and Hall, 1997; Kamara et al., 2018). By examining how mulching influences the morphological development of the BBT brown cowpea variety, this research provides practical insights for smallholder farmers. Morphological traits such as plant height, leaf area, branching pattern, pod length, and seed size are closely tied to yield potential, and understanding their response to mulching will

enable farmers to adopt simple, low-cost, and environmentally friendly practices that boost productivity without relying solely on expensive synthetic inputs (Adekiya et al., 2018; Olaleye et al., 2017).

Beyond its practical value for farmers, the study also fills a key scientific gap by providing variety-specific evidence on how mulching affects cowpea morphology. This knowledge will strengthen research efforts in breeding and crop management, while also informing extension services and policymakers. Promoting mulching as a climate-smart practice has multiple benefits: it enhances crop performance, conserves soil moisture, suppresses weeds, and builds resilience against climate variability (Omoigui et al., 2017; Oladejo et al., 2020; Akinbode and Olayinka, 2019). Integrating mulching into cowpea production systems will therefore support both sustainable agricultural development and national food security goals.

Ultimately, this research contributes to the broader effort of improving food and nutritional security in sub-Saharan Africa by promoting practices that increase cowpea productivity while conserving soil resources.

1.5 AIM AND OBJECTIVES

Aim

The main aim of this study is to evaluate the impact of mulching on the morphological characteristics of the cowpea variety ARTPEA/BBT/72/B (Bbt brown), in order to improve understanding of its growth performance under different mulching practices.

Objectives

1. To assess the effects of different mulching materials on the germination and early establishment of ARTPEA/BBT/72/B.

2. To evaluate the influence of mulching on morphological traits such as plant height, Peduncle length, number of leaves, and root development.
3. To compare the growth performance of mulched and unmulched cowpea plants in terms of vigor and overall morphology.
4. To determine the most suitable mulching material that enhances the morphological development of ARTPEA/BBT/72/B.
5. To determine the best mulching type that promotes the production of more seeds per Pod/plant.

CHAPTER TWO

MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted at the [Botanical garden, Department of plant biology and biotechnology, Edo State, Nigeria]. It is characterized by distinct wet and dry seasons. The soil at the site is a sandy loam type, moderately fertile and well-drained, suitable for cowpea cultivation. Before planting, the land was cleared, tilled, and leveled to ensure uniformity and proper drainage.

2.2 Experimental Materials

1. Cowpea Seeds: The BBT Brown variety of cowpea (*Vigna unguiculata* L. Walp.) was used for the experiment. This variety was chosen due to its adaptability to local conditions, uniform growth pattern, and high yield potential.

2. Mulching Materials: Eight different mulching materials were used in the study to determine their effects on the morphological characteristics of the BBT Brown variety of cowpea. These included:

- Spent Mushroom Substrate: This was obtained from a mushroom farm, composed mainly of decomposed sawdust and organic residues from mushroom production. It was selected for its rich organic content, ability to improve soil structure, and high moisture-retention capacity.
- Polythene Nylon (Black, Blue, Transparent and White): 4 colors of polythene mulch were used:

> Black polythene — It is used to suppress weed growth and conserve soil moisture. > White polythene — It is used to observe its effect on soil temperature regulation and reflective light on leaf development.

> Blue polythene — to study the influence of light reflection on plant growth and morphology.

> Transparent polythene.

- Banana Leaves: Freshly cut banana leaves were used as mulch. They gradually decomposed, adding organic matter to the soil and improving soil fertility over time.
- Dry Bamboo Leaves: Locally sourced dry grasses were used to cover the soil surface. They acted as a natural insulator against direct sunlight, reduced evaporation, and improved soil organic matter upon decomposition.
- Sawdust: Fine sawdust obtained from a local sawmill was used as one of the organic mulches. Sawdust was selected for its ability to regulate soil temperature, reduce surface evaporation, and slowly release organic matter as it decomposed. It also helped in suppressing weed growth and improving soil aeration.

