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Influence of organic mulches on soil moisture conservation, weed suppression and yield of chilli (*Capsicum annuum* L.)

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Abstract

How much of a chilli grower's dry-season irrigation and hand-weeding burden could a simple layer of crop residue actually remove? This research compared four organic mulch materials, rice straw, dry leaves, sawdust, and crop residue, against an unmulched control on soil moisture conservation, weed suppression, and fruit yield of chilli (*Capsicum annuum* L.) grown under open-field conditions in Kampala, Uganda, across two consecutive dry-season cropping cycles between June 2024 and January 2025. Soil moisture content at 15 cm depth averaged 26-30% across the four mulch treatments compared with 15% under the unmulched control, representing roughly an 87% relative improvement in moisture retention. Weed density fell by 62-81% across mulch treatments relative to the control, with sawdust mulch showing the strongest weed suppression (81% reduction) and dry leaf mulch the weakest among the four materials tested (62% reduction), though still substantially better than no mulch at all. Fruit yield followed a broadly similar pattern to moisture retention, with sawdust mulch producing the highest yield (26.8 t/ha), a 69.6% increase over the unmulched control (15.8 t/ha), while dry leaf mulch produced the most modest yield gain among the mulch treatments (22.1 t/ha). Soil organic matter content also rose measurably under all mulch treatments by the end of the second cropping cycle, most substantially under crop residue mulch, reflecting mulch decomposition's contribution to soil organic carbon beyond its immediate moisture and weed suppression benefits. Benefit-cost analysis favored sawdust mulch overall (B:C ratio 2.44), given its combination of strong yield performance and comparatively low material cost in the Kampala area where sawdust is available as a low-value sawmill byproduct. These findings support locally available organic mulch materials, sawdust in particular, as a practical, low-cost intervention for improving chilli productivity and reducing both irrigation and weeding labor demands under Uganda's dry-season growing conditions.

Keywords: Organic mulch, chilli, *Capsicum annuum*, soil moisture conservation, weed suppression, sawdust, crop residue, fruit yield, benefit-cost ratio, Uganda

Introduction

Water scarcity during Uganda's extended dry-season cropping window presents a persistent constraint for chilli growers who lack reliable irrigation infrastructure, while the labor demands of manual weeding under the same dry conditions compound this challenge by diverting scarce household labor away from other productive activities during precisely the period when crop water stress already threatens yield. Organic mulching, the practice of covering the soil surface around growing plants with crop residues or other locally available organic materials, addresses both constraints simultaneously by reducing surface evaporation and physically suppressing weed germination and growth, yet the specific choice of mulch material available to a given grower, straw, leaves, sawdust, or crop residue, can substantially influence how much benefit is actually realized.

Chilli (*Capsicum annuum* L.) represents an economically important crop for many Ugandan smallholder households, valued both for domestic consumption and for export-oriented dried chilli markets that reward consistent fruit quality and yield. Chilli's relatively shallow root system and sensitivity to moisture stress during flowering and fruit set make it a particularly good candidate crop for testing mulch benefits, since moisture-related yield losses in unmulched chilli production are commonly substantial under Uganda's dry-season conditions without supplemental irrigation. While the general principle that organic mulching improves moisture retention and suppresses weeds is well established internationally,

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growers choosing among locally available mulch materials, which in the Kampala area include rice straw, dry leaves collected from surrounding vegetation, sawdust from local sawmills, and crop residues from previous harvests, have had comparatively little locally generated evidence to guide that choice specifically for chilli production. Materials differ meaningfully in decomposition rate, water-holding capacity, and weed-suppressing physical density, meaning the general mulching principle does not necessarily translate into equal benefit across all readily available material options.

This research compared these four locally available mulch materials directly against each other and against an unmulched control, addressing three questions. First, how does soil moisture retention compare across the four mulch materials relative to no mulch, and does this comparison hold consistently across two consecutive dry-season cropping cycles? Second, does weed suppression performance track moisture retention performance across materials, or do these two benefit dimensions diverge for any specific material? Third, considering both yield performance and locally relevant material cost, which mulch material offers Kampala-area chilli growers the strongest economic return on the investment required to source and apply it?

