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The Impact of Organic and Inorganic Mulch on Soil Temperature, Moisture Retention, and Weed Control in Bell Pepper (*Capsicum annuum*) Cultivation

[1] Ezra Nampasa, [2] Lumamba Sydney

[1] BA, Science in Agriculture, Information and Communications University, Lusaka, Zambia

[2] Department of Agriculture and Environmental Sciences, Information and Communications University, Lusaka, Zambia

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Corresponding Author: **Ezra Nampasa**

Abstract

Mulching is a vital agronomic practice that positively influences soil properties including soil temperature, moisture-holding capacity, and weed suppression thereby improving crop growth and productivity. In the cultivation of bell pepper (*Capsicum annuum*), upholding favorable soil temperature, conserving moisture, and suppressing weeds are vital for optimal plant health and yield. Various mulching materials both have different impacts on soil quality and resultant plant growth. The study aimed to determine the effects of organic and inorganic mulching materials on soil temperature regulation, moisture retention, and weed control in the cultivation of bell pepper. A field experiment was established in a Complete Randomized Block Design (CRBD) with three Treatments namely: Inorganic mulch (T1), organic mulch (T2) and an untreated control (T3). Data on soil temperature, soil moisture, and weed population density were recorded and later analyzed statistically for treatment effects through ANOVA using SPSS-24. Results showed that inorganic mulch (plastic) was more effective in alleviating soil temperature, reducing weed populations, and enhancing soil moisture conservation than organic mulch (grass). Both mulching types outperformed the untreated control in improving soil conditions and weed management. Although inorganic mulch outperformed its organic counterpart, both forms of mulching were beneficial for soil moisture conservation, temperature regulation and weed suppression. The findings contribute useful information towards practical and cost effective alternative for enhancing soil health under smallholder production system.

Keywords: Agronomic Practices, Bell Pepper, Smallholder Farming, Soil Health**,** and Sustainable Farming

1. Introduction

Bell pepper (Capsicum annuum) is an important crop for nutrition and income, rich in vitamins C, A, E, antioxidants, fiber, and phytochemicals (Sharma and Singh, 2021) [34]. It supports livelihoods and is a high-value crop grown globally, with major producers including China, Mexico, and the United States. Belonging to the Solanaceae family, it is cultivated for fresh use and processing (Bosland and Votava, 2012) [5]. Its culinary versatility and nutritional benefits have increased demand in local and international markets (Tripathi *et al*., 2018) [39]. Beyond nutrition, bell pepper contributes to agricultural diversification and employment (Ali and Kelly, 2015) [2]. Rising health awareness has further expanded its cultivation across diverse agro-ecological zones (Sreelathakumary and Rajamony, 2004) [35]. However, successful production depends on factors such as temperature, soil quality, moisture, and pest control. Bell pepper grows best in warm, frost-free conditions of 20–30°C (Gude *et al*., 2017) [12] and prefers well-drained loamy soils rich in organic matter to avoid waterlogging (Ndangui *et al*., 2019) [24]. Maintaining consistent moisture is essential because both drought and excess water reduce yield and quality (Rahman *et al*., 2014) [29]. Moisture fluctuations can disrupt nutrient uptake and cause flower drop or fruit cracking (Anjum *et al*., 2011) [3]. Soil degradation from poor practices and continuous cropping further limits productivity. Moisture-retention methods such as mulching, organic matter application, and drip irrigation help stabilize soil conditions, especially during dry or cold periods (Sandal and Acharya, 1997) [33]. Loss of nutrients like N, P, and K leads to weak growth and fruiting (Agbna *et al*., 2017) [1], while excessive chemical inputs cause pollution and soil acidification, making sustainable soil fertility management crucial (Das *et al*., 2018) [6]. Weed infestation also reduces pepper yields by competing for nutrients, water, and light, while acting as hosts for pests and diseases (Ramesh and Rao, 2015) [30]. Integrated weed management including mulching, manual weeding, and selective herbicides can minimize weed pressure and environmental impacts (Hussain *et al*., 2017) [16]. Organic mulches improve soil temperature, moisture, and structure, while inorganic mulches like polyethylene films effectively reduce weed growth and evaporation, though they raise disposal concerns.

