International Journal of Plant & Soil Science

Volume 38, Issue 8, Page 641-648, 2026; Article no.IJPSS.163396
ISSN: 2320-7035

Impact of different *in-situ* Moisture Conservation on Tree Fodder Yield in Degraded Wastelands of Silvipastoral System

M. Suganthi [a*], S. Gunasekaran [a], J. Ramesh [a] and C. Bandeswaran [b]

[a] *Institute of Animal Nutrition, Kattupakkam, Tamil Nadu Veterinary and Animal Sciences University, Chennai -51, India.*
[b] *Central Feed Technology Unit, Kattupakkam, Tamil Nadu Veterinary and Animal Sciences University, Chennai -51, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2026/v38i86247

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://pr.sdiarticle5.com/review-history/163396

Original Research Article

Received: 14/05/2026
Accepted: 30/07/2026
Published: 07/08/2026

Abstract

Land degradation caused by soil erosion can reduce soil-water retention and fodder productivity in silvipastoral systems. This study evaluated six *in-situ* moisture-conservation treatments in a 23-year-old *Gliricidia sepium*-based silvipastoral system established on degraded wasteland at Kattupakkam, Tamil Nadu, during the kharif and rabi seasons of 2024. The treatments were *Cenchrus ciliaris* leaf mulch (T1), *Stylosanthus* sp. leaf mulch (T2), residues of leftover Bajra Napier grass with goat manure (T3), Bajra Napier hybrid crop residue (T4), *G. sepium* leaf mulch (T5), and an unmulched control (T6). The experiment

---

**Corresponding author: E-mail: agrisuganthi@yahoo.com;*

Cite as: *Suganthi, M., Gunasekaran, S., Ramesh, J., & Bandeswaran, C. (2026). Impact of different in-situ Moisture Conservation on Tree Fodder Yield in Degraded Wastelands of Silvipastoral System. International Journal of Plant & Soil Science, 38(8), 641–648. https://doi.org/10.9734/ijpss/2026/v38i86247*

followed a randomised block design with six replications, each comprising three trees. Mulch was applied at 10 kg per treatment in trenches measuring 90 cm wide and 30 cm deep. Tree growth, fodder biomass, and selected soil properties were assessed. T1 recorded the highest total biomass yield (16.35 ± 0.72 t/ha), followed by T3 (16.12 ± 0.78 t/ha); these treatments were statistically at par. The control recorded the lowest biomass yield (14.18 ± 0.55 t/ha). After mulching, T3 recorded the highest soil nitrogen (363.00 ± 6.02 kg/ha) and potassium (175.20 ± 1.29 kg/ha), whereas T5 recorded the highest phosphorus (56.63 ± 0.28 kg/ha). Bulk density declined in all mulched treatments relative to the pre-mulching value but remained unchanged in the control. Locally available grass residues and goat-manure-associated fodder residues therefore showed potential for supporting fodder production and selected soil properties under the study conditions.

Keywords: In-situ moisture conservation; silvipastoral system; Gliricidia sepium; organic mulch; degraded wasteland; fodder biomass; soil bulk density; goat manure; soil nutrients; dryland restoration.

1. Introduction

Soil erosion is one of the main causes of land degradation (Ali *et al.,* 2017). An estimated 24 billion tonnes of fertile soil, an essential non-renewable geo-resource, are lost every year because of erosion worldwide (Food and Agriculture Organization of the United *Nations [FAO],* 2022). Nearly 29.32% (96.4 Mha) of India's total geographical area is affected by land degradation (National Academy of Agricultural Sciences [NAAS], 2022). Gross soil erosion in India has been estimated at 5.11 billion tonnes per year (Sharda & Ojasvi, 2016). Of this total, approximately 23% is transported outside the country, mainly to the oceans, 34% is deposited in reservoirs, and 43% is redistributed within river basins (Sharda & Ojasvi, 2016). An official synthesis estimated annual economic losses from land degradation and land-use change at US$46.90 billion in 2014–15 (NAAS, 2022). Recent global modelling confirms that water erosion remains a major threat to soil functions and that land-use and climate trajectories may intensify erosion pressure in vulnerable regions (Borrelli et al., 2017, 2020). Because erosion removes nutrient-rich topsoil and weakens water-storage capacity, restoration strategies should combine surface protection with measures that rebuild soil structure and organic matter (Kader et al., 2017; Prosdocimi et al., 2016).