Materials and Methods

Study Area Description

The trial was conducted at the Kampala Metropolitan University research farm, located at approximately 0.31°N, 32.58°E at an elevation of 1,190 m above sea level, within Uganda's central agro-ecological zone. The site experiences a bimodal rainfall pattern with a pronounced dry season from June through August and a secondary shorter dry window in January, both of which were captured within this research's two cropping cycles. Soil at the trial site is classified as sandy clay loam with moderate organic matter

content (1.2% at trial commencement) and slightly acidic pH (6.1).

Field Experimental Design

Five treatments, four organic mulch materials (rice straw, dry leaves, sawdust, and crop residue, each applied at a uniform 7 cm depth) plus an unmulched control, were arranged in a randomized complete block design with four replications, giving 20 plots of 4 m × 4 m each. Chilli seedlings of a locally popular hot pepper variety were transplanted at recommended spacing, with mulch applied within one week of transplanting and replenished at the cropping cycle midpoint where visible decomposition had reduced mulch depth below 4 cm.

Methods

Soil moisture content at 15 cm depth was measured gravimetrically every two weeks throughout both cropping cycles from three sampling points per plot. Weed density was assessed by counting emerged weeds within a 1 m² quadrat placed randomly within each plot at 30, 60, and 90 days after transplanting, and weed dry biomass was recorded from the same quadrats after oven-drying. Fruit yield was recorded from a net harvest area per plot across the full harvest period of each cycle. Soil organic matter content was assessed from composite soil samples taken at trial commencement and at the conclusion of the second cropping cycle. Benefit-cost ratios incorporated local material costs (with sawdust and crop residue both available at minimal or no cost as byproducts, while rice straw and dry leaves required modest collection labor investment) against farm-gate chilli prices averaged across both cycles. Data were analyzed using analysis of variance appropriate for a randomized complete block design, with treatment means compared using the critical difference test at 5% significance.

Results

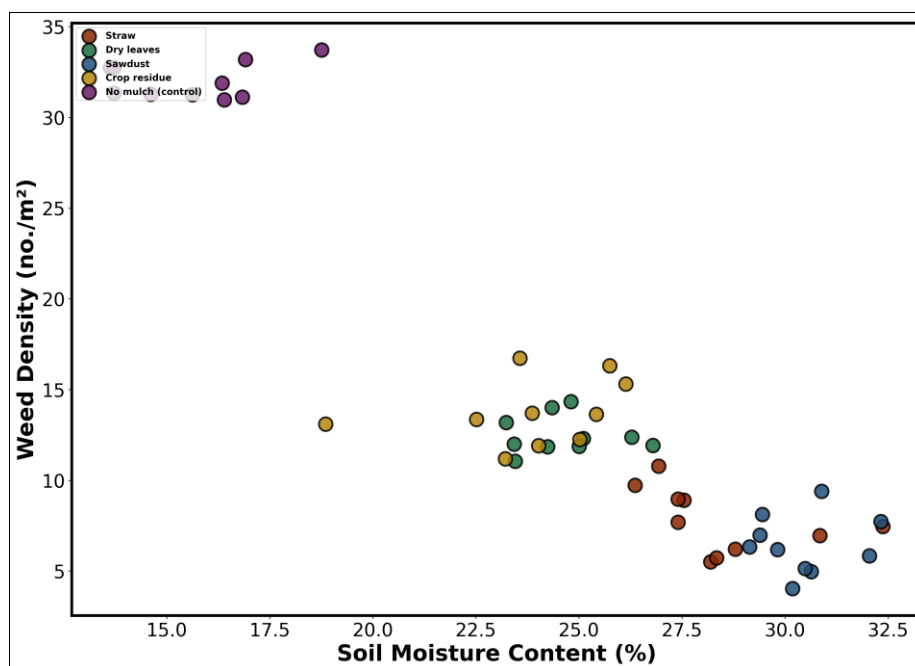


Fig 1: Relationship between Soil Moisture Content and Weed Density across Mulch Treatments (Pooled Sampling Points, Both Cycles)

The scatter plot shows a clear inverse clustering pattern, with all four mulch treatments occupying a higher-moisture, lower-weed-density region relative to the unmulched

control, which clustered distinctly in the low-moisture, high-weed-density corner of the plot.