Water scarcity is another challenge, especially in semi-arid and tropical regions with irregular rainfall (Gebremedhin *et al*., 2021) [10]. Efficient irrigation systems such as drip irrigation enhance water use and yield while reducing evaporation. Complementary strategies like rainwater harvesting and soil-moisture conservation help buffer dry spells. Pest and disease management is equally important; insects such as aphids, thrips, and whiteflies spread viruses like CMV and TMV (Rashid *et al*., 2016) [31], while fungal diseases such as Phytophthora blight and anthracnose cause major losses (Islam *et al*., 2018). Integrated Pest Management (IPM), using biological control, resistant varieties, and cultural practices, reduces reliance on chemicals (Khan and Rahman, 2020) [19]. Climate change adds further risks through temperature fluctuations, irregular rainfall, and emerging pest and disease strains, making adaptive strategies essential (Rosenzweig *et al*., 2014) [32].

Given these challenges, sustainable practices are vital for productivity and environmental conservation. Selecting suitable mulching materials based on climate, crop type, availability, and cost is important. Despite known benefits, research on how different mulches affect bell pepper growth, yield, and soil health remains limited. As issues like soil degradation, water scarcity, and weed pressure increase, mulching presents an eco-friendly, sustainable option consistent with reduced chemical use and improved water conservation (Teame *et al*., 2017) [37]. Therefore, evaluating organic and inorganic mulches for their effects on soil temperature, moisture retention, and weed control in bell pepper production is highly relevant. This study aims to provide insights that enhance crop management, improve yields, and promote sustainable agriculture, contributing to food security and long-term agricultural resilience.

Statement of the Problem

In Zambia, sustainable agriculture is facing serious challenges mostly due to unpredictable rainfall, and deteriorating soil health. Smallholder farmers, who contribute the most to household food security, struggle with the challenges of water stress, which are exacerbated by extreme temperature shifts resulting in compromised crop yields. According to Noriss and Kogan (2000) [25], reviewed that weeds can harbor insects and pathogens, increasing pest infestation risks. These challenges are destructive for valued subsistent vegetables such as tomatoes and eggplants, requires consistent moisture and highly sensitive to weed competition. This is particularly severe in regions with sandy or degraded soils, where effective water conservation and weed management are essential for successful farming (Zulu *et al*, 2018) [42].

Objective of the study

Main Objectives

The aim is to evaluate and compare the impact of organic and inorganic mulch on soil temperature, moisture retention, and weed control in bell pepper (*Capsicum annuum*) cultivation.

Specific objectives

1. To evaluate the effect of organic and inorganic mulches on soil temperature in bell pepper cultivation under smallholder farming systems in Lusaka.
2. To assess the influence of organic and inorganic mulches on soil moisture retention in bell pepper cultivation following smallholder management practices in Lusaka.
3. To determine effect of organic and inorganic mulches on weed control or suppression in the cultivation of bell pepper grown under smallholder management systems in Lusaka.

Hypothesis

HO: There is no significant difference in the effect of organic and inorganic mulching on soil temperature, moisture retention, and weed control in the cultivation of bell pepper under smallholder farming systems.

HI: There is significant difference in the effect of organic and inorganic mulching on soil temperature, moisture retention, and weed control in the cultivation of bell pepper under smallholder farming systems.

Significance of the study

The research findings from this study maybe beneficial for small-scale farmers, by providing them with knowledge of profitable and less costly moisture conserving and weed suppression. This was beneficial to farmer's that produced bell pepper. This study may contribute to vast streams of knowledge that already exist with hopes of intervening and providing the satisfaction of increased vegetable productivity.

