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IMPACTS OF *ACACIA SALIGNA* CANOPY ON INDIGENOUS WOODY SPECIES DIVERSITY, HERBACEOUS COVER, AND BIOMASS PRODUCTION IN TIGRAY, NORTHERN ETHIOPIA

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ABSTRACT

This study was conducted in Atsbi-wonberta district, Tigray, northern Ethiopia. The aim of this paper is to study the impacts of *Acacia saligna (A. saligna)* canopy on indigenous woody species diversity, herbaceous cover and biomass production. Systematic sampling methods were employed to estimate woody species diversity, herbaceous cover and biomass in 12 replications at 1m^2 for woody species, and 0.25 m^2 for herbaceous cover, and biomass production from underneath and away from *A. saligna* canopy. The experiment was composed of four treatments, and randomized complete block design was followed for woody species identification and herbaceous biomass productions. Shannon diversity index, Simpson's diversity index, and Margalef's species richness were used for diversity index estimation. Both woody species diversity, and herbaceous biomass were analyzed and compared using ANOVA between underneath, and away from the canopy at P<0.05. A total of 35 vascular indigenous woody species belonging to 22 families were regenerated naturally underneath and away from the *A. saligna* canopy. The outer segment of the *A. saligna* canopy showed significantly higher Shannon diversity than underneath (P<0.05). However, Margalef's species richness, and Equitability of species did not show a significant difference (P>0.05). The herbaceous biomass was significantly varied, with 146.42g/m^2 under the *A. saligna* canopy, and 247.17g/m^2 away from the *A. saligna* canopy (P<0.05). It can be generally concluded that, the indigenous woody species diversity, herbaceous cover and biomass production was significantly affected under the canopy of *A. saligna* tree stand. Less light for photosynthesis and competition from tree roots for soil nutrients could be the main causes of the decline in herbaceous biomass and indigenous woody species diversity. Further studies should be needed on the soil seed bank and carbon stock potential under the canopy of *A. saligna* tree stand.

***Keywords*:** Diversity, Regeneration, *Acacia saligna*, Canopy, Herbaceous biomass

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1. INTRODUCTION

Forest degradation and deterioration of land productivity due to the conversion of forest land, overexploitation of natural resources, overgrazing practices, population pressure and poor farming systems are among the major driver forces for forest degradation in Ethiopia and throughout the entire world (Deresa and Legesse 2015). The driver forces for forest degradation mainly destroy the most palatable and useful species in the plant mixture, increasing the erosion hazard and reducing the nutritive value and carrying capacity of the land (FAO 2005), and land use changes can alter soil microbial community structure and have profound effects on ecosystem functions and processes (Lan et al. 2020). Forest restoration is the process of returning trees to previously forested land and improving the state of degraded forests (Mishra and Agarwal 2024). Forest degradation in Ethiopia could be solved by the establishment of forest plantations in hostile environments (Evans and Turnbull 2004). Plantations can recuperate the productive potential of the degraded forest land (Lemenih and Teketay 2004).

In Ethiopia, modern exotic plantations started at the turn of the 19th century (FAO 1984), and indigenous woody species and the exotic species like: *Casuarina*, *Eucalyptus*, *Cupressus*, *Acacia*, *Pinus*, and *Leucaena leucocephala* were frequently planted for environmental rehabilitation (Senbeta et al. 2002; Mehari et al. 2005). *A. saligna* is an exotic species in many parts of the world (Holmes and Cowling 1997), and it is one of the exotic tree species in Ethiopia, and it was introduced in the Tigray region in 1972, purposely to be used for environmental rehabilitation and soil and water conservation (Rinaudo and Admasu 2010).