To achieve Sustainable Development Goal 15 and land-degradation neutrality, India has pledged to restore 26 million hectares of degraded land by 2030 (NAAS, 2022). Bioengineering is a cost-effective, long-term, sustainable, and practical approach to restoring degraded ecosystems (Ali *et al*., 2020). Among the different conservation methods, mulching and trenching are widely used and preferred surface-runoff conservation measures for non-arable lands across slopes of 2–33% in both low- and high-rainfall areas (Ali et al., 2024). Developing a suitable silvopastoral system together with *in-situ* moisture conservation can increase system productivity, enhance fodder availability, and reduce soil erosion (Soni *et al*., 2013; Sharma, 2014; Tanwar *et al.,* 2018). Organic mulches can reduce raindrop impact and overland flow while moderating soil temperature and evaporation, although the magnitude of these effects varies with the mulch material, application rate, slope, and climate (Kader et al., 2017; Mulumba & Lal, 2008; Prosdocimi et al., 2016). In degraded drylands, integrating woody perennials with forage components can support rehabilitation by improving ground cover, nutrient cycling, and the temporal distribution of feed (Jose & Dollinger, 2019; Murgueitio et al., 2011).

In silvipastoral systems, grasses provide green forage during the monsoon season, while trees provide top feed during the winter and summer seasons (Kumar *et al*., 2017; Ram *et al*., 2019). Silvopastoral systems may therefore buffer seasonal feed shortages while providing soil-protection and microclimatic benefits; however, their productivity depends on compatible tree-forage combinations and site-specific management of water and nutrients (Jose & Dollinger, 2019; Murgueitio et al., 2011). Evidence from *Gliricidia*-based agroforestry also indicates that the species can influence soil nutrient status and crop microclimate, supporting its evaluation as a multipurpose tree component under moisture-conserving management (Marin et al., 2006).

A recent synthesis focused on India identifies silvopastoral systems as a practical approach for combining fodder production with soil- and land-management functions, while emphasising the need for site-specific species selection and management (Kumar et al., 2025). Comparative evidence from established silvopastures indicates that tree-forage integration can improve soil water status and overall soil quality without necessarily reducing forage production, although the magnitude of the response depends on system design and local conditions

(Amorim et al., 2023). Evidence from diversified restoration models on degraded land in India further supports the potential of tree-based agricultural systems to improve soil physicochemical properties and soil carbon pools (Meena et al., 2024). In perennial foliage production, recycling locally generated organic residues as manure has also been associated with improved soil nutrient status and microbial abundance, supporting the evaluation of similar circular organic inputs in tree-based systems (Shravanilakshmi et al., 2025).

However, the comparative performance of locally available organic mulch materials in an established *Gliricidia*-based silvipastoral system on degraded wasteland remains insufficiently documented, particularly with respect to biomass yield and post-mulching soil properties under the conditions of the present study.

In view of this gap, the present study evaluated the effects of different *in-situ* moisture-conservation techniques on the fodder-production potential of *Gliricidia* under degraded wasteland conditions in a silvipastoral system.

2. Materials and Methods

This experiment was conducted during *the Kharif* and *Rabi* seasons of 2024 in an established 23-year-old *Gliricidia sepium*-based silvipastoral system on degraded wasteland at the Institute of Animal Nutrition, Kattupakkam, Tamil Nadu. The system comprised the fodder tree *Gliricidia sepium* with *Stylosanthes hamata* as the understorey. The soil at the site had a sandy-loam texture. The annual precipitation in the study area was 1,981 mm.

Treatment details

The experiment comprised six treatments.

The experiment was laid out in a randomised block design with six replications. Each replication included three trees.

The treatments were as follows:

T1 - *Cenchrus ciliaris* leaf mulch
T2 - *Stylosanthus sp*. leaf mulch
T3 - Residues of leftover Bajra Napier grass + goat manure
T4 - Crop residue (Bajra Napier hybrid crop residue)
T5 - *Gliricidia sepium* leaf mulch
T6 - Control (without any mulch)