Scope of the Study

This study aimed at exploring how different mulching materials affect soil temperature, moisture retention, and weed control when growing bell pepper. Mulching is a common agricultural technique that can really influence crop growth and yield by altering the microclimate around the plants. The study also compared variety of mulches, including organic options like straw, wood chips, and dried leaves, as well as synthetic choices such as black plastic and biodegradable films. The goal was to see how these materials affect important soil factors to identify which ones create the best conditions for bell pepper growth. The research took place in a controlled field environment, to enable monitoring of soil temperature and moisture levels at regular intervals. Data were collected data on how well the different mulches suppress weeds by measuring weed biomass and the types of species present under specific mulch treatment.

Additionally, the research took a closer look at how these mulches affect the yield and health of the bell pepper plants. By evaluating the effectiveness of each type of mulch, this study aimed to offer valuable insights for farmers and agricultural professionals who are looking for sustainable and efficient ways to cultivate bell pepper. The results could help improve resource management, lessen reliance on herbicides, and boost productivity in bell pepper farming.

Conceptual frameworks

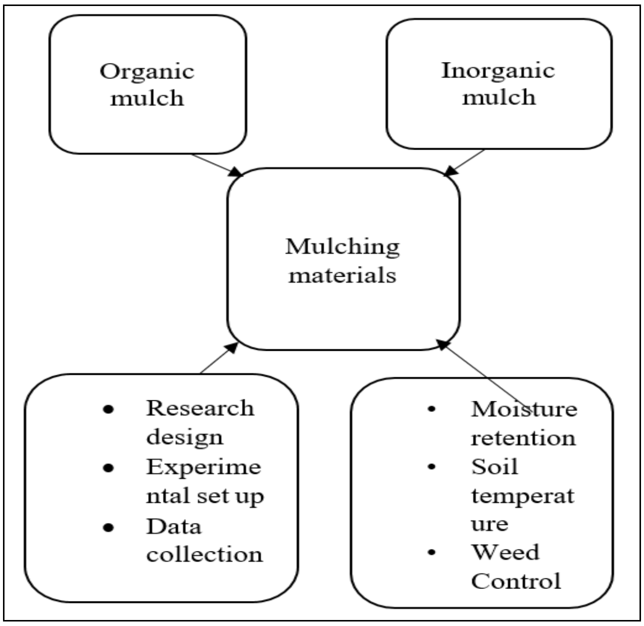
The conceptual framework of the research intends to explore the direct interaction between the different mulching materials and their impact on the soil moisture, soil temperature, and weed control in bell pepper (*Capsicum annuum*) cultivation.

Key components of conceptual framework are independent, dependent and mediated variables.

Independent variables: mulching material (organic and inorganic mulch).

Dependent variables: Soil moisture, soil temperature, and weed control.

Mediating variables: Soil characteristics, weather conditions, microbial activity.



Ethical considerations

The purpose and nature of the research were explained to some of the local residents near the study site for accountability and transparency to ensure adherence to the social, culture and dietary preferences. The inorganic fertilizers were used according to the recommended rates. Additionally, proper disposal of fertilizer bags was ensured to prevent potential health risks. Furthermore, the researcher ensured that the consent of the participants involved in the study was obtained. There was no coercion of any participant.

