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EVALUATING THE IMPACT OF ORGANIC MULCH ON CLIMATE-RESILIENT COTTON PRODUCTION: A REGENERATIVE AGRICULTURE APPROACH FOR SUSTAINABLE FARMING

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ABSTRACT

Organic mulches offer environmentally friendly benefits for cotton in challenging environments. A study was conducted in the farmer field and research station of the Rural Education and Economic Development Society (REEDS) Pakistan in 2023 to evaluate the effect of various organic mulches on soil properties, cotton yield, and quality in a semi-arid region. Results showed that wheat straw, rice, and sugarcane leaves straw maintained moderate soil temperatures (27.3°C to 27.4°C), unlike the control (41.6°C). Soil pH remained stable (7.9 to 8.1), and organic mulches raised soil carbon (0.68% to 0.72% vs. 0.51% control). Nutrient availability increased, with higher nitrogen (0.045% to 0.049%), phosphorus (6.2 mg kg^{-1} to 6.5 mg kg^{-1}), and potassium (89 mg kg^{-1} to 92 mg kg^{-1}) compared to control (0.028%, 5.6 mg kg^{-1}, and 71 mg kg^{-1}). Organic matter content rose (0.77% to 0.81%) versus the control (0.51%). Weed density decreased (4 to 5 weeds m^2 vs. 23 weeds m^2 control) with mulches. Cotton height, bolls per plant, and open-boll weight increased with mulches, elevating cotton yield (2704 kg ha^{-1} to 2743 kg ha^{-1}) over control (2117 kg ha^{-1}), with consistent ginning outturn (36.62% to 37.2%). Cotton quality remained similar, while mulches reduced irrigation frequency (7 irrigations) and total amount (533 mm); control needed more (9 irrigations, 685 mm). Crop water use efficiency improved with mulches (0.50 to 0.51 kg m^{-3} vs. 0.30 kg m^{-3} control). This study highlights organic mulch's potential to enhance soil properties, nutrient availability, weed suppression, cotton yield, and water use efficiency.

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INTRODUCTION

Climate change has emerged as a major threat to agriculture worldwide, posing significant challenges to crop production, soil health, and overall sustainability (Nguyen et al., 2023). The shifting climate patterns associated with global warming have led to various adverse impacts on agricultural systems (Skendžić et al., 2021; Abbass et al., 2022). Altered rainfall patterns, characterized by erratic distribution and changes in the timing and intensity of precipitation, have caused difficulties in crop management and reduced overall productivity (Skendžić et al., 2021). Moreover, the increased frequency of extreme weather events, including heat waves, droughts, floods, and storms, has further compounded the challenges faced by farmers (Lee et al., 2023). Rising temperatures, prolonged heat waves, and drought stress during critical growth stages of crops can negatively affect crop development and productivity (Brito et al., 2019; AghaKouchak et al., 2020).

Furthermore, extreme weather events associated with climate change, such as heavy rainfall and flooding, pose significant challenges to soil health and fertility (Lesk et al., 2022). Intense rainfall can cause soil erosion and loss of topsoil, essential nutrients, and organic matter (Anabaraonye et al., 2021; Wheeler and Lobley, 2021). This erosion can affect soil structure, reduce water-holding capacity, and diminish soil fertility, ultimately hampering crop growth and agricultural productivity (Malik et al., 2022). These adverse conditions can result in significant economic losses and food insecurity. To address the adverse impacts of climate change on agriculture, it is crucial to implement both mitigation and adaptation strategies.

Cotton is an important cash crop, providing income and employment for millions of farmers and workers worldwide (Sahay, 2019; Khanpara and Vala, 2023). Its high consumer demand drives economic growth, trade, and job creation, making cotton a pivotal contributor to global economies and livelihoods (Mbatha, 2020; Abdukhalil, 2023). Climate change has wide-ranging and profound effects on cotton production and the cotton industry. One of the primary impacts is the changing growing conditions for cotton crops. Rising temperatures associated with climate change can lead to heat stress in cotton plants, hindering their growth and development (Abbas, 2022).