In the existing silvipastoral system on degraded wasteland, the following in-situ soil-moisture conservation treatments were applied around *Gliricidia sepium* trees: *Cenchrus ciliaris* leaf mulch, *Stylosanthus sp*. leaf mulch, residues of leftover Bajra Napier grass + goat manure, crop residue (Bajra Napier hybrid crop residue), *Gliricidia sepium* leaf mulch, and a control without mulch. Leaf mulches were collected and allowed to dry partially. Trenches measuring 90 cm in width and 30 cm in depth were formed around the *Gliricidia* trees and filled with the mulch material specified for each treatment. A uniform quantity of 10 kg of mulch was applied per treatment. The materials were placed in 90-cm-wide trenches around each *Gliricidia sepium fodder tree.*

Data on the number of branches, stem weight, leaf weight, and palatable stem weight were recorded. A fresh 500-g sample was collected randomly from each plot, pooled across both seasons, and dried in a hot-air oven at 70 °C to estimate dry matter and crude protein. Available soil moisture was measured at a depth of 15–30 cm, and soil samples were collected. The measurements were recorded using standard methods, and the data were analysed by analysis of variance (ANOVA) using IBM SPSS.

3. Results and Discussion

The effects of different *in-situ* moisture-conservation measures on soil physical parameters and biomass yield in a degraded-wasteland silvipastoral system were evaluated, and the data are presented in Tables 1–3.

Table 1. Soil physical parameters in silvipasture system on *Gliricidia sepium* yield in degraded waste land (Mean* ± SE) (Before mulching)

System	Soil pH	Electrical Conductivity (EC) (ds/m)	Bulk density	Texture	Nitrogen (Kg/ha)	Phosphorus (Kg/ha)	Potassium (Kg/ha)
Silvipasture in degraded waste land	7.11 ± 0.11	0.07 ± 0.01	1.33 ± 0.01	Sandy loam	180.87 ± 2.14	28.45 ± 0.95	105.68 ± 1.00

**Mean of six replications*

Table 2. Effect of different moisture conservation methods on *Gliricidia sepium* yield in silvipasture system (Mean ± SE)

Parameters	T1	T2	T3	T4	T5	T6
No. of branches	$34.00^{c} \pm 4.10$	$27.25^{bc} \pm 2.35$	$21.00^{ab} \pm 5.87$	$27.00^{bc} \pm 2.61$	$20.25^{ab} \pm 3.07$	$14.00^{a} \pm 4.45$
Stem weight	$14.04^{c} \pm 2.19$	$10.57^{ab} \pm 0.80$	$9.66^{ab} \pm 2.41$	$13.12^{b} \pm 1.01$	$6.98^{a} \pm 0.48$	$6.15^{a} \pm 2.14$
Leaf weight	$6.40^{b} \pm 1.86$	$2.72^{ab} \pm 0.62$	$3.72^{ab} \pm 1.02$	$5.18^{b} \pm 1.23$	$3.36^{ab} \pm 0.89$	$1.25^{a} \pm 0.99$
Palatable stem weight	$0.28^{c} \pm 0.08$	$0.14^{ab} \pm 0.04$	$0.21^{ab} \pm 0.04$	$0.21^{ab} \pm 0.01$	$0.14^{ab} \pm 0.03$	$0.05^{a} \pm 0.034$
Total biomass yield (t/ha)	$16.35^{b} \pm 0.72$	$15.98^{ab} \pm 0.63$	$16.12^{b} \pm 0.783$	$15.80^{ab} \pm 0.35$	$15.48^{ab} \pm 0.24$	$14.18^{a} \pm 0.55$

**Mean of six replications. Mean bearing different superscripts within rows differ significantly(P<0.05)*

Table 3. Soil physical parameters in silvipasture system on *Gliricidia sepium* yield in degraded waste land (Mean* ± SE) (After mulching)