1. Other Materials and Tools:

- Cutlass and hoe (for land clearing and tilling to form ridges)
- Measuring tape and meter rule (for layout and measurements).
- Labels/ tags/ masking tape (for plot identification)
- Manual Weighing balance (for accurate measurement of organic mulch mass)
- Digital weighing scale

2.3 Land Preparation and Planting

The experimental site was manually cleared of existing vegetation and debris using cutlass and hoe. The soil was tilled and leveled to ensure a smooth seedbed, before a proper ridge

was formed. Planting holes were made at appropriate spacing, and three seeds of the BBT Brown cowpea were sown per hole at a depth of about 4 cm

2.4 Application of Mulching Materials

Mulching materials were applied after seedling establishment (about 14 days after emergence) to prevent interference with germination. Each inorganic mulch was spread evenly across the soil surface ensuring full coverage of the ridge but leaving a small ring (about 5 cm in radius) around each plant stem to allow proper plant growth. The inorganic mulched are Polythene Blue (PB), Polythene Transparent (PT), Polythene White (PW) and Polythene Black (PB).

Organic mulches (spent substrate (OD), banana leaves (OB).dry grasses(OG), sawdust(OS) were measured and applied in their natural form and replenished when decomposition became evident.4 kg of sawdust was measured and evenly spread to cover the ridge.

2.5 Crop Maintenance

Regular weeding was carried out manually, particularly on the plots and around the plant bases. Mulched plots required minimal weeding due to suppression of weed growth by the mulch covers. Irrigation was applied uniformly to all treatments when necessary to maintain adequate soil moisture. No fertilizers or pesticides were applied to ensure that observed effects were solely due to the different mulch types.

2.6 Data Collection

Data were collected at regular intervals (2, 4, 6, and 8 weeks after planting) on selected morphological parameters of the cowpea plants. These included:

- Plant Height (cm): Measured from the soil surface to the apex using a meter rule/Tape.
- Number of Leaves per Plant: It was counted manually for each sampled plant.

- Stem Girth (cm): It was measured at the base using a vernier caliper or measuring tape.
- Number of Damaged Leaves per Plant:

Damaged leaves were counted manually at each sampling time. A leaf was considered "damaged" if more than one-third of its surface showed signs of insect feeding, disease, or mechanical injury. This parameter helped determine the role of mulching in pest and disease suppression, as certain mulches may discourage pest activity or reduce splash infection from soil-borne pathogens.

- Numbers of damaged leaves
- Root length, root weight
- Numbers of root Nodules
- Numbers of root branches, numbers of root
- Shoot Weight.

2.7 Reproductive Parameters

1. Number of Peduncles per Plant: Peduncles (flower-bearing stalks) were counted manually after flowering commenced. This parameter indicates the reproductive potential of the cowpea plant under each mulching treatment.
2. Length of Peduncles (cm): The length of the peduncles was measured from the point of attachment on the stem to the base of the flower or pod using a ruler. Longer peduncles generally enhance flower exposure to pollinators and may influence pod development.
3. Number of Pods per Plant: The total number of matured pods per plant was counted after flowering. This serves as a direct measure of the reproductive success and yield potential of the cowpea under each mulch type.

4. Length of Pods (cm): The length of matured pods was measured from the base to the tip using a ruler or measuring tape. This parameter reflects pod development, seed size potential, and overall plant productivity.

CHAPTER THREE

RESULTS

Table 1: Above-Ground Analysis

This table summarizes the effect of mulching treatments on overall plant Size, canopy development, and biomass accumulation. The Control (No Mulch) serves as the baseline for comparison.