2. Literature Review

Mulching organic and inorganic improves soil moisture retention, regulates temperature, suppresses weeds, and influences microbial activity, thereby enhancing soil fertility and crop productivity (Hochmuth *et al.*, 2001) [15]. Organic mulches decomposes to release nutrients, enrich microbial communities and support long-term soil health, while inorganic mulches mainly modify the microclimate without contributing organic matter (Zhou *et al.*, 2019) [41]. The decomposition rate of organic mulches depends on their C:N ratio and lignin content, shaping nutrient cycling and availability (Melillo *et al.*, 1982) [22]. These soil processes interact with crop rotation, irrigation and fertilization to influence microbial dynamics and nutrient efficiency. Broader biogeochemical cycles including carbon, nitrogen, water, phosphorus and sulfur are essential for ecosystem stability but are disrupted by desforestation, industrial agriculture, and pollution, eutrophication, and soil degradation (Foley *et al.*, 2005) [9]. Besides that (Pretty, 2008) [27]. Added that, sustainable agricultural practices, reduced pollution, and ecosystem conservation are therefore crucial to restoring balance and maintaining productive. However, mulching effectiveness is shaped by multiple mediating factors, including soil temperature, moisture retention, and weed control (Lamont, 2005) [20]. Mulches regulate soil temperature by modifying heat transfer, helping maintaining the optimal 22-30ºC required for bell pepper growth (Guan, 2019) [11]. They also enhance soil moisture by reducing evaporation, improving infiltration, and supporting healthy root and microbial activity, with residue mulches lowering evaporation by up to 50% (Hatfield *et al.*, 2001) [13]. In weed management, mulches suppress growth by blocking light and, in some cases, releasing allelopathic compounds, while alternative strategies includes chemical, mechanical, cultural and biological control vary in efficiency depending on weed biology, environment, and management practices (Radosevich *et al.*, 2007) [28]. However, each control methods offer distinct advantages and limitation, chemical provide rapid, cost-effective control but risk resistance and environmental contamination (Heap, 2024) [14]. Mechanical method avoids chemicals but are labor-intensive and can damage soil (Bond and Grundy, 2001) [4]. Besides, Liebman and Dyck, (1993) [21]. Cultural methods enhance long-term sustainability through prevention-based practices like crop rotation and cover crop. Lastly biological control provides targeted species, environmentally compatible suppression though often slow and species- specific (Winston, *et al*., 2017) [40].

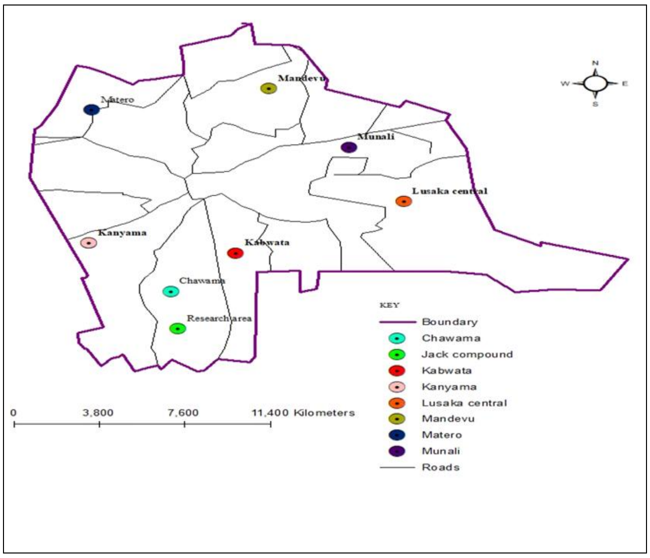
3. Materials and Methods

Description of the study site

The study was conducted in Jack compound at the Information and Communications University (ICU) demo plot in Lusaka district, located southeast of Lusaka town in Lusaka province. This area is located between latitudes 15.43000S and 28.32280E. The farm covers approximately 30 ha of land. According to agro- ecological conditions, mainly the area lies in Region II of Zambia. The region is characterized by vegetable maize farming with crops of the brassica family, Solanaceae, cucumbacea and leguminacea among others. This region receives a total annual rainfall of between 800 to1000--mm. Temperatures range from about 26^0 C to 32^0 C during the hot season and 4^0 C to 14.9^0 C in the cold season (Patrick, 2009) [26]. However, the region remains one of the main agricultural centers because of its favorable climate and soil type that is suitable for crop farming.