Treatment	Soil pH	EC (ds/m)	Bulk density	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)
T1	$6.48^{b} \pm 0.08$	$0.08^{b} \pm 0.002$	$1.22^{b} \pm 0.01$	$274.57^{c} \pm 4.59$	$49.07^{c} \pm 0.70$	$92.08^{a} \pm 1.00$
T2	$5.70^{a} \pm 0.14$	$0.12^{c} \pm 0.01$	$1.23^{b} \pm 0.01$	$238.33^{a} \pm 1.02$	$44.47^{b} \pm 0.95$	$150.02^{d} \pm 0.58$
T3	$6.15^{b} \pm 0.23$	$0.14^{d} \pm 0.01$	$1.22^{b} \pm 0.01$	$363.00^{d} \pm 6.02$	$47.72^{c} \pm 1.26$	$175.20^{f} \pm 1.29$
T4	$5.67^{a} \pm 0.21$	$0.09^{b} \pm 0.001$	$1.25^{bc} \pm 0.01$	$238.00^{a} \pm 1.07$	$39.27^{a} \pm 0.25$	$139.50^{c} \pm 1.34$
T5	$5.98^{ab} \pm 0.24$	$0.06^{a} \pm 0.001$	$1.18^{a} \pm 0.01$	$240.13^{ab} \pm 3.30$	$56.63^{d} \pm 0.28$	$158.52^{e} \pm 0.56$
T6	$5.975^{ab} \pm 0.28$	$0.05^{a} \pm 0.001$	$1.33^{c} \pm 0.01$	$256.17^{b} \pm 3.74$	$48.98^{c} \pm 1.53$	$135.60^{b} \pm 2.43$

**Mean of six replications. Mean bearing different superscripts within columns differ significantly(P<0.05)*

Among the i*n-situ* soil-moisture conservation treatments, *Cenchrus ciliaris* leaf mulch *(T1) and* residues of leftover Bajra Napier grass + goat manure (T3) recorded the highest biomass yields of *Gliricidia* and were statistically at par. T1 recorded 16.35 ± 0.72 t/ha, followed by T3 with 16.12 ± 0.78 t/ha. The control recorded the lowest biomass yield.

In terms of soil physical properties, the soil pH was closer to neutral under *Cenchrus ciliaris* leaf mulch and residues of leftover Bajra Napier grass + goat manure than under the other treatments. Bulk density was lower after mulching in all treatments except the control. The highest soil nitrogen content (363.00 ± 6.02 kg/ha) and potassium content (175.20 ± 1.29 kg/ha) were observed under residues of leftover Bajra Napier grass + goat manure, whereas the highest phosphorus content (56.63 ± 0.28 kg/ha) was observed under *Gliricidia sepium* leaf mulch.

Bulk density was lower after mulching in all treatments except the control, relative to the pre-mulching value. Soil bulk density is important for plant growth, particularly root penetration, and can therefore affect crop yield. A decrease in bulk density can improve water and nutrient uptake and availability, thereby supporting tree-fodder biomass production. Liu *et al*. (2014) reported that crop-residue mulch improved soil physical properties and the soil microclimate, which subsequently increased crop yield. Conversely, high soil bulk density can adversely affect soil physical properties, limit microbial activity, and restrict biochemical processes that are important for nutrient availability. The observed reduction in bulk density under mulched treatments is consistent with the capacity of surface organic residues to protect aggregates, moderate raindrop impact, and conserve near-surface water (Mulumba & Lal, 2008; Prosdocimi et al., 2016). Because lower bulk density generally corresponds to greater pore space and improved root exploration, this response provides a plausible physical mechanism for the higher biomass recorded under *Cenchrus ciliaris* leaf mulch (T1) and residues of leftover Bajra Napier grass + goat manure (T3); however, infiltration and root growth were not measured directly in the present experiment (Celik et al., 2004; Kader et al., 2017).

Cenchrus leaf mulch recorded the highest biomass yield of *Gliricidia*, followed closely by residues of leftover Bajra Napier grass + goat manure. The favourable performance of T3 may have been associated with improved moisture availability. Saputra *et al.* (2023) characterised bokashi produced from Etawa goat faeces as an organic fertiliser, supporting the potential value of goat manure as an organic input. The comparable total biomass yields of *Cenchrus ciliaris* leaf mulch (T1) and residues of leftover Bajra Napier grass + goat manure (T3) suggest that the response was not determined solely by nutrient addition: residue cover may have reduced evaporation and buffered soil temperature, whereas goat manure may have supplied mineralisable nutrients and organic carbon (Diacono & Montemurro, 2010; Kader et al., 2017). Long-term evidence indicates that manure effects on crop performance vary with decomposition rate, nutrient composition, and soil conditions; therefore, the superior nutrient status under residues of leftover Bajra Napier grass + goat manure (T3) should be interpreted as treatment-specific rather than universally applicable (Edmeades, 2003; Haynes & Naidu, 1998).