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Mixed tree plantations are believed to promote the regeneration potential and diversity of indigenous species in their understory compared to pure plantations (Rouhi-Mogh et al. 2007). On the other hand, some believe that the regeneration potential of indigenous woody species under the canopy of exotic tree plantations could be hampered, as a result of plants competing with each other for natural resources (Bernhard-Reversat 2001). Similarly, numerous studies have indicated that the species composition and diversity of understory flora can be influenced by the upper canopy species (Yu and Sun 2013), light resources (Ameztegui et al. 2012), litter properties (North et al. 2005), and mixed stands can influence individual tree growth and stand yield potential (Cicșa et al. 2022). Understory vegetation in coniferous forests, hardwood forests, and mixed-wood forests has been well studied (Chávez and Macdonald 2010). Similarly, the regeneration potential and diversity of indigenous woody species under the canopies of exotic plantations of *C. lusitanica*, *E. camaldulensis*, *G. robusta*, and *C. equstifolia* in the moist montane forest ecosystem has been studied (Getachew and Abiyot 2006). However, evidence is insufficient on woody species diversity, herbaceous species cover and biomass production under the canopy of *A. saligna*. This study aims to evaluate the impacts of the *A. saligna* canopy on woody species diversity, herbaceous cover and biomass production in semi-arid conditions in northern Ethiopia.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in Atsbi-Womberta district, which is geographically bounded between 13º 36"North latitude and 39º 36``East longitude (Meaza 2010). The district has an altitudinal variation ranging from 988 to 3063 meters above sea level (m a.s.l.). The particular study area was found in Barka Adisebha, which is geographically situated between 39° 39'30"-39°45'30" East longitude and 13° 45'0"- 13° 51'0" North latitude and has an altitudinal range of 2171 to 2718 m a.s.l. (Fig. 1).