Moreover, altered precipitation patterns can result in droughts or excessive rainfall, harming cotton crop (Zafar et al., 2021). Drought and changes in rainfall patterns can limit the availability of water for irrigation, which is crucial for cotton farming (Zafar et al., 2021). Consequently, farmers may face challenges in securing sufficient water resources for their crops, potentially leading to reduced cotton cultivation or increased competition for water with other sectors (Hussain et al., 2020; Chiarelli et al., 2022). Reliance on irrigation may become more necessary in such situations, straining water supplies and increasing production costs. Mulching is a widely adopted technique wherein materials are placed on the field before, during, or after sowing. This process aims to provide support and coverage to the soil surface using various materials like crop residues, livestock manure, and even sand (El-Beltagi et al., 2022; Kun et al., 2023). This practice serves multiple purposes, such as reducing evaporation, preventing erosion, regulating soil temperature, enhancing soil water retention capability, and inhibiting weed growth (Iqbal et al., 2020; Prem et al., 2020; El-Beltagi et al., 2022; Anuja et al., 2023). Organic mulch is more environment friendly as it is composed of biodegradable materials like straw, leaves, or compost that serve as a protective shield for the soil, preserving moisture and reducing erosion, and promoting soil health and fertility as the mulch breaks down over time (Iqbal et al., 2020; Kaur et al., 2020; El-Beltagi et al., 2022). Organic mulches play a significant role in mitigating nitrate leaching, improving soil's physical properties, promoting biological activity, harmonizing the nitrogen cycle, contributing organic matter, as well as regulating soil temperature and moisture retention (Iqbal et al., 2020; El-Beltagi et al., 2022; Scavo et al., 2022). Mulching in agricultural fields offers a range of advantages, including reducing soil water loss, suppressing weed germination, preventing soil erosion, and mitigating water droplet kinetic energy (Prem et al., 2020; El-Beltagi et al., 2022). It enhances soil structure and facilitates increased earthworm activity within the soil (McTavish and Murphy, 2022). Additionally, it can lower the soil's pH, thereby augmenting the accessibility of nutrients (El-Beltagi et al., 2022). As organic mulch undergoes decomposition, it imparts nutrients to the soil, prolonging their availability over an extended period (Ma et al., 2021; El-Metwally et al., 2022). The breakdown of organic mulch also accelerates the improvement of soil organic content, thereby enhancing the soil's water retention capacity (Navyashree et al., 2019; El-Beltagi et al., 2022). By curbing evaporation, mulches create an environment where more excellent moisture is retained close to plant roots, extending the duration during which plants can absorb water (Prem et al., 2020; El-Beltagi et al., 2022).

The mulch acts as an insulating layer, regulating soil temperature and minimizing temperature fluctuations that can stress cotton plants (El-Beltagi et al., 2022; Tang et al., 2023). Moreover, organic mulch acts as a weed suppressor and can reduce the need for herbicides and manual weed removal, promoting a more environmentally friendly and cost-effective approach to weed control (El-Beltagi et al., 2022; El-Metwally et al., 2022; Monteiro and Santos, 2022). By reducing weed competition, cotton plants have better access to essential nutrients and water, allowing for healthier growth and higher yields. In addition, mulch encourages beneficial microbial activity, enhancing nutrient cycling and promoting a robust soil ecosystem (El-Beltagi et al., 2022; Waheed et al., 2023). Healthy soils increase water infiltration and retention, reducing irrigation needs and enhancing water-use efficiency.

Organic mulch aids in reducing soil erosion by acting as a physical barrier, preventing raindrops from directly impacting the soil surface (El-Beltagi et al., 2022; Waheed et al., 2023). Hence, mulch mitigates the risk of soil erosion and nutrient runoff, preserving valuable topsoil and safeguarding water quality. Therefore, by employing this natural and environment-friendly technique, cotton farmers can enhance soil health, conserve water, control weeds, and promote overall crop productivity while minimizing the reliance on synthetic inputs. It can effectively improve their cotton cultivation practices' long-term viability and environmental sustainability. Considering the impacts of climate change on cotton cultivation, a study was planned to evaluate the influence of different organic mulches derived from wheat, rice, and sugarcane residues. The treatments included applying each type of mulch at a rate of 5 tons/ha, uniformly spread over the soil surface after cotton emergence. The study aimed to assess their effects on soil properties, cotton growth, and yield under changing climate conditions.

MATERIALS AND METHODS

The experiment was conducted in the farmer fields and Rural Education and Economic Development Society (REEDS) research station, Rahim Yar Khan, Pakistan. District Rahim Yar is situated at 28◦ 41′ N latitude and 70◦ 30′ E longitude and longitude 70◦ 30′ E, and falls within an extensive alluvial plain located adjacent to the Indus River. It occupies a substantial expanse of an alluvial plain alongside the Indus River. The weather temperatures ranged from 16.4°C in November to 30.5°C in June 2023 (Table 1).

