Plant Sci. Arc.
Plant Science Archives
An International Journal of Plant Biology

Original Research Article
ISSN 2518-6965
Journal Homepage: www.plantarc.com

Herbaceous biomass variation across contrasting riparian conditions along the Tsurang River, Nagaland, North-East India

Seyievino Catherine Chasie[1], **Maibam Romeo Singh**[1], **Neizo Puro***[1], **and Wati Temjen**[2]

[1]*Department of Botany, Nagaland University Lumami- 798627, India*
[2]*Department of Botany, Fazl Ali College, Mokokchung- 798601, India*

Citation: Seyievino Catherine Chasie, Maibam Romeo Singh, Neizo Puro, and Wati Temjen (2026). Herbaceous biomass variation across contrasting riparian conditions along the Tsurang River, Nagaland, North-East India. *Plant Science Archives.*
DOI: https://doi.org/10.51470/PSA.2026.11.2.112

Corresponding Author: **Neizo Puro** | E-Mail: **(romeomaibam@nagalanduniversity.ac.in)**

Received 21 March 2026 | Revised 17 April 2026 | Accepted 20 May 2026 | Available Online 22 June 2026

ABSTRACT

Riparian herbaceous vegetation is highly sensitive to environmental disturbances and serves as an effective indicator of ecosystem health and stability. The research was conceived from field observations along the Tsurang River under Changki village, where one riparian stretch is exposed to grazing, periodic flooding, and proximity to drainages originating from coal-mining areas, while another retains relatively natural forest vegetation. These contrasting conditions provided the basis for proposing a comparative assessment of herbaceous biomass as an indicator of riparian condition. Accordingly, this study assessed above-ground (AG) and below-ground (BG) herbaceous biomass at two riparian habitats along Tsurang River, Nagaland, North-East India: An Impacted Site (IS) exposed to anthropogenic disturbances and a Reference Site (RS) under relatively natural forest conditions. Herbaceous biomass was quantified monthly over one annual growing cycle (January 2023–January 2024) using the harvest method. The RS produced greater AG and BG biomass consistently, indicating more favourable soil moisture and nutrient conditions that supported greater plant productivity and root development. The IS, in contrast, was dominated by disturbance-tolerant grasses and opportunistic species that exhibited comparatively higher AG biomass during parts of the growing season with lower BG biomass. One-way ANOVA showed no significant seasonal variation in AG biomass at the IS ($F = 1.329$, $p = 0.325$) and the RS ($F = 1.468$, $p = 0.288$). However, BG biomass varied significantly among seasons at both the IS ($F = 4.627$, $p = 0.032$) and the RS ($F = 4.004$, $p = 0.043$). Mann Whitney test also found significant difference between the two sites BG biomass, $p = 0.026$ where RS generated a mean rank of 16.85, higher than IS (mean rank = 10.15) indicating greater BG biomass at RS. Both sites exhibited higher BG biomass during winter, suggesting increased allocation of resources to underground organs before the subsequent growing season. In providing an estimation of biomass repeatedly across one annual growing cycle, this study offers a detailed understanding of herbaceous productivity under contrasting riparian conditions. The findings demonstrate the potential of herbaceous biomass as indicators of riparian disturbance and provide baseline information for ecological monitoring, restoration, and conservation of riparian ecosystems in North-East India.

Keywords: *Harvest method, Herbs, Monthly biomass, Riparian site.*

Introduction

Riparian forests form transitional zones between terrestrial and aquatic ecosystems and are among the most productive and species-rich habitats, providing essential ecological functions such as nutrient retention, pollutant filtration, and bank stabilization [1,2,3]. Within these ecosystems, the herbaceous layer constitutes the largest proportion of plant diversity and responds rapidly to environmental change, making it a reliable indicator of ecosystem condition and disturbance [4,5,6].

Herbaceous vegetation contributes substantially to primary productivity, nutrient cycling, soil stabilization, and energy flow through the production and turnover of biomass [7,8,9,10]. Owing to their rapid regeneration and short life cycles, herb species respond more quickly to environmental disturbances than woody vegetation, making herbaceous biomass an effective measure of vegetation dynamics and ecosystem recovery [11,12,13]. Variations in above-ground and below-ground biomass also reflect changes in soil moisture, nutrient availability, and seasonal resource allocation [5,14].