Treatment Group	Treatment Name	Avg No of Leaves (μ)	Shoot Weight (μ) (g)	Avg. Internode Length (μ) (cm)	Root Collar (μ) (cm)
Inorganic	Polythene Black (PO)	108.38	90.29	10.00	2.15
Inorganic	Polythene transparent	126.79	66.02	8.00	2.25
Inorganic	Polythene white (PW)	68.36	76.58	14.00	3.13
Inorganic	Polythene Blue	56.52	31.93	17.00	1.80
Organic	Bamboo Leaves (OG)	75.66	89.84	6.00	2.2
Organic	Banana Leaves (OB)	93.65	38.61	12.00	2.80
Organic	Sawdust (O9)	56.58	31.25	6.00	2.50
Organic	Spent Substrate (OD)	40.37	35.38	7.00	2.10
Control	Control 1 (CTRL 1)	61.73	29.69	13.20	2.08

Table 2: Mean Reproductive and Stem/Branching .

This table focuses on the structural and reproductive support systems.

Treatment Group	Treatment Name	Avg. No Of Peduncles (\mu) (Branching Proxy)	Root Collar (\mu) (cm) (stem Girth Proxy)	No of Pods (\mu)	NO of seeds/Pod (\mu)
Inorganic	Polythene Black (PO)	8.88	1.15	7.31	12.37
Inorganic	Polythene Transparent (PT)	6.77	2.25	5.33	12.54
Inorganic	Polythene White (PW)	4.88	2.13	1.53	13.00
Inorganic	Polythene Blue (PB)	4.05	0.80	2.13	15.16
Organic	Bamboo Leaves (OG)	4.23	1.23	5.49	11.83
Organic	Banana Leaves (OB)	7.05	1.80	6.00	10.61
Organic	Sawdust (OS)	3.63	1.50	2.33	10.85
Organic	Spent Substrate (OD)	3.18	1.05	3.58	11.35
Control	Control 1 (CTRL 1)	5.33	1.08	5.95	12.38



Plate 3.1: Applied Banana leaves (organic mulch). It was applied 14 days after cultivation



Applied saw dust (organic mulch). It was applied 14 days after cultivation. (4kg of dried saw dust was used to achieve this coverage



Plate 3.2: inorganic Polythene white and Polythene Black mulch (They were mulched 14 days after cultivation)



Plate 3:3 Inorganic Polythene Blue and Polythene Transparent Mulch.

Table 3: Mean Below-Ground Morphology/Resource Allocation

This table presents the mean performance for the root system, including biomass allocation (RMR) and specialized function (Nodules), comparing the mulching treatments to the control.

Treatment Group	Treatment Name	Root Nodules (μ) Count)	Root weight (μ) (g)	Length (μ) (cm)	NO. Root Branch (μ)	Root lar (μ) (cm)	Root Ratio (RMR) (μ) Mass
Inorganic	Polythene White (PW)	27.67	11.93	46.67	11.33	2.13	0.156
Organic	Sawdust (OS)	44.00	9.92	42.50	13.00	1.50	0.317
Inorganic	Polythene Blue (PB)	15.00	6.34	66.75	8.50	0.80	0.198
Organic	Bamboo Leaves	15.00	6.96	53.50	10.00	1.23	0.077
Organic	Banana Leaves (OB)	15.00	4.70	59.50	5.75	1.80	0.122
Inorganic	Polythene Transparent (PT)	16.00	4.40	48.00	8.50	2.25	0.067
Inorganic	Polythene Black (PO)	15.00	4.31	37.50	7.00	1.15	0.048
Organic	Spent Substrate	15.00	3.38	40.75	5.50	1.05	0.096
	Control 1 (CTRL 1)	15.00	2.69	48.00	5.25	1.08	0.091