Weather data provides valuable insights into the climate changes during the specified period. The net plot area for individual treatment was 16.60 × 30.50 m, while the total area was 66.40 m × 121.90 m. Each treatment plot consisted of 21 rows, with each row containing 100 plants.

Table 1. Weather data of experimental trial during 2023.

Months	Avg. min. Temperature ˚C	Avg. Max. Temperature ˚C	Rainfall (mm)	Humidity (%)
April	23.0	38.7	-	28
May	27.8	42.1	-	23
June	30.5	43.1	-	34
July	30.5	40.8	18	48
August	29.1	38.6	43	57
September	27.3	38.0	111	70
October	23.0	34.0	-	43
November	16.4	30.1	-	46

Land preparation and crop husbandry

Land preparation for cotton cultivation was essential to ensure a good yield. To provide a favorable seedbed and optimal field tilth, thorough land preparation was carried out in multiple stages. Initially, on April 5th, the field was cultivated twice using a tractor-mounted cultivator, followed by planking. Afterward, soaking irrigation was applied. On April 9th, soil moisture reached the desired field capacity, the field was cultivated twice using a tractor-driven cultivator, followed by planking. Subsequently, the field was rotavated to achieve a well-prepared seedbed, and beds were formed, each 75 cm wide. Before planting the cotton crop, soil samples to a depth of 30 cm (0-15 cm and 15-30 cm) were taken using an auger.

The collected soil samples were meticulously marked with unique numbers for identification purposes. Subsequently, these samples were dispatched to the soil and water testing laboratory situated in District Rahim Yar. The soil texture was clay loam, while the pH was 8.1. Alike, electrical conductivity (EC) was 1.2 mS cm^{-1}. Organic matter increased 0.50%, and bulk density was 1.12 g cm^{-3}. Saturation was 36%, indicating moisture retention. Available nitrogen was 0.026%, phosphorus

5.4 mg kg^{-1}, and potassium was 66 mg kg (Table 2). For the sowing process, seeds of the cotton variety CKC-3 were used at a rate of 20 kg per hectare (ha^{-1}). The sowing was executed manually, ensuring a spacing of 30 cm between individual plants and 75 cm between rows. A randomized complete block design was implemented to facilitate the study, with each treatment replicated three times. For effective nutrient management, fertilizers were administered following the guidance of the Soil and Water Testing Laboratory in Rahim Yar Khan, Pakistan. The fertilizer application encompassed the nitrogen (200 kg ha^{-1}), phosphorus (120 kg ha^{-1}), and potash (100 kg ha^{-1}). The phosphorus, potash, and one-third of the nitrogen dose were applied during sowing. Subsequently, the remaining nitrogen was distributed evenly in three separate applications: 35 days after planting, during square formation, and at boll formation.

Table 2. Physiochemical properties of experimental soil.

Soil Properties	Value
Texture	clay loam
pH	8.1
EC (mS-cm)	1.2
Organic matter (%)	0.50
Bulk density (g cm^{-3})	1.16
Saturation (%)	36
Available N (%)	0.026
Available P (mg kg^{-1})	5.4
Available K (mg kg^{-1})	66

Mulching

Organic mulching rice, wheat, and sugarcane straw at a rate of 5 tons ha^{-1} was used. Mulch was applied to the cotton field when the cotton plants were 30 days old because early mulching can interfere with seedling emergence. This is because the mulch can after the emergence of seedlings. The straw mulch was spread evenly over the cotton beds and furrows. The thickness of the mulch layer was 2 inches.

Irrigation water

The crop was irrigated by canal water, and each field plot was irrigated independently to ensure precise monitoring and control of soil moisture levels. A digital soil moisture meter (Misol WH0291, China) was inserted to measure soil moisture content accurately. Daily soil moisture readings were recorded from each plot using the digital soil moisture meter. This enabled us to closely monitor the soil's water content and make informed decisions regarding irrigation scheduling. The irrigation strategy was based on maintaining an optimal soil moisture level of 25% in each plot. Once the average soil moisture content in a plot reached the predetermined threshold of 25%, irrigation was applied to replenish the water deficit and maintain an ideal moisture level for cotton growth and development.

Observations

Accurate and comprehensive observations regarding the different parameters of crop are crucial for drawing meaningful conclusions. The parameters recorded during the study are described briefly.

Soil health and fertility indicators

As mentioned above, soil samples were collected before sowing. Similarly, samples were retaken after crop harvesting to assess any changes in soil properties, including texture, pH, EC, OM, bulk density, saturation %, available N, P, and K (Table 3).