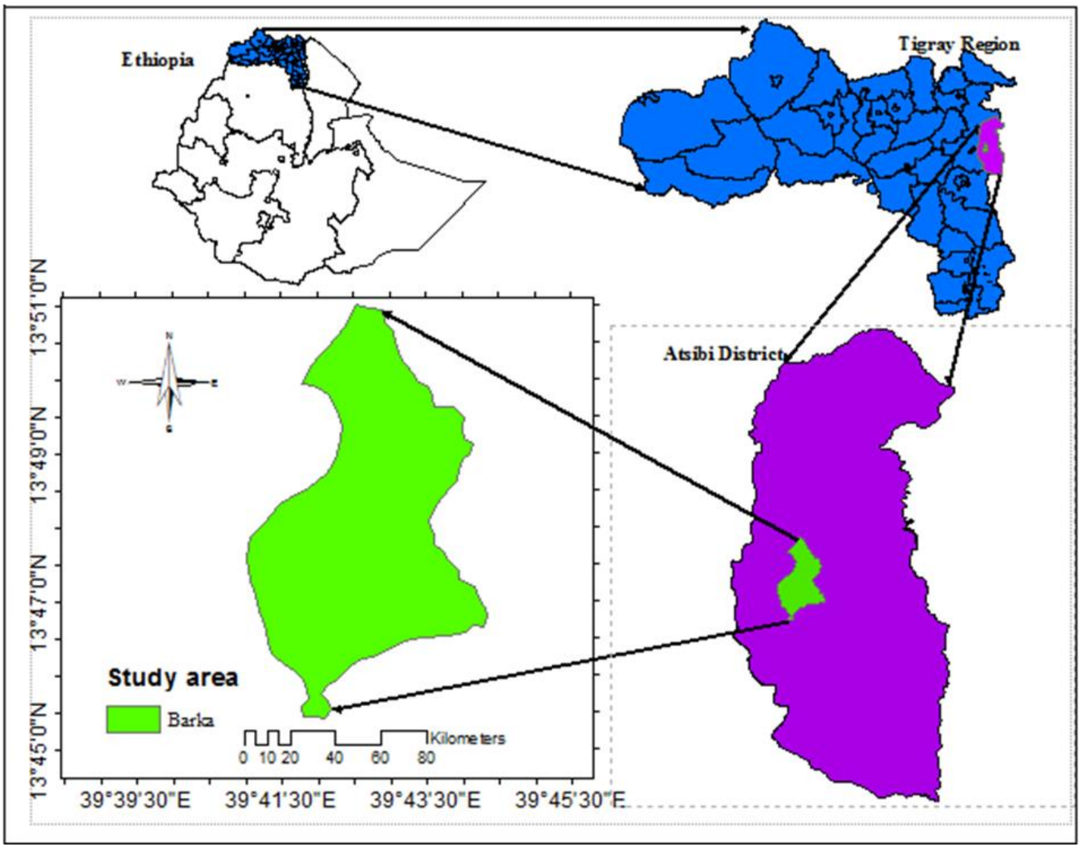

Fig. 1: Map of the study area.

The geological formation of the study area is characterized by sandstones, Paleozoic sedimentary rocks, tillite, and recent alluvial sediments (Nata and Bheemalingeswara 2010) and the dominant soil types are leptosols, regosols, cambisols, and fluvisols (Gessesse 2016).

In the long-term (2006–2016), the average monthly rainfall of Atsbi-Wemberta district was 613mm, while the mean monthly temperature of the district varies from 6.4-22.8°C. The area has a unimodal rain fall with a short rainy season from June-September (Fig. 2).

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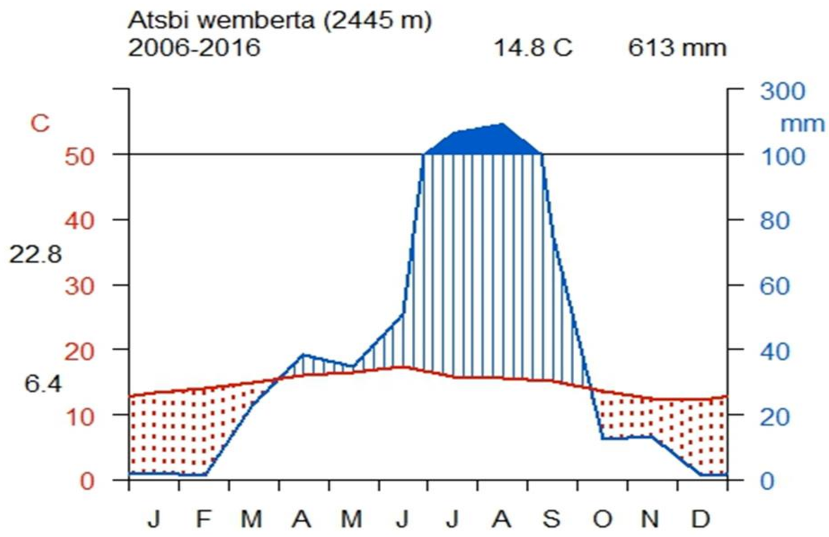

Fig. 2: Walter -Lieth climatic diagram for Atsbi wemberta district (Source; Tigray Regional Meteorological service center).

2.2. Sampling Technique

2.2.1. Vegetation and Herbaceous Sampling Technique: To study the effect of the exotic *A. saligna* tree canopy on indigenous woody plant diversity, we used the approach developed by Jäger et al. (2007) with a slight adjustment. The experiment was composed of 48 experimental units: four distance treatments (under canopy, periphery, 3 m away from periphery, and 50 m away from periphery, replicated twelve times using the randomized complete block design (RCBD).The selection of exotic *A. saligna* tree stands was based on the similarity of their canopy cover, diameter, height, and ages. The quadrates with a size of $1m^2$ were visually placed along the distance from the *A. saligna* tree trunk to the outer segments of *A. saligna* tree stand for all studied stands of *A. saligna*. Accordingly, in order to assess the regeneration dynamics, it is important that, during sampling, seedlings, and saplings are enumerated as well. In this study, the identification of all woody plants and the total number, as well as the height and dsh of individual seedlings and saplings of each species, were recorded. For regenerated seedlings (height <0.5m), only their numbers were recorded. Individual woody categorizations were made as height <0.5m and dsh <2.5 for seedlings, h >0.5m and dbh <5cm for saplings (Birhane et al. 2007).