Within Nagaland, the importance of below-ground edaphic conditions has also been demonstrated through studies of rhizospheric soils, where soil physicochemical characteristics and fungal communities were examined in relation to soil health [15].

Riparian habitats are increasingly affected by land-use change, grazing, and other anthropogenic disturbances, which alter species composition and biomass production [6]. Disturbance often favours fast-growing, opportunistic species that dominate community biomass and influence ecosystem functions, including nutrient cycling and phytoremediation potential [12,16].

The present investigation originated from field observations along the Tsurang River under Changki village, Mokokchung district, where riparian stretches occur under markedly contrasting conditions. One stretch is exposed to grazing, periodic flooding, and proximity to drainages originating from coal-mining areas, whereas another retains relatively natural forest vegetation.

This contrast provided the basis for proposing a comparative assessment of herbaceous biomass to determine whether disturbance is reflected in above-ground and below-ground biomass production.

Although several studies have examined herbaceous biomass dynamics in riparian ecosystems [7,8,12,13,14,17], information on biomass variation under contrasting disturbance conditions remains limited. Therefore, this study compares above-ground and below-ground herbaceous biomass between an anthropogenically impacted riparian site and a relatively undisturbed reference site along the Tsurang River, Nagaland, North-East India.

Materials and Methods

Study area

To compare the influence of site conditions on changes in monthly herb biomass production, two sites were selected along Tsurang river under Changki village in Mokokchung district of Nagaland. The first site selected was labelled as "Impacted Site" (IS): Latitude: 26^{0}48′47.8″N and Longitude 94^{0}34′24.8″E, where the riparian area was exposed to anthropogenic disturbances such as the frequency of animal grazing, periodic flooding and the site's proximity to drainages sourced from coal mine sites. A second site labelled as "Reference Site" (RS) of natural forest: Latitude 26^{0}47′82.4″N and Longitude 94^{0}33′16.1″E, was selected to compare with the IS biomass and to estimate the differences in above-ground (AG) and below-ground (BG) biomass production. Four seasons were demarcated for the study, *viz* Spring (Feb, 2023 to Apr, 2023), Summer (May, 2023 to Jul, 2023), Autumn (Aug, 2023 to Oct, 2023) and Winter (Nov, 2023 to Jan, 2024).

Sampling design

A 50m x 50m area was demarcated on both sites IS and RS, stretching from the edge of the riparian vegetation. For harvesting the AG and BG herbaceous biomass, fifteen 1m x 1m quadrats were sampled at random for 13 months [7] on both sites from January 2023 to January 2024 to complete one growing cycle. Monthly collection was done to identify the peak of herb biomass.

Biomass collection and dry weight estimation

Biomass was harvested on site, segregated into AG and BG, and brought back to the laboratory, where samples were thoroughly washed to remove all soil debris. AG and BG biomass samples were then oven-dried until constant weight was achieved. All sample dry weights were recorded using a weighing balance and calculated as "g/m^2".

Statistical Analysis

To determine whether biomass differed significantly among seasons, a one-way Analysis of Variance (ANOVA) was performed. Statistical significance was assessed at $p < 0.05$. All statistical analyses were performed using IBM SPSS Statistics.