Yield and quality parameters

A randomized selection process was employed to choose ten plants from each specific site within a given plot. The height of each selected plant was meticulously measured from the soil surface to the highest point of the plant. Subsequently, the quantification of bolls per plant was undertaken. The number of bolls each plant bears directly determines the ultimate cotton yield. Furthermore, individual bolls' weight has a notable influence over the final yield outcome. Ten cotton plants were arbitrarily designated across three distinct sites within each plot.

The mature, open bolls of these selected plants were precisely weighed using a digital balance, and these measurements were subsequently averaged to ensure accurate representation. To evaluate ginning out turn (GOT) and other quality attributes such as fiber length, strength, fineness, and uniformity, harvested cotton samples were transported to the Fiber Testing Laboratory in Multan. To determine GOT, 100 g seed cotton yield samples were obtained from each plot, subsequently undergoing sun drying and cleaning before ginning. An electrical ginning machine segregated the lint from the seed cotton. The lint weight was then measured, and the GOT was calculated using the formula outlined in the work by Khan et al. (Khan et al. 2020).

$$\text{Ginning out turn (\%)} = \frac{\text{Lint yield}}{\text{Seed cotton yield}} \times 100$$

For the measurement of fiber length, strength, fineness, and uniformity, a high-volume instrument system in Fiber Testing Laboratory, Multan, was used to calculate fiber length, strength, fineness, and uniformity.

Table 3. Effect of organic mulch on soil and its nutrient availability.

Treatment	Soil temp. (°C)	Soil pH	Soil carbon (%)	N (%)	P (mg kg^{-1})	K (mg kg^{-1})	Soil organic matter (%)	Weed population (m^2)	Plant height (cm)	Bolls per plant	Open boll weight (g)	Seed-cotton yield (kg ha^{-1})
Wheat straw @ 5 tons ha^{-1}	27.4 a	7.9 a	0.68 a	0.048a	6.50 a	89 a	0.78 a	4 b	145 a	35 a	3.10 a	2743 a
Rice straw @ 5 tons ha^{-1}	27.3 a	7.9 a	0.72 a	0.045a	6.40 a	92 a	0.81 a	4 b	139 a	33 a	3.14 a	2704 a
Sugarcane leaf straw @ 5 tons ha^{-1}	27.4 a	7.9 a	0.70 a	0.049a	6.43 a	92 a	0.77 a	5 b	142 a	34 a	3.12 a	2713 a
Control (no mulch)	41.6 b	8.1 a	0.51 b	0.028b	5.60 b	71 b	0.51 b	23 a	102 b	29 b	3.0 b	2117 a
LSD at 5%	2.18	ns	0.11	0.008	0.35	5.47	0.10	1.34	12.45	2.13	0.082	63.72

Number of irrigations and water use efficiency (WUE)

The total number of irrigations was documented during the entire crop season. The irrigation strategy was based on maintaining an optimal soil moisture level of 25% in each plot. The daily soil moisture (%) was noted using a digital soil moisture meter (Misol WH0291, China). Once the average soil moisture content in a plot reached the predetermined threshold of 25%, irrigation was applied to replenish the water deficit and maintain an ideal moisture level for cotton growth and development. Water use efficiency in crop production measures how effectively a crop utilizes water to produce a certain amount of biomass or yield. It's a critical parameter to assess the sustainability and productivity of agricultural systems, especially in regions with water scarcity. The water use efficiency of cotton crop was calculated by considering the ratio of economic yield to the amount of water used in irrigation or rainfall (Saeed et al., 2021).

Crop water use efficiency (kg m^{-3}) = Economic yield (kg)/ total amount of water supplied (m^3).

Statistical analysis

The data acquired for the various parameters were subjected to statistical analysis using Statistix 8.1 software (Hussian et al., 2013). To evaluate the variations between the different treatments, a least significant difference (LSD) test was employed at a significance level of 5% (Steel et al., 1997).

RESULTS AND DISCUSSION

The results of the study showing the impact of different organic mulch treatments on soil properties and nutrient availability are given in Table 3. In terms of soil temperature, applying all three types of organic mulches maintained a relatively moderate average temperature of around 27.3°C to 27.4°Cas compared to control (41.6°C). The pH of the soil remained stable across all treatments, approximately at 7.9 to 8.1. The application of wheat straw, rice straw, and sugarcane leaf straw mulches increased soil carbon content to 0.68%, 0.72%, and 0.70%, respectively. In contrast, the control treatment exhibited a lower soil carbon content of 0.51%. Regarding nutrient availability, available N increased in the presence of organic mulch, ranging from 0.045% to 0.049%, compared to control treatment

(0.028%). Similarly, available P increased (6.4 mg kg^{-1} to 6.5 mg kg^{-1}) and available K (ranging from 89 mg kg^{-1} to 92 mg kg^{-1}) compared to the control treatment (5.6 mg kg^{-1} for P and 71 mg kg^{-1} for K). Furthermore, applying organic mulch significantly increased soil organic matter content (0.77 to 0.81%). In contrast, the control treatment exhibited a lower organic matter content of 0.51%.