The nested quadrate plot design was employed to sample the herbaceous cover and biomass production. Accordingly, the subplots with a size of 0.5m x 0.5m were established at the center of each main plot of the treatments. In each sub plots of the study area, herbaceous cover was estimated and each species was identified, and the destructive method was used to quantify the herbaceous biomass production. The harvested fresh herbaceous biomasses were weighed in each quadrat and subsample of the fresh herbaceous biomass was oven dried at 65°C for 24hrs and weighed again to determine the herbaceous biomass production.

2.3. Data Analysis

The woody species diversity and its components were calculated for plots following the equations for diversity parameters.

$$H' = -\sum_{i=0}^{s} pi \ln pi \qquad \text{Eq (1)}$$

Where H‟ = Shannon diversity index, Pi= the proportion of individuals in the i^{th} species, S = the number of species, and ln = the natural logarism.

$$\text{Equitability (J)} = \frac{H'}{H'max} = \sum_{i=1}^{s}\left(\frac{pi \ln pi}{lns}\right) \qquad \text{Eq (2)}$$

Where (H’) is the observed diversity, Hmax equal to maximum diversity (i.e the natural logarithm of the total number of species).

J = Evenness, H' = Shannon diversity index, ln S = the natural logarithm of the total number of species in each quadrat, S = number of species in each quadrat (Shannon 1948). The ground cover of herbaceous species was categorized based on the proportions to the ground cover classes (Misra 1975; Birhane et al. 2007).

2.4. Statistical Analysis

Prior to the analysis of treatment effects, assumption of normality data on species diversity and herbaceous biomass was checked using the Shapiro – Wilk test. The significant difference between the means of the treatments

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was determined by using one way analysis of variance (ANOVA) between the inner and outer segments of the *A. saligna* tree canopy with the post hock test of Tukey at P<0.05 using SPSS for Windows version 20.

3. RESULTS AND DISCUSSION

3.1. Floristic Composition and Diversity of Woody Species

In total, 35 vascular indigenous woody species belonging to 22 families were recorded under the four treatments (i.e., under canopy, periphery, 3m away, and 50m away from the periphery). Of these, 17 indigenous woody species were commonly observed in all treatments. From the total vascular indigenous woody species, 10 species (28.6%) were trees, 19 species (54.3%) were shrubs, and 6 species (17.1%) were trees or shrubs (Table 1). Fabaceae and Lamiaceae were the most dominant families, with an equal number of 5 species (14%) for each and followed by Celastraceae 3 (8.5%), Anacardiaceae 2 (5.5%) Apocynaceae 2(5.5%), Oleaceae 2(5.5%), and the other families were represented each by 1 (2.9%) (Table 1).