The soils in the study area are leptosols. The soil depth varies appreciably but is generally shallow, and has low inherent fertility. This soil type is a complex of well-drained and poorly drained sandy clay loams and clays interspersed with sandy ridges, developed on old leptosol. The textural classes range from fine to medium with near neutral P.H levels. The study area is particularly suitable for organic mulch farming as there is an evolved, naturally occurring ecosystem with a wide range of both plants and livestock biodiversity. These soils are suitable for most shallow rooted crops even though timely supplementation of the existing soil fertility through inorganic fertilizer or organic manure is essential to ensure continued crop production. The climate is favorable for most crops including bell peppers and members of the solanaceae family. Vegetable crops and maize production dominate the farm area.

Map indicating the study area



Source: Researcher, 2025

Experimental design and treatment layout

The experiment was arranged in a Randomized Complete Block Design (RCBD) with three treatment replicated three times organic mulch (such as elephant grass) and inorganic mulch (such as black plastic) were used because organic mulch is locally available and inorganic is cost efficiency.

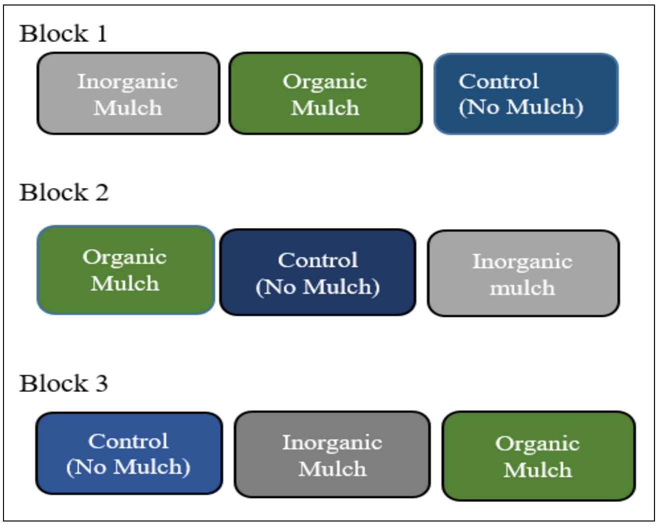
Main treatments

Treatment 1: Inorganic Mulch (Black Plastic)

Treatment 2: Organic Mulch (Elephant Grass)

Treatment 3: control (no mulch)

Field Layout



Planting and fertilization

The bell pepper seedlings were planted directly into the ground in lines that are 20mm depth and 0.50m at apart. Planting time was early in the morning in irrigated field conditions. Inorganic mulch was applied at 2-3 weeks of plant growth when the plants had about 4-6 leaves per plant. On the other side, organic was applied at planting period. The planting exercise was done on 23rd June 2025. The experiments used two types of fertilizers and these are Compound D whose grade is 10:20:10 (N:P:K) (Patrick, 2009) [26]. The second was urea, used as top dressing, which has a nitrogen content of 40%. Urea is the most concentrated solid nitrogen fertilizer and is often available in pelleted form. Both inorganic fertilizers were sourced from the Farmer's Barn local agro store.

Sampling and Sample Size

The study had 3 treatment groups inorganic mulch, organic mulch, and control group as it is typical recommended in agricultural studies to include at least tree replication for each treatment. Randomized Complete Block Design (RCBD) approach would be used with 3 replicates for treatment having a total sample size of 9 experimental units.

Materials

No.	Item/Materials	Description of Use
1.	Hoe, rake and shovel	These material will be used for land preparation to turn the soil, gathering soil when making beds, and leveling the soil in beds
2.	Measuring tape	This will be used for measuring the meters for beds
3.	Bell pepper seedlings	The seedlings will be used in the research to serve time in obtaining the results
4.	Watering can, hosepipe and buckets	These materials will be used for watering the crops
5.	Black plastic and dry grass	These will be used to cover the soil surface to assess soil temperature, moisture retention, and weed control
6.	Notebook and pen	For writing and recording observations manually in the field
	Android tecno phone	The phone will be used for recording data to have it as the soft copy
7.	4in1 soil survey instrument	The instrument will be used for observing soil temperature variation and measuring soil moisture retention in the field
	Microsoft excel	The excel will be used to enter the collected data to prepare it for analysis

Data collection

Data on soil temperature variation, soil moisture and weed density per area unit were collected. Physical inspection and manual recording of data were done on randomly selected plants. This helped to ensure data quality and reliability.