The observed moderation of soil temperature (27.3°C to 27.4°C) through organic mulch application is of paramount significance. Mulches act as a buffer against temperature and moisture fluctuations (Lal, 2016), creating a more stable environment conducive to the optimal growth and development of microorganisms and plants (Chen et al., 2014; Gao et al., 2022). The notable increase in soil carbon and organic matter content resulting from the application of wheat straw, rice straw, and sugarcane leaf straw mulches is indicative of enhanced organic matter input, which in turn has positive implications for soil health, carbon sequestration, water retention, and overall plant growth and productivity (Turmel et al., 2015).

The effects of organic mulch treatments on critical aspects of cotton, including weed population dynamics, cotton plant growth, boll production, and yield-related traits, are given in Table 3. The application of organic mulch treatments notably impacted weed population control. The wheat straw, rice straw, and sugarcane leaf straw treatments reduced weed density remarkably, with only 4 to 5 weeds per square meter. In contrast, the control treatment demonstrated a considerably higher weed population of 23 weeds m^2, underscoring the weed-suppressive effect of organic mulch. The significant suppression of weed populations under organic mulch treatments is paramount. The decline in weed population observed with mulches can be attributed to their ability to suppress weed growth by intercepting sunlight necessary for photosynthesis (El-Beltagi et al., 2022). This shading effect disrupts weed plants' energy production and metabolic processes (Singhal et al. 2020), curbing their growth and ultimately leading to a more favorable environment for cultivated crops. Cotton plant height was positively influenced by the organic mulch treatments (139 cm to 145 cm). The increase in plant height might be due to more nutrients available. By minimizing extreme temperature variations, mulches foster favorable conditions for plants, soil organisms, nutrient cycling, and root activity (El-Beltagi et al., 2022; Sun et al., 2022), ultimately enhancing plant growth and height..

A substantial correlation was observed between organic mulch application and boll production. Cotton plants under the wheat straw, rice straw, and sugarcane leaf straw treatments yielded higher numbers of bolls per plant (33 to 35 bolls per plant). The control treatment displayed a lower boll count per plant, averaging 29 bolls. The effect of organic mulch extended to open boll weight, a crucial yield-related trait. Open bolls in the wheat, rice, and sugarcane leaf straw treatments exhibited similar weights, measuring approximately 3.10g, 3.14g, and 3.12g, respectively.

In comparison, the lowest open-boll weight (3.0g) was recorded in the control treatment where mulch was not applied. Perhaps most significantly, organic mulch treatments yielded higher quantities of seed cotton. The application of wheat straw resulted in a higher yield (2743 $kgha^{-1}$); however, there was a non-significant difference with rice straw and sugarcane leaf straw treatments, which yielded 2704 $kgha^{-1}$ and 2713 $kgha^{-1}$, respectively, while all the mulch treatments had higher yield than control treatment, which yielded 2117 $kgha^{-1}$. Regarding ginning out turn (Table 4), all treatments exhibited relatively consistent percentages (36.62% to 37.2%).

This aspect of yield processing showed no significant variations between the organic mulch treatments and the control treatment. Mulches suppressed the weeds, and cotton plants fully utilized the available resources, improving crop yield (El-Beltagi et al., 2022). Thus, the overall improvement in cotton yield-related traits, such as boll count and open boll weight, shows the positive influence of these treatments on cotton productivity (Zhang et al., 2020). Results showed that mulching reduced irrigation frequency and overall irrigation water quantity compared to control treatment. The number of irrigations in wheat straw, rice straw, and sugarcane leaf straw treatments received 7, resulting in a total irrigation amount of 533 mm. In contrast, the control treatment received 9 irrigations, resulting in relatively higher total irrigation amount of 685 mm. Similarly, crop water use efficiency differed significantly in cotton. Organic mulch treatments showcased distinct impacts on crop water use efficiency. The wheat straw, rice straw, and sugarcane leaf straw treatments yielded greater efficiencies ranging from 0.50 to 0.51 kgm^{-3}. In contrast, the control treatment displayed a comparatively lower efficiency value of water use efficiency (0.30 kgm^{-3}). This can be attributed to the protective layer created by the mulch on the soil surface which minimized the direct exposure of the soil to sunlight, wind, and other environmental factors (Shah and Wu, 2020; Zheng et al., 2022). Consequently, the rate of evaporation from the soil is lowered. As the mulch layer prevents rapid moisture loss, the soil retains more water for extended periods (Prem et al., 2020). This diminished evaporation and prolonged moisture retention contribute to a decreased demand for frequent irrigation.