Table 1: Total list of woody species /shrub species found in the study area

No.	Local name	Scientific name	Family	Life form
1	Atami	*Rhus retinorrhoea*	Anacardiaceae	T
2	Awlie	*Olea europaea ssp. Cuspidata* L.	Oleaceae	T
3	Bwak	*Triumfetta flavescens*	Tilaceae	ST
4	Chea	*Acacia seyal. Delile*	Fabaceae	T
5	Chiendog	*Otostegia integrifolia* **(**Forssk.)	Lamiaceae	S
6	Dander	*Carduus nyassanus*	Easteraceae	S
7	Habitelim	*Jasminum abyssinicum* (Hochst. Ex) DC.	Oleaceae	S
8	Hatsawuts	*Calpurnia aurea* (Ait.) Benth.	Fabaceae	ST
9	Hehot	*Rumex nervosus.* Vahl	Polygonaceae	S
10	Kalesha	*Laggera tomentosa* (Sch.Bip ex A.Rich)	Asteraceae	S
11	Kleaw	*Euclea racemosa L.*	Ebenaceae	ST
12	Mebtie	*Aconkanthera shimperi* (A.DC.) Schweinf	Apocynaceae	T
13	Meseguh	*Merendra bengalensis* (Roxb.) Benth.	Lamiaceae	S
14	Kerets	*Osyris quadripartite* Salzm. Ex Decne.	Santalaceae	S
15	Qebiqeb	*Maytenus senegalensis*	Celastraceae	T
16	Qentaftaf	*Pterolobium stellatum* (Forssk) Brenan	Fabaceae	S
17	Quaquata	*Colutea abyssinica*	Celastraceae	S
18	Sasa	*Premna oligotricha.* Baker	Lamiaceae	S
19	Nefasito	*Albizia amara*	Mimosoideae	T
20	Shewuha	*Clerodendrum myricoides* (Hochst.) R.Br.	Lamiaceae	S
21	Sogo	*Senna alexanderina*	Caesalpinioideae	S
22	Swakerni	*Leucas abyssinica* (Benth.) Briq.	Lamiaceae	S
23	Tahses	*Dodonaea angustifolia L.f.*	Sapindaceae	ST
24	Tebeb	*Becium grandiflorum* (Lam.) Pic.ser	Labiatae	S
25	Tetaelo	*Rhus natalensis* Bernh. ex Krauss	Anacardiaceae	T
26	Hambohambo	*Senna singueanea* (Delile)Lock	Fabaceae	ST
27	Tsihdi	*Juniperus procera*	Cupressaceae	T
28	Agam	*Carissa edulis*	Apocynaceae	ST
29	Atiat	*Mytenus arbutifolia* (A. Rich.) Wilczek	Celastraceae	S
30	Kusihe	*Lippia adoensis*	Varbenaceae	S
31	Metere	*Buddleja polystachya.* Fresen	Buddlejaceae	S
32	Qolqual	*Euphorbia abyssinica* J.F.Gmel.	Euphorbiaceae	T
33	Qostanisto	*Asparangus africanus*	Asparagaceae	S
34	Sraw	*Acacia etbaica* Schweinf	Fabaceae	T
35	Qorenet	*Solanum shimperianum* Hochst. ex A.Rich	solanaceae	S

S= Shrub, T= Tree, ST= Shrub/ Tree

The number of species found among the inner and outer segments of the *A. saligna* canopy was higher than (19) indigenous species under the *A. saligna* tree stand in Egypt (Abd El Gawad and El-Amier 2015), and close to (37) indigenous species in *Cupressus lusitanica, Eucalyptus globulus, Pinus patula, Pinus radiate,* and *Juniperus procera* with the adjacent indigenous *Coniferous* plantation in Ethiopia (Senbeta and Teketay 2001), and lower than (55 species) (Alem, 2013) in the plantation of *Eucalyptus grandis* and adjacent natural forest, (58 species) Omoro et al. (2010) in the exotic forest plantations of *Pine, Eucalyptus, Cypress* and the adjacent exclosure. Similar to our study, canopy gaps hosted a higher number of woody species with greater plant height in temperate forests (Kermavnar et al. 2019). Tree layer composition and soil characteristics are crucial contributors to variations of understory species composition which may be changed by forest management approaches over time (Marefat et al. 2020). The variation in indigenous woody species availability might be due to the ecological significance of the species or the adaptability potential of the indigenous woody species with exotic species and soil characteristics variation between under the canopy and out of the canopy.

The indigenous woody species diversity in the study area was significantly affected by the canopy of *A. saligna* stand trees (Table 2). Shannon diversity index was significantly lower under the canopy of an *A. saligna* tree than outside segments of the tree canopy (P<0.05, Table 2). In this study, the value of the Shannon Wiener diversity index is between 1.38 and 1.78, whereas the value obtained under the canopy was 1.38. This value indicates that indigenous tree species diversity is significantly lower under the canopy of *A.saligna*. When compared to under canopy sites, canopy gaps generally displayed higher species richness and evenness and, consequently, greater species diversity (Garg et al. 2022).