Increasing soil porosity can improve soil structure and thereby support crop yield. Soil aeration influences water and nutrient uptake, whereas poor infiltration can restrict these processes. Sunarya and Sumarsih (2017) reported that animal-manure application and soil-moisture treatments improved growth parameters of *Fimbristylis globulosa*, including plant height, tiller number, fresh weight, and biomass yield. Organic amendments can reduce soil compactness and promote aggregation, thereby increasing total porosity and the continuity of water- and air-filled pores (Celik et al., 2004; Haynes & Naidu, 1998). This mechanism is compatible with the lower post-mulching bulk density observed in the present study, but direct measurements of porosity, infiltration, and soil aeration would be required to confirm the proposed pathway (Mulumba & Lal, 2008).

Soil nitrogen, phosphorus, and potassium contents were higher after mulching than before mulching. Increased soil nitrogen was observed under residues of leftover Bajra Napier grass + goat manure (T3) and may partly explain its favourable tree-fodder yield. The higher soil N, P, and K concentrations after mulching are consistent with nutrient release during decomposition and with improved retention of nutrient ions in soils receiving organic inputs (Diacono & Montemurro, 2010; Edmeades, 2003). The particularly high N and K values under residues of leftover Bajra Napier grass + goat manure (T3) may reflect the combined contribution of fodder residues and goat manure, whereas the higher P value under *Gliricidia* leaf mulch may be related to the nutrient composition and mineralisation behaviour of the applied biomass (Haynes & Naidu, 1998; Marin et al., 2006).

Nevertheless, because the nutrient inputs of the individual mulch materials were not chemically characterised, these explanations should be considered plausible mechanisms rather than direct causal evidence.

4. Conclusion

In-situ organic mulching supported fodder biomass production and improved selected soil properties in the established *Gliricidia sepium*-based silvipastoral system on degraded wasteland. *Cenchrus ciliaris* leaf mulch produced the highest total biomass yield (16.35 ± 0.72 t/ha), while residues of leftover Bajra Napier grass combined with goat manure produced a statistically comparable yield (16.12 ± 0.78 t/ha). The unmulched control recorded the lowest yield (14.18 ± 0.55 t/ha). The residue-and-goat-manure treatment also recorded the highest post-mulching soil nitrogen and potassium contents, whereas *Gliricidia sepium* leaf mulch recorded the highest phosphorus content. Bulk density was lower after mulching in all mulched treatments but remained unchanged in the control, indicating that surface organic inputs may support favourable soil physical conditions. Under the conditions of this study, locally available *Cenchrus* leaf material and leftover fodder residues combined with goat manure appear suitable for moisture-conservation management in *Gliricidia*-based silvipastoral systems. Wider recommendations require validation across additional locations, seasons, soil types, and rainfall conditions.

5. Limitations

The study was conducted at one location within a single established silvipastoral system, which limits wider generalisation. Seasonal rainfall distribution, plot size, treatment-allocation details, and post hoc statistical procedures were not fully reported. Soil moisture, infiltration, porosity, root growth, and the nutrient composition and decomposition rates of the mulch materials were not directly measured. Consequently, the mechanisms linking mulch application with biomass yield and post-mulching soil properties could not be confirmed directly.

Declaration of AI Use

This manuscript was prepared through the combined contributions of all author(s), including contributions to the study design, data, content development, results, interpretation, and related scholarly work. The author(s) acknowledge the use of Grammarly and ChatGPT to assist with grammar checking, language refinement, reference formatting. These AI-assisted tools were not used as authors and did not replace the intellectual contributions or scholarly judgment of the author(s). All AI-assisted outputs, including content, references, and interpretations, were carefully reviewed, revised, verified, and approved by the author(s). The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that no competing interests exist.

References

Ali, S., Sethy, B. K., Mina, B. L., Meena, H. R., Kala, S., Kumar, A., Rashmi, I., Meena, G. L., & Sharma, G. K. (2024). Treatment effects of conservation trenching on regulating and provisioning ecosystem services. *Journal of Environmental Management, 370*, Article 122924. https://doi.org/10.1016/j.jenvman.2024.122924

Ali, S., Sethy, B. K., Parandiyal, A. K., Kumar, A., Singh, R. K., Somasundaram, J., & Mina, B. L. (2020). Long-term effects of rainwater conservation measure on improving yield, runoff use efficiency and soil properties of horti-pastoral system on the degraded ravine lands of India. *Agricultural Water Management, 233*, Article 106068. https://doi.org/10.1016/j.agwat.2020.106068