Results and Discussion

Table 1: List of herbaceous species collected

Herbaceous Species	Family	Reference Site (RS)	Impacted Site (IS)
Arundo donax L.	Poaceae	+	+
Arundinella setosa Trin.	Poaceae	+	+
Ageratum conyzoides L.	Asteraceae	+	+
Aramanthus spinosus L	Amaranthaceae	+	-
Alpinia nigra (Gaertn.) B.L. Burtt	Zingiberaceae	+	+
Alternanthera sessilis (L.) R.Br. ex DC.	Amaranthaceae	+	-
Blechnum orientale L.	Blechnaceae	+	+
Boehmeria macrophylla Hornem.	Fabaceae	+	-
Bidens pilosa Linn. Var. Radiata	Asteraceae	+	+
Crassocephalum crepidioides (Benth.) S. Moore	Asteraceae	+	+
Chromolaena odorota (L.) R.M. King & H. Rob	Asteraceae	+	+
Colocassia esculenta (L.) Schott	Araceae	+	+
Cyperus cyperoides (L.) Kuntze	Cyperaceae	+	+
Cyperus compactus Retz.	Cyperaceae	+	+
Cyperus rotundus L.	Cyperaceae	+	-
Cyperus odoratus L.	Cyperaceae	+	+
Cyperus iria L.	Cyperaceae	+	+
Cuphea carthagenensis (Jacq.) J.F.Macbr.	Lythraceae	+	+
Cyclosorus dentata (Forssk.) Ching	Thelypteridaceae	+	+
Digitaria setigera Roth	Poaceae	+	+
Diplazium esculentum (Retz.) Sw.	Athyriaceae	+	+
Dicranopteris linearis (Burm. Fil.) Underw.	Gleicheniaceae	-	+
Euphorbia hirta L.	Euphorbiaceae	+	+
Erigeron linifolius Willd.	Asteraceae	+	-
Eleusine indica (L.) Gaertn.	Poaceae	+	+
Fimbristylis dichotoma (L.) Vahl.	Cyperaceae	+	+
Gnaphalium polycaulon P.	Asteraceae	+	+
Hyptis brevipes Poit.	Lamiaceae	+	+
Hypoestes phyllostachya Baker	Acanthaceae	+	-
Kyllinga brevifolia Rottb.	Cyperaceae	+	+
Lycopodium cernuum L.	Sellaginellaceae	+	-
Lygodium flexuosum (L.) Sw.	Lygodiaceae	-	+
Ludwigia sp	Onagraceae	+	-
Mimosa pudica L.	Leguminoceae	+	+
Mitracarpus hirtus (L.) DC.	Rubiaceae	+	+
Microlepia sp.	Dennstaedtiaceae	+	-
Musa sp.	Musaceaa	+	+
Acmella paniculate (Wall. Ex. DC.) R.K. Jansen	Asteraceae	+	-
Oxalis debilis Kunth.	Oxalidaceae	+	-
Oplismenus compositus (L.) P.Beauv	Poaceae	+	-
Paspalum dilatatum Poir.	Poaceae	-	+
Persicaria chinensis (L.) H. Gross	Polygonaceae	+	+
Panicum sp.	Poaceae	+	+
Panicum brevivolium L.	Poaceae	+	+
Panicum auritum Presl	Poaceae	+	+
Pteris biaurita L.	Pteridaceae	+	-
Paspalum conjugatum P. J. Bergius	Poaceae	+	+
Ricinus communis L.	Euphorbiaceae	-	+
Seteria pumila (Poir.) Roem. & Schult.	Poaceae	+	+
Solanum nigrum L.	Solanaceae	-	+
Setaria palmifolia (J. Koenig) Stapf.	Poaceae	+	+
Scleria terrestris (L.) Fassett.	Cyperaceae	+	-
Spermacoce latifolia Aubl.	Rubiaceae	+	+
Sphagneticola trilobata (L.) Pruski.	Asteraceae	+	-
Salomonia cantonienis Lour.	Malvaceae	-	+
Torrenia violaceae (Blanco) Pennell	Thelypteridaceae	+	+
Thelypteris dentata (Forssk.) E.P. St. John	Thelypteridaceae	+	+
Thelypteris nudata (Roxb.) C.V. Morton	Thelypteridaceae	+	+
Thysanolaena latifolis (Roxb. Ex Hornem.) Honda.	Poaceae	+	+

"+" indicating presence and "-"indicating the absence of a species

Herbaceous Species Composition

A total of 59 herbaceous species belonging to several taxonomic families were recorded from the two riparian sites during the study period (Table 1). The Reference Site (RS) supported a richer herbaceous community, with a greater abundance of moisture-loving ferns and broad-leaved herbs, whereas the Impacted Site (IS) was dominated by grasses and disturbance-tolerant species, reflecting the influence of grazing and other anthropogenic disturbances. Members of the Poaceae and Cyperaceae were well represented at both sites; however, species such as *Paspalum conjugatum*, *Chromolaena odorata*, *Ageratum conyzoides*, and *Mimosa pudica* predominated at the IS, while *Diplazium esculentum*, *Persicaria chinensis*, *Colocasia esculenta*, and *Boehmeria macrophylla* were more common at the RS. These compositional differences indicate that disturbance favours opportunistic, fast-growing species, whereas relatively undisturbed conditions support moisture-dependent herbs that contribute to greater ecosystem stability and biomass production [5,17,18].