Table 2: Treatment effects on the diversity indices of indigenous woody species under the canopy and outside the canopy of *A. saligna* tree

Treatments	Species type	Abundance	Simpson_1D	Shannon_H	Margalef	Equitability_J
Under canopy	8.75±0.54^{a}	52±3.7^{ab}	0.74±0.03^{a}	1.38±0.09^{b}	1.97±0.11^{a}	0.78±0.03^{a}
Periphery	8±0.46^{a}	48±4.8^{b}	0.75±0.02^{a}	1.67±0.06^{ab}	1.86±0.13^{a}	0.80±0.01^{a}
3 m away	9.05±0.56^{a}	68±5^{a}	0.69±0.03^{a}	1.58±0.09^{ab}	1.93±0.12^{a}	0.72±0.04^{a}
50 m away	9.17±0.60^{a}	61±4.5^{ab}	0.76±0.03^{a}	1.78±0.09^{a}	2.0±0.15^{a}	0.81±0.02^{a}
P value	0.42	0.017	0.316	0.015	0.871	0.079

The mean values along columns with similar letters indicate a significant difference (P<0.05).

The analysis of indigenous woody species diversity indicated that, the inner segment of the *A. saligna* tree stand showed a clear reduction in species diversity from the outer portions of the *A. saligna* canopy. This result is in agreement with previous findings, by which *A. saligna* exerts a negative effect on indigenous woody species diversity, as a result of its fast growth and large amount of litter fall as compared with the indigenous species (Hellmann et al. 2011). Another factor, contributing to the reduction of indigenous woody species diversity under the canopy of *A. saligna* might be the availability of more *A. saligna* seedlings growing under the canopy, which is superior to the other understory indigenous species. As a result of large canopy cover and high transpiration rates, *Acacia* species also reduce water content and field capacity of soil, which leads to an unfavorable environment for indigenous woody species diversity (Musil 1993). The other key factor that affects the presence and distribution of indigenous woody species under the canopy of *A. saligna* is branch felling and more leaf litter accumulation under the canopy, which disturbs the seedlings of indigenous woody species under the canopy (Nigusse et al. 2019).The other diversity indices like, Simpson (D), Margalef and Equitability were non-significant between the inner and outer segments of the *A. saligna* canopy; this indicates that dominant species interactions under the canopy and outside of the canopy were equal. This is in lines with Del vecchio et al. (2013), the *A. saligna* canopies do not affect the total indigenous species, and as a result very few species could dominate the site.

3.2 Density of Indigenous Woody Species

The density of naturally regenerated indigenous woody species was significantly affected by distance to the exotic *A. saligna* tree canopy (P<0.05; Table 3).

Table 3: Effects of position from the canopy of *A. saligna* stand trees on mean density of sapling, seedling and total density/ha

Treatments	Seedlings	Saplings	Total density
Under canopy	8,177±1335^{b}	8541±1729^{a}	16,718±2414^{b}
Periphery	10,625±2068^{b}	7864±1760^{a}	18,489±2917^{b}
3 m away	19,427±3238^{a}	10,260±1123^{a}	29,687±3207^{a}
50 m away	13,489±2098^{ab}	11,979±1600^{a}	25,468±1975^{ab}
P value	0.009	0.26	0.004

Values (mean±SE) along columns followed by similar letter(s) are not significantly different (P>0.05); while the different letter(s) along the columns indicates a significance difference between the treatments effect (P<0.05).