Table 4. Effect of organic mulch on cotton quality, number of irrigations, total irrigation amount, and crop water use efficiency.

Treatments	Ginning out turn (%)	Staple length (mm)	Fiber fineness (µg/inch)	Fiber uniformity index (%)	Fiber strength (tppsi)	No. of irrigations	Total irrigation water (mm)	Crop water use efficiency (kg m^{-3})
Wheat straw @ 5 tons ha^{-1}	37.2 a	28.1 a	4.2	92 a	93.2 a	7 b	533 b	0.51 a
Rice straw @ 5 tons ha^{-1}	37.1 a	28.2 a	4.2	91 a	93.1 a	7 b	533 b	0.50 a
Sugarcane leaf straw @ 5 tons ha^{-1}	37.2 a	28.1 a	4.3	92 a	93.2 a	7 b	533 b	0.50 a
Control (no mulch)	36.6 b	26.1 b	4.3	89 b	93.1 a	9 a	685 a	0.30 b
LSD at 5%	0.32	0.75	ns	0.76	ns	0.45	34.10	0.09

The impact of organic mulch treatments on crucial aspects of cotton fiber quality, irrigation practices, and crop water use efficiency are given in Table 2. The length of cotton fibers, known as staple length, displayed minor variations among treatments. The wheat straw, rice straw, and sugarcane leaf straw treatments yielded staple lengths of 28.1 mm to 28.2 mm, significantly higher than the staple lengths of the control treatment, measuring 26.1 mm. Likewise, fiber fineness remained relatively uniform across all mulched treatments (4.2 µg/inch) and control treatment (4.3 µg/inch). Similarly, the fiber uniformity index demonstrated minor fluctuations. The wheat, rice, and sugarcane leaf straw treatments showed uniformity indices of 92%, while the control treatment exhibited a slightly lower index of 89%. Fiber strength, a crucial determinant of cotton quality, appeared consistent across treatments.

CONCLUSION

In conclusion, this study demonstrates the significant positive effects of various organic mulch treatments on multiple aspects of cotton production. Applying organic mulches effectively moderated soil temperature, enriched soil carbon content, and improved nutrient availability. These treatments exhibited weed-suppressive effects, promoting healthier cotton plant growth, increased boll production, and enhanced yield-related traits. Moreover, the mulches positively influenced the quality of cotton fiber, such as staple length, fineness, and uniformity. Notably, organic mulch treatments improved crop water use efficiency, showcasing their potential for sustainable irrigation practices. These findings collectively highlight the multifaceted benefits of organic mulches in enhancing soil health, cotton growth, yield, and fiber quality while promoting efficient water utilization in cotton production systems.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest to report regarding the present study.

REFERENCES

Abbas, S. 2022. Climate change and major crop production: evidence from Pakistan. Environmental Science and Pollution Research, 29:5406–5414

Abbass, K., Qasim, M. Z., Song, H., Murshed, M., Mahmood, H. and Younis, I. 2022. A review of the global climate change impacts, adaptation, and sustainable mitigation measures. Environmental Science and Pollution Research, 29:42539–42559

Abdukhalil, A. 2023. Increasing the economic efficiency of cotton growing in cotton clusters on scientific theory. The Journal of Economics, Finance and Innovation, 961–969

AghaKouchak, A., Chiang, F., Huning, L.S., Love, C. A., Mallakpour, I., Mazdiyasni, O., ... and Sadegh, M 2020. Climate extremes and compound hazards in a warming world. Annual Review of Earth and Planetary Sciences, 48:519–548

Anabaraonye, B, Okafor. J.C., Ewa, B. O, Anukwonke. C.C. 2021. The impacts of Climate Change on Soil Fertility in Nigeria. Clim Chang Microbiome Sustenance Ecosph 607–621

Anuja, J.K., Silas, V.J., Lal, M., Kishor, B. 2023. Effect of organic manure and mulching on growth, yield, and quality of cauliflower (Brassica oleracea var. botrytis L.)