Ali, S., Sethy, B. K., Singh, R. K., Parandiyal, A. K., & Kumar, A. (2017). Quantification of hydrologic response of staggered contour trenching for horti-pastoral land use system in small ravine watersheds: A paired watershed approach. *Land Degradation & Development, 28*(4), 1237–1252. https://doi.org/10.1002/ldr.2517

Amorim, H. C. S., Ashworth, A. J., O'Brien, P. L., Thomas, A. L., Runkle, B. R. K., & Philipp, D. (2023). Temperate silvopastures provide greater ecosystem services than conventional pasture systems. *Scientific Reports, 13*, Article 18658. https://doi.org/10.1038/s41598-023-45960-0

Borrelli, P., Robinson, D. A., Fleischer, L. R., Lugato, E., Ballabio, C., Alewell, C., Meusburger, K., Modugno, S., Schütt, B., Ferro, V., Bagarello, V., Van Oost, K., Montanarella, L., & Panagos, P. (2017). An assessment of the global impact of 21st century land use change on soil erosion. *Nature Communications, 8*, Article 2013. https://doi.org/10.1038/s41467-017-02142-7

Borrelli, P., Robinson, D. A., Panagos, P., Lugato, E., Yang, J. E., Alewell, C., Wuepper, D., Montanarella, L., & Ballabio, C. (2020). Land use and climate change impacts on global soil erosion by water (2015–2070). *Proceedings of the National Academy of Sciences of the United States of America, 117*(36), 21994–22001. https://doi.org/10.1073/pnas.2001403117

Celik, I., Ortas, I., & Kilic, S. (2004). Effects of compost, mycorrhiza, manure and fertilizer on some physical properties of a Chromoxerert soil. *Soil and Tillage Research, 78*(1), 59–67. https://doi.org/10.1016/j.still.2004.02.012

Diacono, M., & Montemurro, F. (2010). Long-term effects of organic amendments on soil fertility: A review. *Agronomy for Sustainable Development, 30*, 401–422. https://doi.org/10.1051/agro/2009040

Edmeades, D. C. (2003). The long-term effects of manures and fertilisers on soil productivity and quality: A review. *Nutrient Cycling in Agroecosystems, 66*, 165–180. https://doi.org/10.1023/A:1023999816690

Food and Agriculture Organization of the United Nations. (2022). *Science and innovation forum: Innovations in soil and plant nutrient management*. https://www.fao.org/global-soil-partnership/areas-of-work/soil-fertility/Science-and-Innovation-Forum/en/

Haynes, R. J., & Naidu, R. (1998). Influence of lime, fertilizer and manure applications on soil organic matter content and soil physical conditions: A review. *Nutrient Cycling in Agroecosystems, 51*, 123–137. https://doi.org/10.1023/A:1009738307837

Jose, S., & Dollinger, J. (2019). Silvopasture: A sustainable livestock production system. *Agroforestry Systems, 93*, 1–9. https://doi.org/10.1007/s10457-019-00366-8

Kader, M. A., Senge, M., Mojid, M. A., & Ito, K. (2017). Recent advances in mulching materials and methods for modifying soil environment. *Soil and Tillage Research, 168*, 155–166. https://doi.org/10.1016/j.still.2017.01.001

Kumar, A., Vaishnav, R., Deori, C., Timung, B., Roy, S., Pradhan, R., Prakash, R., & Bochalya, R. S. (2025). Silvopastoral systems in India for fodder production and livestock sustainability: A review. *Journal of Experimental Agriculture International, 47*(3), 112–135. https://doi.org/10.9734/jeai/2025/v47i33321

Kumar, R. V., Singh, H. V., Kumar, S., Roy, A. K., & Singh, K. A. (2017). Growth and biomass production of fodder trees and grasses in a silvipasture system on non-arable land of semi-arid India. *Range Management and Agroforestry, 38*(1), 43–47. https://www.indianjournals.com/article/rma-38-1-006

Liu, E. K., He, W. Q., & Yan, C. R. (2014). 'White revolution' to 'white pollution': Agricultural plastic film mulch in China. *Environmental Research Letters, 9*(9), Article 091001. https://doi.org/10.1088/1748-9326/9/9/091001

Marin, A. M. P., Menezes, R. S. C., Silva, E. D., & Sampaio, E. V. S. B. (2006). Efeito da *Gliricidia sepium* sobre nutrientes do solo, microclima e produtividade do milho em sistema agroflorestal no Agreste Paraibano. *Revista Brasileira de Ciência do Solo, 30*(3), 555–564. https://doi.org/10.1590/S0100-06832006000300015