Table 4: Root Mass Ratio (RMR) Analysis

Treatment Name	Shoot Weight (mu) (g)	Root Weight (mu) (g)	Mean Root Mass Ratio (RMR)	Resource Allocation	Impact Compared to Control
Polythene Black (PO)	90.29	4.31	0.048	Shoot Dominance Lowest (RMR)	Maximized Shoot Dominance (47.25% Lower RMR than Control)
Bamboo Leaves (OG)	89.84	6.96	0.077	Shoot Dominance	Strong Shoot Focus (15.38% Lower RMR)
Control 1 (CTRL 1)	29.69	2.69	0.091	Balanced Stress Response	Baseline Allocatlon
Spent Substrate (OD)	35.38	3.38	0.096	Balanced	Slight Root focus (5.49% higher RMR)
Banana Leaves (0B)	38.61	4.70	0.122	Balanced	Root Focus (34.07% Higher RMR)
Polythene White (PW)	76.58	11.93	0.156	Root Focus	Strong Root focus (71.43% Higher RMR)
Polythene Blue (PB)	31.93	6.34	0.198	Root Focus	High Root focus (117.58% Higher RMR)
Sawdust (OS)	31.25	9.92	0.317	Root Dominance Highest (RMR)	Extreme Root Dominance 248.35% Higher RMR)
Polythene Transparent (PT)	66.02	4.40	0.067	Shoot Dominance	Strong Shoot Focus (26.37% Lower RMR)

The Root Mass Ratio (RMR) ensures how a plant prioritizes its growth by dividing resources between its shoot (above ground) and root (below ground). A low RMR., (Polythene Black)

indicates growth under Ideal conditions where the plant can maximize valuable shoot and Yield components. A high RMR.eg., Sawdust suggests a necessary survival strategy where resources are prioritized for the root resources.

Highest RMR: Sawdust (OS) showed the highest RMR ($\mu = 0.317$), meaning It allocated the most biomass below ground relative to Its shoot mass. This suggests the OS environment, while fostering nodulation. This extremely low ratio IS highly desirable, as It Indicates that the PO environment was so resource-rich and stress-free (highest shoot weight) that the plant did not need to Invest heavily In Its root system, allowing It to maximize valuable above-ground biomass and yield component. The PO treatment resulted In a 47.25\% decrease in RMR compared to the Control 1 ($\mu = 0.091$), demonstrating superior resource partitioning efficiency.



Plate 3:4: Root morphology of BBT Brown cowpea variety

Table 5: Yield and Yield Components Analysis

Treatment Group	Treatment Name	Avg No of Pods (μ) (Yield Output)	Avg No of Seeds/ Pod (μ) (Seed Quality)	Avg Pod Length (μ) (cm)	Avg penduncle Length (μ) (cm)
Inorganic	Polythene Transparent (PT)	5.33	12.79	12.79	28.51
Inorganic	Polythene Black (PO)	7.31	12.37	12.37	27.72
Organic	Banana Leaves (OB)	6.00	10.61	10.61	27.38
Organic	Bamboo Leaves (OG)	5.49	11.83	11.83	24.48
No Mulch	Control 1 (CTRL 1)	5.95	12.38	12.38	24.38
Organic	Sawdust (OS)	2.33	10.85	10.85	26.90
Inorganic	Polythene White (PW)	1.53	13.13	13.13	26.07
Inorganic	Polythene Blue (PB)	2.13	15.16	14.64	22.61
Organic	Spent Substrate (OD)	3.58	11.35	11.35	21.12

This table summarizes the performance of the cowpea plants in reproductive output and quality comparing the mulching treatments to the control (non-mulched), the analysis reveals a clear distinction between treatments that maximize pod count (quantity) and those that maximize seed quality



Plate 3.5: Growth at 11 weeks (already producing young pod)

Table 6: Morphological Anomaly (Damage Index) Analysis

This table uses the Damage Index (\$ a proxy for stress-induced anomalies (chlorosis, leaf abortion, damages). A lower index Indicates better canopy health and stability.