The distribution of seedlings and saplings indicates the regeneration status of indigenous woody species in the study area. The regeneration status of indigenous woody species was determined by comparing the ratio of seedlings to saplings and the distribution of seedlings among the treatments. Accordingly, the ratio of seedlings to saplings under the canopy, at the periphery, 3 m away from the periphery and 50m away from the periphery was found to be 0.95, 1.35, 1.89, and 1.12, respectively. The regeneration status of indigenous woody species under canopy of *A. saligna* was categorized as fair regeneration, whereas at the periphery, 3 m away from the

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periphery and 50 m away from the periphery was observed good regeneration potential of indigenous woody species. Even though, the regeneration status under canopy is fair, it is lower than the outer part of the canopy, and this might be due to the absence of mature indigenous stems to produce seed. This agrees with Bekele and Abebe (2018); better regeneration status was observed under the *Eucalyptus camaldulensis* plantation stand compared to *Cupressus lusitanica* due to the presence of old trees to produce seed under the *Eucalyptus camaldulensis* plantation.

The greater the number of seedlings on the outer side of the canopy, it might be associated with several factors, but most probably, light availability under the canopy of *A. saligna* tree stand might be one factor for the low availability of seedlings under the canopy. In temperate forests, light availability was found favorably connected with understory cover and understory plant species diversity (Dormann et al. 2020). Additionally, in the study a greater number of new growing *A. saligna* seedlings were observed and this might be one factor in the reduction of indigenous woody species distribution under the canopy. The reduction or absence of new regenerated seedling stages in indigenous woody species might be an indication that they are unable to compete with the seedlings and saplings of exotic species. This result indicates that, the higher proportion of seedlings were not growing properly due to the competitive variation between the exotics and indigenous species in the mountain cloud of East Africa (Omoro and Luukkanen, 2011). Different regeneration techniques may be employed by canopy and understory seedling populations growing in the forest understory in response to future climate change scenarios (Pan et al. 2024). The other factor contributing to the low existence of seedlings under the canopy of *A. saligna* tree stand could be shade. This is lined with the findings of Knight et al. (2008) and Karolewski et al. (2020). According to them, light was one important component and had significant positive effects on understory species regeneration. However, the statistical analysis of vegetation parameters also indicated that the numbers of individuals under the categories of sapling stage in both the inner and outer segments were shown no variation. This result indicates that, the higher proportion of individual sapling stages was not affected by the exotic *A. saligna* canopy, and they can grow properly to the mature stem.

3.3. Herbaceous Biomass Production

There was a significant variation in herbaceous biomass production between the inner and outer segments of the exotic *A. saligna* canopy. The above ground herbaceous biomass production at 50 m away from the periphery was significantly higher (247.17±25.9g/m^2) than under the canopy of the *A. saligna* tree (146.42±9.8g/m^2) and from the periphery of the canopy (140.12±9.6g/m^2) (Fig. 3).

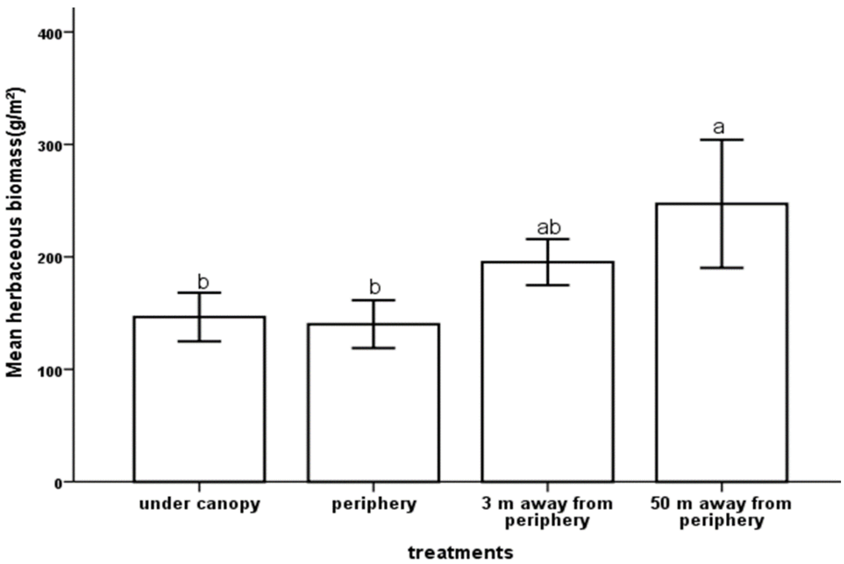

Fig. 3: Mean herbaceous biomass with different lowercase letters above the bar indicates statistical difference (P<0.05), while the different lowercase above the bar indicates that there is a significant difference between the treatments (P<0.05).