Brito, C., Dinis, L.T, Moutinho-Pereira, J., Correia, C.M. 2019. Drought stress effects and olive tree acclimation under a changing climate. Plants 8:232

Chen, Y., Wen, X., Sun, Y., Zhang, J., Wu, W. and Liao, Y. 2014. Mulching practices altered soil bacterial community structure and improved orchard productivity and apple quality after five growing seasons. Sci Hortic (Amsterdam), 172:248–257

Chiarelli, D.D., D’Odorico, P., Müller, M.F., Mueller, N.D., Davis, K.F., Dell’Angelo, J., ...and Rulli, M.C. 2022. Competition for water induced by transnational land acquisitions for agriculture. Nature Communication, 13:505

El-Beltagi, H.S., Basit, A., Mohamed, H.I., Ali, I., Ullah, S., Kamel, E.A., ... and Ghazzawy, H.S. 2022. Mulching as a sustainable water and soil saving practice in agriculture: A review. Agronomy, 12:1881

El-Metwally, I.M, Saudy, H.S, Elewa, T.A 2022. Natural plant by-products and mulching materials to suppress weeds and improve sugar beet (Beta vulgaris L.) yield and quality. Journal of Soil Science and Plant Nutrition, 22:5217–5230

Gao, X., Fu, C., Li, M., Qi, X. and Jia, X. 2022. Effects of Biodegradation of Corn-Starch–Sodium-Alginate-Based Liquid Mulch Film on Soil Microbial Functions. International Journal of Environmental Research and Public Health, 19:8631

Hussain, S., Ahmad, A., Wajid, A., Khaliq, T., Hussain, N., Mubeen, M., ...and Nasim, W. 2020. Irrigation scheduling for cotton cultivation. Cotton Production and Uses: Agronomy, Crop Protection, p59–80

Hussian, I., Ahmad, R., Farooq, M., Wahid, A. 2013. Seed priming improves the performance of poor quality wheat seed. International Journal of Agriculture and Biology, 15:1343-1348

Iqbal, R., Raza, M.A.S., Valipour, M., Saleem, M.F., Zaheer, M.S., Ahmad, S. & Nazar, M.A. 2020. Potential agricultural and environmental benefits of mulches—a review. Bulletin of the National Research Centre, 44: 1-16.

Kaur, R, Bains, S., Sethi, M. 2020. Environment-friendly mulch mats from paddy straw. International Journal of Farm Sciences, 10:28–31

Khan, M.A., Wahid, A., Ahmad, M., Tahir, M. T., Ahmed, M., Ahmad, S. and Hasanuzzaman, M. 2020. World cotton production and consumption: An overview. Cotton production and uses: Agronomy, crop protection, and postharvest technologies, 1-7.

Khanpara, B.M., Vala, V.S. 2023. Cotton harvesting. International Journal of Agriculture Sciences, 19: 329–335

Kun, Á., Simon, B., Zalai, M., Kolozsvári, I., Bozán, C., Jancsó, M., ...and Bakti, B. 2023. Effect of mulching on soil quality in an agroforestry system irrigated with reused water. Agronomy, 13(6):1622

Lal. R. 2016. Soil health and carbon management. Food Energy Security, 5:212–222

Lee, G. W., Vine, K., Atkinson, A. R., Tong, M., Longman, J., Barratt, A., ...and Rahman, K.M. 2023. Impacts of climate change on health and health services in northern New South Wales, Australia: a rapid review. International Journal of Environmental Research and Public Health, 20(13): 6285.

Lesk, C., Anderson, W., Rigden, A., Coast, O., Jägermeyr, J., McDermid, S., ...and Konar, M. 2022. Compound heat and moisture extreme impacts on global crop yields under climate change. Nature Reviews Earth and Environment, 3(12): 872-889.

Ma, Z., Zhang, X., Zheng, B., Yue, S., Zhang, X., Zhai, B., ... and Razavi, B.S. 2021. Effects of plastic and straw mulching on soil microbial P limitations in maize fields: Dependency on soil organic carbon demonstrated by ecoenzymatic stoichiometry.

Geoderma, 388, 114928.

Malik, S., Chaudhary, K., Malik, A., Punia, H., Sewhag, M., Berkesia, N., ... and Boora, K. 2022. Superabsorbent polymers as a soil amendment for increasing agriculture production with reducing water losses under water stress condition. Polymers, 15(1), 161.