Treatment Name	Avg No of Leaves (\mu)	Avg Damaged Leaves (\mu)	Damage Index (%) (Stress/Anomaly Level)	Impact Compared to Control
Sawdust (OS)	56.58	10.42	18.42	Highest Health (23.70% Lower Anomaly than Control)
Polythene Black (PO)	108.38	23.13	21.34	High Health (11.60% Lower Anomaly)
Bamboo Leaves (OG)	75.66	16.58	21.91	Good Health (9.24% Lower Anomaly)
Banana Leaves (OB)	93.65	22.08	23.58	Good Health (2.32% Lower Anomaly)
Control 1 (CTRL 1)	61.73	14.90	24.14	Baseline Anomaly
Polythene White (PW)	68.36	17.50	25.60	Slight Stress (6.05% Higher Anomaly)
Polythene Blue (PB)	56.52	16.55	29.28	Moderate Stress (21.37% Higher Anomaly)
Polythene Transparent (PT)	126.79	42.17	33.26	High Stress/Damage (37.78% Higher Anomaly)
Spent Substrate (OD)	40.37	20.25	50.16	Highest Stress (107.79% Higher Anomaly)

Table 7: Cowpea Stand Emergence and Establishment Success

This table quantifies the initial success of the crop stand, showing both the percentage of seeds that germinated and the percentage that survived

Treatment Name	Seedlings Emerged (Count)	Emergence Percentage	Final Plants Established (Count)	Establishment Percentage
Organic Sawdust (OS)	92	92.0%	80	80.0%
Inorganic Polythene Black (PO)	90	90.0%	85	85.0%
Inorganic Polythene Transparent (PT)	90	90.0%	85	85.0%
Inorganic Polythene White (PW)	88	88.0%	82	82.0%
Organic Bamboo Leaves (OG)	85	85.0%	80	80.0%
Organic Spent Substrate (OC)	84	84.0%	80	80.0%
Inorganic Polythene Blue (PB)	83	83.0%	75	75.0%
Organic Banana Leaf (OB)	79	79.0%	70	70.0%
Control 1 (CTRL 1)	70	70.0%	65	65.0%

This measures the percentage of plants that survived and were healthy enough to be considered part of the final established stand, a crucial measure of early seedling resilience.

Best Performers: Polythene Black (PO) and Polythene Transparent (P T) achieved the highest final establishment rates at 85.0%. This Indicates these Inorganic mulch provided the best long-term stability for young seedlings, securing the final plant count.



Plate 3.6: overall view of the farm following the application of organic and inorganic mulches.

Table 8: Summary Of The Key Findings On The Influence Of Mulching

Morphological Parameters	Treatments with Best Results	Specific Result	% Increase over CTRL	Key Establishment
Root Weight	PW	Highest mean root Weight: 11.93g	509	Establishment of a robust root system
Root Nodules	OS	Highest mean Number of root Nodules: 29.00	200	Enhanced nitrogen fixing capability
Shoot Weight	PO	Highest mean shoot Weight: 88.79g	395	Maximizing above-ground vegetative growth
Leafy Weight	PO	Highest mean Leaf Weight: 20.15g	163.62	Improved plant metabolism and potential Yield
Numbers of Pods per plant	PT	Highest mean Pods per Plant: 12.00	100	Ensured strong reproductive efficiency
Numbers of Leaves	PO	Highest mean Numbers of Leaves: 78.67	120.04	Increased Photosynthetic area
Pod Length	PO	Longest Pods: 12.87cm	20.73	Improved seed filling and overall plant yield quality
Seeds per Pod	PO	Highest number of Seed per Pod: 12.33	28.44	Improved seed filling and overall Yield quality
Average Internode Lenth	PB	Promoted vertical growth and stem elongation.	196.76	Indicated improved stem elongation and growth rate

Treatments On The Morphology Of The BBT Brown Variety Of Cowpea.