IS biomass vs RS biomass

Variations in AG biomass

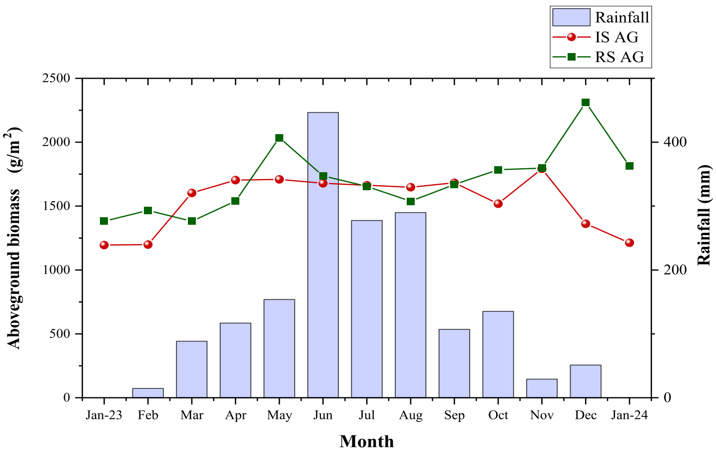

Figure 1 Monthly AG between IS and RS

The monthly pattern of above-ground (AG) biomass differed between the Impacted Site (IS) and the Reference Site (RS) (Figure 1). Overall, the RS produced greater AG biomass than the IS throughout most of the study period. AG biomass at the IS ranged from 1198.56 g m^{-2} in February to 1792.30 g m^{-2} in November, while the RS showed distinct peaks in May (2036 g m^{-2}) and December (2311.00 g m^{-2}). Total AG biomass in the RS was found to be greater than at IS; however, during the months from March-April and July-September, IS AG biomass was slightly higher, as during these months' opportunistic species from Poaceae were found predominating the site. The higher biomass at the RS is likely associated with more favourable soil moisture and nutrient conditions supporting a diverse herbaceous community [8,17].

Variations in BG biomass

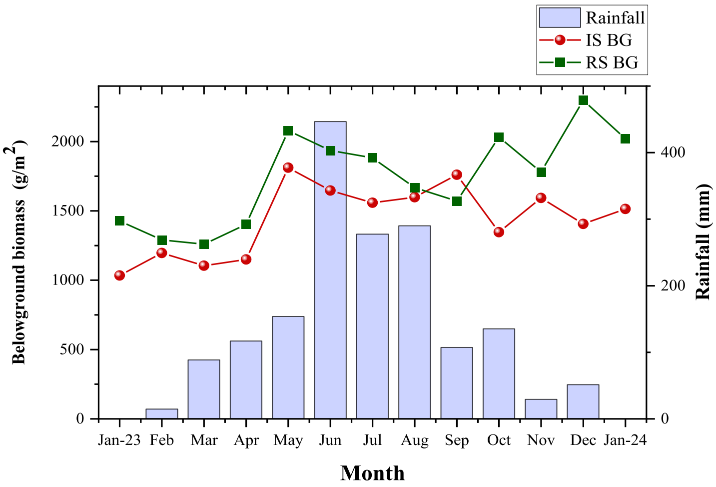

Figure 2 Monthly BG between IS and RS

The RS consistently recorded greater BG biomass than the IS throughout the study period (Figure 2). BG biomass at the IS ranged from 1033.92 g m^{-2} to 1811.30 g m^{-2}, whereas the RS attained peak values of 2078 g m^{-2} in May and 2298.50 g m^{-2} in December. The lower BG biomass at the IS can be attributed to the dominance of shallow-rooted grasses, whose roots rarely exceeded 15 cm in depth but formed dense surface mats that tightly bound soil particles. In contrast, the RS was dominated by moisture-loving species such as *Colocasia esculenta*, *Diplazium esculentum*, *Persicaria chinensis*, *Boehmeria macrophylla*, and *Thelypteris dentata* , which possess more extensive underground systems and are indicative of nutrient-rich, moist soils. These favourable site conditions contributed to greater BG biomass throughout the year. Both sites exhibited relatively higher BG biomass during winter, suggesting increased allocation of assimilates to underground organs for nutrient storage and subsequent regeneration during the following growing season [11].