Statistical Analysis

Data collected on parameters were first compiled in Microsoft Excel (MS-Excel) for proper organization. The data were subjected to Analysis of Variance (ANOVA) to test for significant differences among treatments using SPSS version 20 (Field, 2013). Data analysis was conducted to describe and determine the uniqueness of the different mulching materials in the bell pepper field.

4. Results

Analysis of Variance for Soil Temperature

The results revealed a significant difference among soil temperature readings obtained from the plots treated with organic mulch and inorganic mulch and the untreated control. The asterisk (***) means there was high statistically significant different and asterisk (**) means there was moderate significant different (Table 2).

Table 2: Analysis of variance for Soil Temperature across the different forms of mulch

Source of variation	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	28.222	2	14.111^{**}	21.167	.002
Within Groups	4.000	6	$.667^{**}$		
Total	32.222	8			

The organic treatment had the lowest mean temperature, while the inorganic treatment had the highest mean temperature. The mean temperature of the organic treatment falls between that of the inorganic treatment and control treatment (Figure 4).

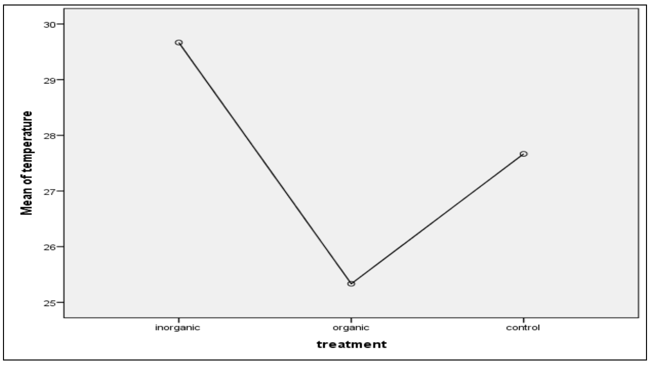


Fig 4: Mean plot of Soil Temperature and types of mulch

Multiple Comparisons of soil Moisture

The results show soil moisture across different treatments (inorganic, organic and control) in different weeks. It highlights that asterisk (**) denotes a moderate statistical difference and (***) means high significant different at the 0.05 level between treatments being compared at that week, while (ns) indicates no significant difference (Table 5).

Table 5: Analysis of variance for soil moisture across the different form of mulch

(I) Treatment	(J) Treatment	Mean Difference (I-J) Week 3	Mean Difference (I-J) Week 6	Mean Difference (I-J) Week 9	Mean Difference (I-J) Week 12
Inorganic	Organic	$.333^{ns}$	1.667^{***}	$.333^{ns}$	$.667^{ns}$
	Control	3.667^{***}	2.667^{***}	3.000^{**}	$.667^{ns}$
Organic	Inorganic	$-.333^{ns}$	-1.667^{***}	$-.333^{ns}$	-667^{ns}
	Control	3.333^{***}	1.000^{*}	2.667^{*}	$.000^{ns}$
Control	Inorganic	-3.667^{***}	-2.667^{***}	-3.000^{**}	-667^{ns}
	Organic	-3.333^{***}	-1.000^{*}	-2.667^{*}	$.000^{ns}$
Std Error		.385	.272	.609	1.155

*. The mean difference is significant at the 0.05 level.

Analysis of variance for number of Weeds

The results revealed a significant difference among number of weeds obtained from the plots treated with organic mulch and inorganic mulch and the untreated control. The asterisk (**) means that there was a significant different (Table 6).