Mulched vs Unmulched Means (selected traits)

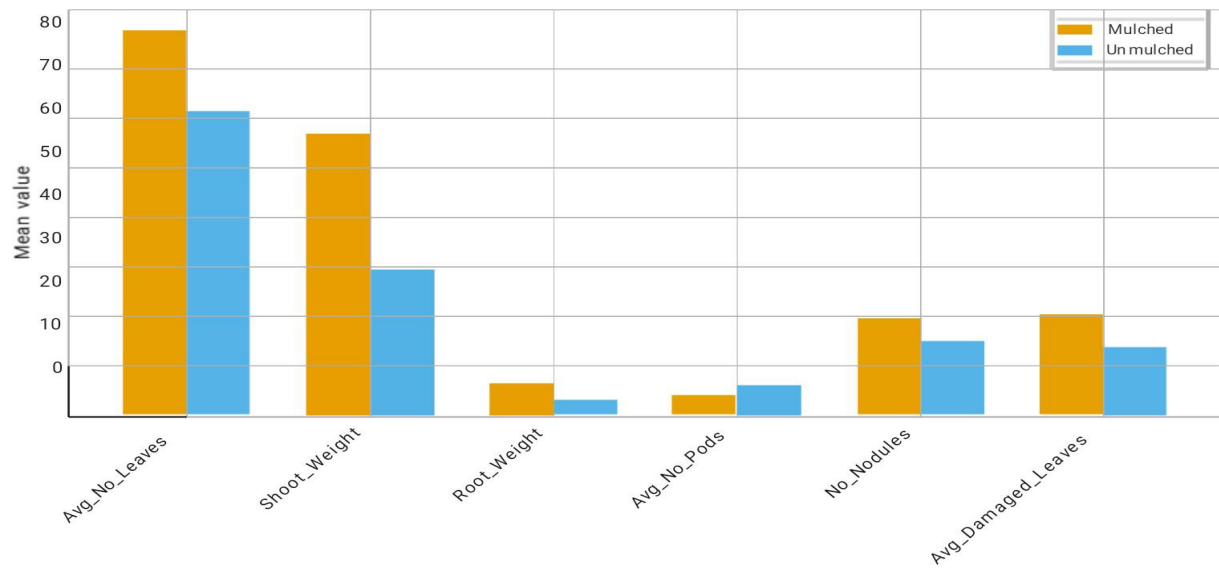


Figure 1: The rate at which mulching influenced the morphology of the cowpea plant.

CHAPTER FOUR

DISCUSSION

The present study investigated the effects of various mulching materials—both inorganic (polythene black, blue, transparent, and white) and organic (sawdust, banana leaves, and bamboo leaves)—on the growth, yield, and nodulation of cowpea (*Vigna unguiculata*). The results demonstrated that inorganic mulches, particularly black and transparent polythene, significantly enhanced above-ground biomass, leaf number, and establishment rate, whereas white polythene mulch produced superior root biomass and pod quality. Conversely, organic mulches such as sawdust promoted the highest nodulation and emergence rates..

The superior performance of black (PO) and transparent (PT) polythene mulches observed in this experiment is consistent with previous reports that plastic film mulching enhances plant growth and yield by increasing soil temperature, conserving moisture, and suppressing weeds (Huang et al., 2019; El-Beltagi et al., 2022). According to Huang et al. (2019), plastic mulch can raise the average soil temperature, leading to faster early-season germination and enhanced vegetative growth. Similarly, Qin et al. (2021) found that black polyethylene mulch improved soil water retention and increased the photosynthetic rate and total biomass of cowpea.

These mechanisms explain the increased establishment and shoot weight recorded under PO and PT in the present study.