Statistical Comparison of Biomass

Mann-Whitney Test was performed to examine the difference in AG and BG between the two sites and to define the magnitude of biomass difference between the two sites. Mann-Whitney test did not find significance between the AG between IS (mean rank = 11.31) and RS (mean rank = 15.69), p = 0.153. Significant difference was found at BG biomass, p = 0.026. The BG biomass at RS was significantly higher (mean rank = 16.85) than IS BG biomass (mean rank = 10.15).

One-way ANOVA was performed to find seasonal significance between AG and BG biomass. AG biomass did not show seasonal significance at IS, (F (3, 9) = 1.329, p = 0.325). The same was observed for AG at RS (F (3, 9) = 1.468, p = 0.288). In contrast, BG biomass varied significantly among seasons at both the IS (F (3, 9) = 4.627, p = 0.032). Spring - Summer season showed significant seasonal difference (p = 0.030) in BG biomass generation, p = 0.030. The same was observed at RS (F (3, 9) = 4.004, p = 0.043), with a distinct Spring-Summer BG biomass difference (p = 0.046). These results suggest that seasonal changes had a greater influence on below-ground biomass allocation than on above-ground biomass, indicating that root growth and nutrient storage were more responsive to seasonal environmental conditions than shoot production.

Biomass and Rainfall Pattern

Monthly herbaceous biomass generally followed the seasonal rainfall pattern, with biomass increasing monsoon periods and reaching its peak value during the post-monsoon, particularly at the RS. This delayed response suggests that biomass accumulation depended not only on rainfall but also on sustained soil moisture and nutrient availability [7,8,14]. The IS also followed this trend but showed comparatively smaller seasonal fluctuations, likely due to anthropogenic disturbance and the dominance of disturbance-tolerant grasses. Similar rainfall-driven patterns of herbaceous productivity have been reported in other riparian ecosystems [12,17,19].

Conclusion

Herbaceous biomass varied between disturbed and undisturbed riparian conditions, demonstrating the strong influence of anthropogenic activities on vegetation productivity and biomass allocation. The RS consistently supported higher AG and BG biomass, reflecting favourable soil moisture and nutrient conditions that promoted the growth of diverse herbaceous communities and extensive root systems. In contrast, the IS was dominated by disturbance-tolerant grasses and opportunistic species that maintained relatively high AG biomass but lower BG investment. Although AG biomass did not differ significantly among seasons, BG biomass exhibited significant seasonal variation at both sites, highlighting the importance of seasonal resource allocation to underground organs. The observed increase in BG biomass during winter suggests enhanced nutrient storage and preparation for subsequent growth.

The monthly assessment of herbaceous biomass provided greater temporal resolution than conventional seasonal studies, enabling the identification of peak biomass production under contrasting riparian conditions. Overall, herbaceous biomass proved to be a sensitive indicator of riparian ecosystem condition and disturbance. These findings provide baseline ecological information for riparian vegetation monitoring and support the use of herbaceous communities in restoration, conservation, and phytoremediation programmes in North-East India.