Table 6: Analysis of variance for weeds across the different forms of mulch

Source of variation	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	35546.000	2	17773.000^{**}	18.995	.003
Within Groups	5614.000	6	935.667^{**}		
Total	41160.000	8			

The inorganic treatment had the lowest mean of weeds, while the untreated control treatment had the highest mean of weeds. The mean of weeds of the organic treatment was between that of the inorganic treatment and control treatment (figure 6).

5. Discussion and Conclusion

Discussion

The findings of this study revealed that mulching significantly influenced soil temperature, soil moisture retention, and weed suppression in the cultivation of bell pepper (*Capsicum annuum*). The differences observed between organic, inorganic, and control treatments underscore the vital role of mulching in modifying the soil microclimate and promoting sustainable crop production.

Soil Temperature

The raw soil temperature data show clear trends in how different mulch treatments influence the soil microclimate throughout the bell pepper growth cycle. However, inorganic mulch (such as black plastic) dependably recorded the highest temperatures such as the week 3 values of 29°C, 30°C, and 30°C reflecting its ability to absorb solar radiation and warm the soil more effectively than organic mulch or the control. The warming can give crops a growth advantage by enhancing germination and speeding up initial development (Tarara, 2000) [36]. In contrast, organic mulch (such as elephant grass) maintained the coolest and most stable temperatures across the field, as seen in Week 12 where temperatures (26°C, 20°C, 26°C) remained far below the peaks observed under inorganic mulch, including an extreme temperature value of 39°C. These findings align with Kader *et al*. (2017) [18], who noted that organic mulches buffer soil temperature fluctuations, while plastic mulches increase soil heat accumulation. For bell pepper, which requires an optimal soil temperature range of 22–30°C (Guan, 2019) [11], both types of mulch were beneficial at different growth stages. This demonstrates the insulating effect of organic materials, which buffer the soil against heat stress and reduce temperature fluctuations during hot periods. The control plots, which lacked any mulch cover, displayed intermediate but more variable temperatures, responding quickly to daily weather changes due to direct exposure. This variability results in a less stable root zone environment compared to both mulched treatments.

Moisture Retention

Significant differences in soil moisture content were recorded among the treatments. The quantitative raw soil moisture data provides a clear visualization of how different mulching treatments influence water conservation throughout the growing season. Inorganic mulch, which used black plastic consistently, produced the highest moisture levels, with readings mostly recorded as Wet+ or Wet across all weeks, demonstrating its strong ability to reduce evaporation and maintain a stable, well-hydrated root environment. Besides that, organic mulch also improved moisture retention compared to the control, showing mostly Wet or Normal levels. The effectiveness dropped over time, with later readings shifting to Normal and even Dry, likely due to gradual decomposition or increased plant water demand. Besides that, the control plots repeatedly exhibited the lowest soil moisture levels, dominated by Dry and Dry+ ratings for most of the experiment, reflecting the rapid moisture loss typical of exposed soil.