Meena, R. S., Pradhan, G., Singh, K., Kumar, S., Singh, A. K., Shashidhar, K. S., Mina, K. K., & Rao, C. S. (2024). Agriculture models for restoring degraded land to enhance CO_2 biosequestration and carbon credits in the Vindhyan region of India. *Science of the Total Environment, 929*, Article 172661. https://doi.org/10.1016/j.scitotenv.2024.172661

Mulumba, L. N., & Lal, R. (2008). Mulching effects on selected soil physical properties. *Soil and Tillage Research, 98*(1), 106–111. https://doi.org/10.1016/j.still.2007.10.011

Murgueitio, E., Calle, Z., Uribe, F., Calle, A., & Solorio, B. (2011). Native trees and shrubs for the productive rehabilitation of tropical cattle ranching lands. *Forest Ecology and Management, 261*(10), 1654–1663. https://doi.org/10.1016/j.foreco.2010.09.027

National Academy of Agricultural Sciences. (2022). *Road map for rehabilitation of 26 Mha degraded lands in India* (Policy Paper No. 117). https://naas.org.in/Policy%20Papers/Policy%20117.pdf

Prosdocimi, M., Tarolli, P., & Cerdà, A. (2016). Mulching practices for reducing soil water erosion: A review. *Earth-Science Reviews, 161*, 191–203. https://doi.org/10.1016/j.earscirev.2016.08.006

Ram, S. N., Kumar, R. V., & Shukla, A. K. (2019). Influence of shrubs and tree densities on three-tier silvopasture components in semiarid rainfed conditions. *Range Management and Agroforestry, 40*(1), 104–108. https://www.indianjournals.com/article/rma-40-1-012

Saputra, I., Syaiful, S. A., & Musa, Y. (2023). Characteristics of bokashi organic fertilizer from Etawa goat feces. *IOP Conference Series: Earth and Environmental Science, 1230*(1), Article 012192. https://doi.org/10.1088/1755-1315/1230/1/012192

Sharda, V. N., & Ojasvi, P. R. (2016). A revised soil erosion budget for India: Role of reservoir sedimentation and land-use protection measures. *Earth Surface Processes and Landforms, 41*(14), 2007–2023. https://doi.org/10.1002/esp.3965

Sharma, K. C. (2014). Production potential of fodder crops sequences in association with ber (*Zizyphus mauritiana* Lamk.) under agri-horticulture system in hot arid ecosystem of western India. *Range Management and Agroforestry, 35*(2), 188–192. https://www.indianjournals.com/article/rma-35-2-003

Shravanilakshmi, V., Kallimani, C. S., Veenita, M. K., Tejaswini, A. S., Shwetha, G. V., Gagana Sindhu, S., & Doreswamy, C. (2025). Influence of silkworm litter liquid organic manure on soil nutrient status and microbial population in mulberry plantation. *Plant Cell Biotechnology and Molecular Biology, 26*(7–8), 456–470. https://doi.org/10.56557/pcbmb/2025/v26i7-89586

Soni, M. L., Yadava, N. D., Beniwal, R. K., Singh, J. P., Kumar, S., & Birbal. (2013). Grass based strip cropping systems for controlling soil erosion and enhancing system productivity under drought situations of hot arid western Rajasthan. *International Journal of Agricultural and Statistical Sciences, 9*(2), 685–692. https://connectjournals.com/file_html_pdf/1819102H_9-685-692a.pdf

Sunarya, Y., & Sumarsih, E. (2017). The effect of soil moisture content and animal manure application on the growth of mendong (*Fimbristylis globulosa* (Retz.) Kunt). *Journal of Tropical Soils, 22*(2), 107–112. https://doi.org/10.5400/jts.2017.v22i2.107-112

Tanwar, S. P. S., Bhati, T. K., Singh, A., Patidar, M., Mathur, B. K., Kumar, P., & Yadav, O. P. (2018). Rainfed integrated farming systems in arid zone of India: Resilience unmatched. *Indian Journal of Agronomy, 63*(4), 403–414. https://doi.org/10.59797/ija.v63i4.5671

Peer-review history:
The peer review history for this paper can be accessed here:
https://pr.sdiarticle5.com/review-history/163396