References

1. Stutter M, Baggaley N, Ó hUallacháin D and Wang C 2021. The utility of spatial data to delineate river riparian functions and management zones: A review. Science of the Total Environment, 757:143982. https://doi.org/10.1016/j.scitotenv.2020.143982
2. Stutter M, Costa F B and Ó hUallacháin D 2021. The interactions of site-specific factors on riparian buffer effectiveness across multiple pollutants: A review. Science of the Total Environment, 798:149238. https://doi.org/10.1016/j.scitotenv.2021.149238
3. Pielech R 2021. Plant species richness in riparian forests: Comparison to other forest ecosystems, longitudinal patterns, role of rare species and topographic factors. Forest Ecology and Management, 496:119400. https://doi.org/10.1016/j.foreco.2021.119400
4. Mölder A, Bernhardt-Römermann M and Schmidt W 2008. Herb-layer diversity in deciduous forests: Raised by tree richness or beaten by beech? Forest Ecology and Management, 256(3):272–281. https://doi.org/10.1016/j.foreco.2008.04.012
5. Germany M S, Bruelheide H and Erfmeier A 2017. Limited tree richness effects on herb layer composition, richness and productivity in experimental forest stands. Journal of Plant Ecology, 10(1):190–200. https://doi.org/10.1093/jpe/rtw109
6. Leishangthem D and Singh M R 2024. Phytodiversity of the riparian forest of Dikhu River, Nagaland, North-East India. In: Deb C R, Talijungla and Puro N (eds), Bioresources Conservation and Sustainability, pp. 73–115. Mittal Publications, New Delhi.
7. Singh J S and Yadava P S 1974. Seasonal variation in composition, plant biomass, and net primary productivity of a tropical grassland at Kurukshetra, India. Ecological Monographs, 44(3):351–376. https://doi.org/10.2307/2937034
8. Das T, Gupta A and Arunachalam A 2010. Biomass and productivity of riparian vegetation along Dikrong River System, Arunachal Pradesh, India. Assam University Journal of Science & Technology: Biological and Environmental Sciences, 6(1).https://www.researchgate.net/ publication/ 277112723_Biomass_and_Pr oductivity_of_Riparian_Vegetation_along_Dikrong_River_System_Arunachal_Pradesh_India
9. Proulx R, Rheault G, Bonin L, Roca I T, Martin C A, Desrochers L and Seiferling I 2015. How much biomass do plant communities pack per unit volume? PeerJ, 3:e849. https://doi.org/10.7717/peerj.849
10. Rawlik M and Jagodziński A M 2022. Herbaceous layer net primary production of oak-hornbeam forest: Comparing six methods of assessment based on the seasonal dynamics of biomass increments. Ecosystems, 25:337–349. https://doi.org/10.1007/s10021-021-00658-0
11. Murphy M T, McKinley A and Moore T R 2009. Variations in above- and below-ground vascular plant biomass and water table on a temperate ombrotrophic peatland. Botany, 87(9):845–853. https://doi.org/10.1139/B09-052
12. Gomes P I A, Wai O W H, Kularatne R K A, Priyankara T D P, Anojika K G M S and Kumari G M N R 2014. Relationships among anthropogenic disturbances representative riparian and non-riparian herbaceous indicators (biomass and diversity), land use, and lotic water quality: Implications on rehabilitation of lotic waters. Water, Air, & Soil Pollution, 225(9):2060. https://doi.org/10.1007/s11270-014-2060-4
13. Jamir W, Pongen A, Temjen W, Singh P R and Singh M R 2026. Seasonal herbaceous biomass dynamics in disturbed and undisturbed riparian zones of the Dikhu River, Nagaland, India. Journal of Diversity Studies, 5(1):25–30. https://doi.org/10.51470/JOD.2026.5.1.25
14. Joshi B and Pant S C 2012. Monthly variation in plant biomass and net primary productivity of a mixed deciduous forest at foothills of Kumaun Himalaya. International Journal of Conservation Science, 3(1):41–50. https://www.researchgate.net/publication/287182271_Monthly_Variation_in_Plant_Biomass_and_Net_Primary_Pr oductivity_of_a_Mixed_Deciduous_Forest_at_Foothills_of_Kumaun_Himalaya
15. Temjen W, Singh M R, Ajungla T, Chophi K Z and Semy K 2022. Fungal diversity and physico-chemical parameters of rhizospheric soil from banana plantation sites at Nagaland, India. Agricultural Science Digest, 42(2):192–195. https://doi.org/10.18805/ag.D-5274
16. Padmavathiamma P K and Li L Y 2007. Phytoremediation technology: Hyper-accumulation metals in plants. Water, Air, & Soil Pollution, 184:105–126. https://doi.org/10.1007/s11270-007-9401-5
17. Dwire K A, Kauffman J B, Brookshire E N J and Baham J E 2004. Plant biomass and species composition along an environmental gradient in montane riparian meadows. Oecologia, 139(2):309–317. https://doi.org/10.1007/s00442-004-1498-2
18. Lyon J and Sagers C L 1998. Structure of herbaceous plant assemblages in a forested riparian landscape. Plant Ecology, 138(1):1–16. https://doi.org/10.1023/A:1009705912710
19. Zheng J, Zhang S, Ding D and Li C 2025. Flooding drives plant diversity–biomass relationships in riparian zones of the Three Gorges Reservoir Area. Environmental Research, 271:121101. https://doi.org/10.1016/j.envres.2025.121101