Mbatha. M.W. 2020. The Agricultural Sector in Improving the Country's Economy. Journal of African Foreign Affairs, 7:77–93

McTavish, M.J. and Murphy, S.D. 2022. Rapid redistribution and long-term aggregation of mulch residues by earthworms (Lumbricus terrestris). Applied Soil Ecology, 169:104195

Monteiro A. and Santos, S. 2022. Sustainable approach to weed management: The role of precision weed management. Agronomy, 12:118

Navyashree, S., Ajithkumar, B. and John C.L. 2019. Effect of mulches on soil chemical properties for enhancing yield of tomato (*Solanum lycopersicum* L.). J Agrometeorology, 248–252

Nguyen, T.T., Grote, U., Neubacher, F., Do, M.H. and Paudel, G.P. 2023. Security risks from climate change and environmental degradation: Implications for sustainable land use transformation in the Global South. Current Opinion in Environmental Sustainability, 63, 101322.

Prem, M., Ranjan, P., Seth, N., Patle, G.T. 2020. Mulching techniques to conserve the soil water and advance the crop production—A Review. Current World Environment, 15:10–30

Saeed, M., Maqbool, A., Ashraf, M. A., Arshad, M., Mehmood, K., Usman, M. and Farid, M.A. 2021. Competency of groundwater recharge of irrigated cotton field subjacent to sowing methods, plastic mulch, water productivity, and yield under climate change. Environmental Science and Pollution Research, 1-15.

Sahay, A. 2019. Cotton plantations in India: the environmental and social challenges. Yuridika 34:429–442

Scavo, A., Fontanazza, S., Restuccia, A., Pesce, G. R., Abbate, C. and Mauromicale, G. 2022. The role of cover crops in improving soil fertility and plant nutritional status in temperate climates. A review. Agronomy for Sustainable Development, 42(5): 93.

Shah F, Wu W (2020) Use of plastic mulch in agriculture and strategies to mitigate the associated environmental concerns. Adv Agron 164:231–287

Singhal, V., Ghose, J., Jinger, D. 2020. Cover crop technology–a way towards conservation agriculture: a review. Indian Journal of Agriculture Science, 12:2275–2284

Skendžić, S., Zovko, M., Živković, I. P., Lešić, V. and Lemić, D. 2021. The impact of climate change on agricultural insect pests. Insects, 12(5), 440.

Steel, R. 1997. Analysis of variance I: The one-way classification. Principles and procedures of statistics a biometrical approach, 139-203

Sun, X., Ye, Y., Liao, J., Soromotin, A. V., Smirnov, P. V. and Kuzyakov, Y. 2022. Organic Mulching Increases Microbial Activity in Urban Forest Soil. Forests, 13(9): 1352.

Tang, M., Liu, R., Li, H., Gao, X., Wu, P. and Zhang, C. 2023. Optimizing soil moisture conservation and temperature regulation in rainfed jujube orchards of China's Loess Hilly Areas Using Straw and Branch Mulching. Agronomy, 13(8): 2121.

Turmel, M. S., Speratti, A., Baudron, F., Verhulst, N., and Govaerts, B. 2015. Crop residue management and soil health: A systems analysis. Agricultural Systems, 134: 6-16.

Waheed, A., Li, C., Muhammad, M., Ahmad, M., Khan, K. A., Ghramh, H. A., ...and Zhang, D. 2023. Sustainable potato growth under straw mulching practices. Sustainability, 15(13): 10442.

Weissert, L.F., Salmond, J.A, Schwendenmann, L. 2016. Variability of soil organic carbon stocks and soil CO2 efflux across urban land use and soil cover types. Geoderma, 271: 80–90

Wheeler, R. and Lobley, M. 2021. Managing extreme weather and climate change in UK agriculture: Impacts, attitudes and action among farmers and stakeholders. Climate Risk Management, 32:100313

Zafar, M. M., Manan, A., Razzaq, A., Zulfqar, M., Saeed, A., Kashif, M., ...and Ren, M. 2021. Exploiting agronomic and biochemical traits to develop heat resilient cotton cultivars under climate change scenarios. Agronomy, 11(9): 1885.

Zhang, S., Wang, Y., Sun, L., Qiu, C., Ding, Y., Gu, H., ... and Ding, Z. 2020. Organic mulching positively regulates the soil microbial communities and ecosystem functions in tea plantation. BMC microbiology, 20: 1-13.

DOI: 10.33687/ijae.012.002.5228

Zheng, Y., Sun, X., Li, S., Zhou, W., Fan, Z., Du, T. and Qu, B. 2022. Soil erodibility after the removal of wood chip mulch: A wind tunnel experiment. Journal of Soil and Water Conservation, 77(5): 493-500.0