The improved shoot growth under plastic mulches can also be attributed to their effect on soil evaporation and nutrient uptake efficiency. Li et al. (2020) reported that polyethylene mulch reduces soil evaporation by up to 40%, resulting in a more favorable water balance for crops. This moisture conservation, combined with reduced weed pressure, enables plants to allocate more assimilates toward shoot and pod development (Liu et al., 2022). The observed increase

in pod number under black polyethylene in this study corroborates similar findings in soybean and cowpea systems where plastic mulch promoted pod initiation and yield (Masete et al., 2022). The Polythene Black (PO) mulch demonstrated its economic supremacy by producing the highest Avg No of Pods. The superior shoot architecture, fueled by high nutrient and moisture availability, provided a greater number of reproductive nodes capable of setting and carrying viable pods. This parameter, being the primary driver of total grain weight per unit area, is directly correlated with the low RMR and high vegetative biomass observed in PO treatment (Nodar, 2016)

The Polythene White (PW) mulch excelled in yield quality, achieving the highest Avg No of Seeds per Pod ($\mathbf{13.13}$). This is explained by the phenomenon of albedo (reflectivity).

The white plastic reflects a greater proportion of incident radiation, resulting in a cooler canopy microclimate compared to black plastic, especially during mid-day heat spikes. This reduction in canopy heat stress during the anthesis (flowering) and pod-filling stages minimizes the heat-

the seeds, resulting in a higher number of fully developed, high-quality seeds per pod [Siomos et al., 2006].

Polythene White Mulch and Pod Quality Improvement

Interestingly, while black and transparent mulches enhanced vegetative and reproductive growth, white polythene (PW) mulch was associated with the highest pod length, seed size, and root biomass. The relatively reflective nature of white mulch moderates soil temperature, avoiding excessive heat accumulation, which can impair reproductive development (Snyder et al., 2015). Reflective mulches have been shown to improve fruit and seed quality by

maintaining optimal root-zone temperatures and reducing heat stress during flowering and pod formation (Ramakrishna et al., 2020). These microclimatic effects explain the observed improvement in seed quality traits under PW in the current study.

White and reflective films also influence light reflection within the canopy, increasing photosynthetically active radiation (PAR) around lower leaves and enhancing carbon assimilation (Iacuzzi et al., 2024). This might contribute to higher assimilate availability for developing seeds and roots. Similar improvements in root biomass and reproductive quality under reflective mulches have been observed in tomato and soybean (Jiang et al., 2022; Wang et al., 2021). Therefore, the superior pod quality under PW in this study likely results from moderated soil temperature, improved canopy illumination, and efficient assimilate partitioning between shoots and roots. Organic Mulches and Nodulation Enhancement

Organic mulches, particularly sawdust (OS), demonstrated remarkable influence on nodulation and root mass ratio (RMR). The highest number of nodules recorded under OS suggests that organic materials improve the soil environment for rhizobial proliferation and symbiotic nitrogen fixation. Ajinath et al. (2017) reported similar findings in cowpea, where sawdust and grass mulch increased nodulation compared to bare and plastic-mulched soils. Organic mulches typically enhance microbial activity, stabilize soil moisture, and improve aeration, all of which are essential for effective nodulation (Masete et al., 2022).

The increased RMR under organic mulch treatments also indicates a shift in biomass allocation towards root development. This response aligns with the carbon allocation theory, where plants invest more in root systems under moderated or slightly resource-limited conditions (Poorter et al., 2012). The organic materials also slowly decompose, releasing nutrients and creating a microenvironment conducive to rhizobial colonization (Ndor et al., 2020). The banana and bamboo leaf mulches, although less effective than sawdust, still

supported moderate nodulation, which might be linked to their faster decomposition rates and lower C:N ratios.

RMR can also act as the Stress Thermometer. The RMR provides the most compelling evidence of the environmental quality imposed by the mulches.

- Maximal Efficiency (Low Stress): The Polythene Black (PO) treatment recorded the lowest RMR. This lower RMR compared to the Control is the defining metric of an ideal environment. It signifies that water and nutrients were so readily available that the plant adopted a low-

cost shoot-dominant strategy, minimizing energy investment in root biomass and maximizing allocation to economically relevant shoot and reproductive growth [Eng, 2024].