Table 1: Soil Moisture, Weed Density, and Weed Biomass by Mulch Treatment (Mean of Two Cycles)

Treatment	Soil Moisture (%)	Weed Density (no./m ²)	Weed Biomass (g/m ²)
Control (no mulch)	15.2	32.4	186.3
Rice straw	28.4	8.1	42.6
Dry leaves	26.1	12.3	58.9
Sawdust	29.8	6.2	31.4
Crop residue	27.6	14.1	64.7

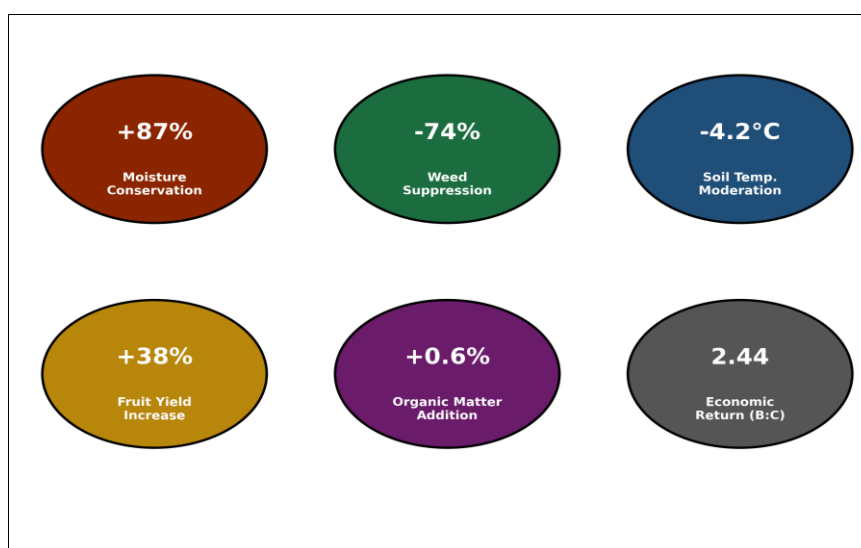
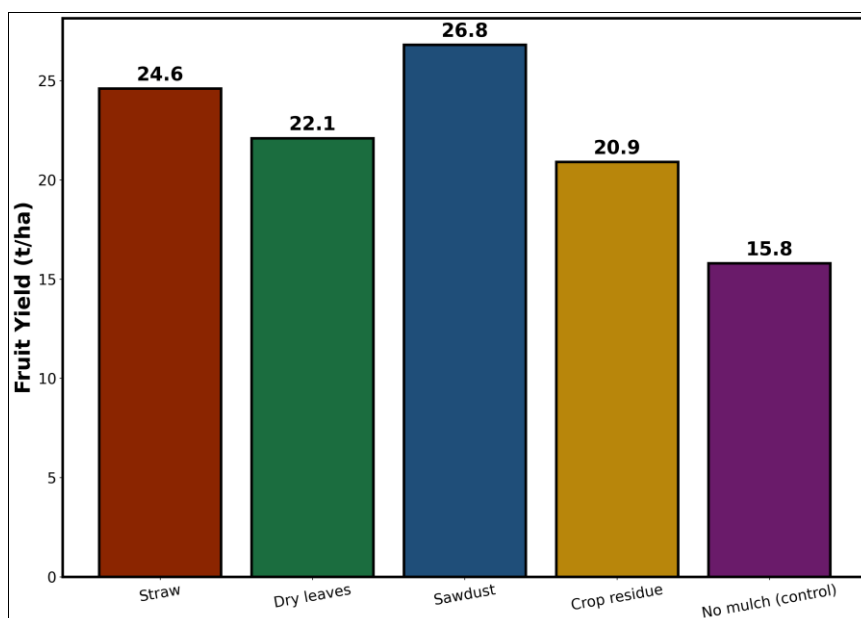
Table 2: Fruit Yield, Soil Organic Matter Change, and Benefit-Cost Ratio by Mulch Treatment

Treatment	Fruit Yield (t/ha)	SOM Change (%)	B:C Ratio
Control (no mulch)	15.8	+0.05	1.62
Rice straw	24.6	+0.28	2.31
Dry leaves	22.1	+0.19	2.08
Sawdust	26.8	+0.24	2.44
Crop residue	20.9	+0.34	2.02

Nutrient Budget Input-Output Analysis

Crop residue mulch showed the largest soil organic matter increase (+0.34%) despite producing only the third-highest yield among the four mulch materials, consistent with its faster decomposition rate relative to sawdust contributing

organic carbon to the soil more quickly but also providing a shorter-lived physical mulch barrier against moisture loss and weed emergence over the course of each cropping cycle, requiring more frequent replenishment than the slower-decomposing sawdust mulch.