Weed Suppression

The study further revealed a significant reduction in weed population under mulched plots compared to the control. The weed count data clearly illustrates how differently the three treatments performed throughout the season. Inorganic mulch (black plastic) was the most effective, maintaining weed counts of 0, 0, and 0 in Week 3, 0, 0, and 0 in Week 6, and 0, 0, and 0 again in Week 9, with only a slight increase by Week 12 where counts rose to 1, 3, and 0. This near-complete suppression shows how the plastic barrier prevents weeds from germinating or penetrating the mulch. This can be attributed to the ability of plastic mulch to create an impenetrable barrier that blocks light, thus preventing weed seed germination (Lamont, 2005) [20]. Organic mulch showed an initial level of control, with Week 3 weed counts at 0, 3, and 10, but its effectiveness diminished as the season evolved. However, by Week 9, weed counts had increased to 15, 18, and 13, and by Week 12 rose further to 19, 17, and 18, indicating that as the organic material decomposed and thinned, more light reached the soil and allowed weeds to emerge. These findings are consistent with Teasdale and Mohler (2000) [38], who highlighted that mulching limits light availability to weed seeds, reducing their germination rate. Furthermore, the control plots experienced the most severe infestation, starting with 3, 9, and 23 weeds in Week 3, rising dramatically by Week 9 to 47, 53, and 70, and escalating to extreme levels in Week 12 with 108, 115, and 203 weeds. This uncontrolled proliferation shows how exposed soil provides ideal conditions for weed germination and vigorous growth, resulting in intense competition with the bell pepper crop for nutrients, water, and light. Overall, the results of this study support both the Soil Health Theory (Doran and Zeiss, 2000) [7] and the Sustainable Agriculture Theory (Pretty, 2008) [27]. The observed benefits of mulching including improved soil moisture, moderated temperature, and effective weed control demonstrate how simple ecological practices can enhance soil biological functions, water conservation, and overall crop productivity. This makes mulching a practical and sustainable method for smallholder farmers in Zambia who face the challenges of erratic rainfall, degraded soils, and weed pressure (Mhlanga *et al*., 2021) [23].

Conclusion

The picture that emerges from the analysis of the collected data regarding the impact effects of organic and inorganic mulches on soil temperature, moisture retention, and weed suppression in the cultivation of bell pepper (*Capsicum annuum*) under smallholder farming systems in Lusaka is relatively encouraging. This is because mulching is one of the most powerful and practical step a small-scale farmer can take to improve crop performance, and this research on bell peppers clearly shows why. Inorganic mulch (such as black plastic) proved to be the strongest option for farmers struggling with weeds and water shortages, almost completely eliminating weed growth and keeping the soil consistently moist saving both labor and irrigation costs. Organic mulch (such as elephant grass) performed best in moderating high temperatures and improving long-term soil health by adding organic matter as it decomposes, though it allows a few weeds to emerge later in the season. Bare soil produced the poorest results, with heavy weed infestation, rapid moisture loss, and stressful temperature fluctuations that weaken crops and reduce yields. In simple terms, farmers should avoid bare soil entirely and choose the type of mulch based on their most pressing needs: use inorganic mulch for maximum weed and water control, or organic mulch to cool the soil and build long-term fertility. Therefore, integrating mulching practices into bell pepper production systems can significantly improve productivity, reduce dependency on herbicides, and promote environmentally friendly farming.

Recommendations/suggestion for future research

Smallholder farmers should incorporate mulching as a standard practice to conserve soil moisture, regulate soil temperature, and suppress weeds. When possible, farmers should choose for organic mulches like dried elephant grasses, crop residues, or leaves. Future studies should investigate the long-term effects of repeated mulching on soil fertility, nutrient cycling and overall soil health

These materials are not only easy to find and budget-friendly. Other than that, they also enhance soil structure and fertility over time. However, in regions facing serious water shortages or limited irrigation options, using inorganic mulches such as black polyethylene sheets is advisable. Additionally, agricultural extension officers and research institutions should give out awareness and training programs for smallholder farmers, focusing on how to choose the right mulch, application techniques, and maintain it for various crops and soil types.

A larger sample size and replications is suggested for future studies, as this would serve to strengthen the statistical reliability of the findings, thereby increasing the validity and generalizability of the results. Additionally, this research should be conducted over different seasons and various agro-ecological zones in Zambia to confirm the consistency of these results.

6. Acknowledgement

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Limitation of the study

This study was limited to a controlled field environment, which may not accurately represent the variability of conditions experienced in open-field farming system. The research covered only a single growing season thereby restricting the assessment of mulch decomposition and its influence on soil fertility. Additionally, chilly temperature for a quiet long period of time which impacted the performance of the crop in terms of growth and yield through making plant roots less active in up taking the necessary nutrients essential for their growth.

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