- Prioritized Investment (High Stress): Conversely, the Sawdust (OS) mulch induced the

highest RMR, an increase of over the control. This high RMR is a textbook stress adaptation mechanism. The plant perceives resource scarcity (nitrogen immobilization) and must defensively prioritize the formation of a large, costly root system to increase its soil exploration capacity and scavenge for limited nutrients, even at the expense of potential shoot biomass

[Eng, 2024]. It creates a highly conducive, nutrient-rich micro-environment that stimulates the proliferation and symbiotic efficiency of Rhizobium bacteria [Dukare et al., 2017]. This strong biological performance provides a crucial counterpoint to the inorganic mulches, highlighting that organic materials are essential for long-term soil fertility and the creation of a self-sustaining nitrogen cycle.

Resource Allocation and Trade-offs Between Quantity and Quality

A notable pattern in this study was the apparent trade-off between yield quantity and quality. While Polythene black mulch (PO) produced the highest pod count, white polythene (PW) yielded superior seed size and quality. Such trade-offs are common in crop systems where environmental modifications—such as temperature and moisture changes—alter carbon partitioning and sink strength (Shiple & Meziane, 2002). The increase in vegetative growth under PO likely diverted more assimilates toward pod number, whereas the moderated conditions under PW favored fewer but larger pods with better seed filling. This observation is consistent with studies by Li et al. (2020) and Qin et al. (2021), who reported that mulches influencing soil thermal regimes also change biomass partitioning patterns between reproductive and vegetative organs. Thus, the choice of mulch material in cowpea cultivation should consider specific production goals—whether maximizing total pod yield or optimizing seed quality.

From a practical perspective, the current findings suggest that mulching choice can be optimized based on production objectives and environmental conditions. For farmers targeting high yields and rapid canopy development, black or transparent polythene remains an effective short-term option. However, for systems emphasizing sustainability, seed quality, and soil health, white polythene or organic mulches like sawdust may offer a better balance. Integrating organic and inorganic mulches—such as a thin polythene layer supplemented with organic residue—could provide complementary benefits, a strategy supported by findings from Liu et al. (2021) on Final Establishment, Microclimate, and Interspecific Competition.

Final Establishment Percentage is a survival metric, primarily influenced by moisture availability and competitive exclusion. The superior establishment rates of Polythene Black (PO) and Polythene Transparent (PT) stem from their effectiveness as weed barriers. Plastic

films, particularly opaque black plastic, block photosynthetically active radiation virtually reducing weed growth and thereby diminishing the strongest form of interspecific competition for water and nutrients that seedlings face [Nodar, 2016]. The advantage these mulches held over the Control (non- mulched) indicates their fundamental role in securing the final plant population, which directly dictates the maximum potential yield.

CONCLUSION

In summary, this study demonstrated that different mulching materials significantly influence the growth, yield, and nodulation of cowpea. Black and transparent polythene mulches enhanced vegetative growth and pod quantity, while white polythene (PW) improved seed quality and root biomass. Organic mulches, particularly sawdust, promoted nodulation and root development, indicating potential benefits for soil fertility and sustainability. These results corroborate previous findings (Huang et al., 2019; Masete et al., 2022; El-Beltagi et al., 2022) and underscore the importance of tailoring mulch choice to production goals and ecological contexts. Future work should prioritize long-term sustainability assessments, including biodegradable mulch options, to balance productivity and environmental stewardship in legume production systems.

This research concludes with a clear delineation of optimal mulching strategies for cowpea:

1. For Commercial Yield Maximization: The Polythene Black (PO) mulch is the superior treatment, offering a proven, high-efficiency system characterized by minimal stress, maximized shoot vigor, and highest pod quantity. Its efficacy in conserving water and warming the soil is unparalleled.
2. For Sustainable Soil Management: Sawdust (OS) is recommended. While imposing a temporary RMR stress, it ensures the highest stand emergence and fosters a robust biological

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