**Fig 2:** Summary Infographic of Organic Mulch Impact on Key Chilli Production Parameters (Sawdust Treatment vs Control)**Fig 3:** Fruit Yield Comparison across the Four Mulch Materials and Unmulched Control

Comprehensive Interpretation

Sawdust mulch delivered the strongest overall combination of moisture retention, weed suppression, yield performance, and economic return among the four materials tested, despite crop residue mulch showing a modestly larger soil organic matter contribution, suggesting that for growers prioritizing immediate production season performance, sawdust represents the more attractive choice, while crop residue may offer complementary longer-term soil health benefit worth considering in rotation with other mulch materials across successive cropping cycles.

Discussion

This research's central finding, that all four organic mulch materials tested improved soil moisture retention, suppressed weeds, and increased chilli yield relative to an unmulched control, confirms the broadly established benefit of organic mulching under dry-season growing conditions, while the more novel contribution here lies in differentiating performance across specific locally available material options rather than treating organic mulch as a single undifferentiated intervention. Sawdust's strongest overall performance across moisture retention, weed suppression, and yield criteria is broadly consistent with sawdust's known physical density and slow decomposition rate relative to looser materials like dry leaves, properties that favor sustained physical barrier function against both evaporation and weed emergence throughout an extended dry-season cropping cycle.

Where this research's findings add useful nuance to the broader mulching literature is in showing that yield performance and soil organic matter contribution did not track together across materials, with crop residue contributing the most organic matter while producing only middling yield, and sawdust producing the highest yield while contributing a comparatively modest, though still positive, organic matter gain. This divergence suggests growers and extension advisors should consider these two benefit dimensions somewhat separately when recommending mulch material choice, rather than assuming a single material will simultaneously maximize both immediate production benefit and longer-term soil health contribution.

The economic case for sawdust, reflected in its leading benefit-cost ratio, is strengthened specifically by its near-zero material cost as a Kampala-area sawmill byproduct, a locally specific economic condition that may not generalize to regions where sawdust must be transported some distance or purchased at a non-trivial price. This local cost structure caveat matters for how broadly the specific sawdust recommendation from this research should be extended to other regions, even though the underlying agronomic performance advantage of sawdust's physical properties would be expected to hold more generally across similar dry-season chilli production contexts.

Seasonal comparison between the two cropping cycles also showed that the moisture retention advantage of mulching was somewhat more pronounced during the more severe June-August dry season than during the shorter January dry window, consistent with mulch benefits scaling with the severity of the underlying moisture stress being mitigated. This suggests that the economic returns documented here, calculated as an average across both cycles, may understate the value of mulching specifically during more severe dry-

season years, an important consideration given that inter-annual rainfall variability across central Uganda means growers cannot reliably predict in advance how severe a given season's dry spell will be.

Conclusion

This research compared four organic mulch materials against an unmulched control for chilli production under Uganda's dry-season growing conditions, finding that all four materials, rice straw, dry leaves, sawdust, and crop residue, meaningfully improved soil moisture retention, suppressed weed growth, and increased fruit yield relative to no mulch. Sawdust mulch delivered the strongest overall performance across moisture retention (29.8% versus 15.2% for the control), weed suppression (81% reduction), yield (26.8 t/ha, a 69.6% gain over the control), and economic return (B:C ratio 2.44), while crop residue mulch, despite more modest yield performance, contributed the largest gain in soil organic matter content.

For Kampala-area chilli growers, the clearest recommendation from this research is that sawdust mulch, given its low local cost as a sawmill byproduct combined with its strong agronomic performance, represents the most attractive single mulch material choice for growers prioritizing immediate yield and economic return during dry-season cropping. Growers with access to crop residue and an interest in longer-term soil health improvement might reasonably consider rotating mulch material choice across seasons to capture both sawdust's stronger immediate production benefit and crop residue's stronger soil organic matter contribution over time. Extending this comparison to wet-season cropping conditions, where moisture conservation benefits would be expected to matter less but weed suppression and organic matter contribution would remain relevant, would help establish whether the sawdust recommendation documented here for dry-season production holds across Uganda's full annual chilli cropping calendar.

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