More herbaceous biomass was accumulated in the outer segment of *A. saligna* canopy, this might be due to the effect of shade under the *A. saligna* canopy and unbalanced competitive capacity of herbaceous species with the seedlings, sapling and tree size of *A. saligna* stands. Higher herbaceous biomass was also documented in open grasslands as opposed to areas covered by trees (Singh et al. 2017). Other findings by Scholes et al. (1997), Yayneshet et al. (2009) and Oba et al. (2001) indicate that significantly lower herbaceous biomass was observed in the area of more species composition and density, which suppresses the growth performance of the understory herbaceous vegetation. More tree species composition and canopy cover have negative impact on ground cover and aboveground biomass yield of herbaceous plant, in eastern Ethiopia (Fikadu and Zewdu 2021). Adding to the fact that evapotranspiration is also another factor in increasing herbaceous biomass, the moderate density of woody species could contribute to reducing the amount of evapotranspiration that leads to increased herbaceous biomass. Similar study conducted by Breshears et al. (1997), Ludwig et al. (2001) low tree density can also facilitate herbaceous biomass by reducing sub-canopy evapotranspiration. According to Shirima et al. (2015) and Garg et al. (2022), there was a negative impact of dense forest canopies on herbaceous biomass production. Similarly, the entry of livestock in the managed pine areas increased the herbaceous plants cover and richness but reduced the herbaceous biomass production and the woody species cover (Foronda Vazquez et al. 2024).

3.4. Ground Cover of Herbaceous Species

The ground cover of herbaceous species varied from poor cover to good cover as a result of the distance effect from the trunk of the *A. saligna* canopy. Accordingly, 66.7% of the total plots under canopy of the *A. saligna* were observed to have a rare cover of herbaceous species. However, at 50m away from the periphery, there was 50% good coverage of herbaceous species (Table 4).

Table 4: Ground cover of herbs under the inner and outer segment of *A. saligna* tree canopy

Treatments	Ground cover classes			
	1	2	3	4
Under canopy	8(66.7)	1(8.3)	3(25)	0
Periphery	2(16.6)	3(25)	5(41.8)	2(16.6)
3 m away	3(25)	1(8.3)	3(25)	5(41.7)
50 m away	1(8.3)	2(16.7)	3(25)	6(50)

Ground cover classes; 1= ≤ 25(rare cover), 2= 26-50(occasional), 3=51-75(intermediate cover), 4= >75% (good cover). Values in parenthesis are percentages.

The herbaceous species cover might be affected by dense tree roots that extend beyond the canopy radius and deplete water or nutrients in the inter-canopy zone (Scholes and Archer 1997). This study suggests that woody species density can significantly reduce the herbaceous cover, because the higher the plant community components are either severely reduced or completely absent of herbaceous species, such an effect could become increasingly important at high tree densities. Herbaceous species increased with increasing gap area and increasing light availability in beech stands (Vajari et al. 2012). Climatic factors, special rainfall is the main factor, which was altering the botanical composition and positive relationships with groundcover of herbaceous species in rangeland types (Asfaw et al. 2020).

4. CONCLUSION and RECOMMENDATION

The results of this study provided evidence that, the comparison made between the inner and outer segments of the *A. saligna* canopy showed that, the diversity of indigenous woody species, and herbaceous biomass was significantly improved in the outer segment of the *A. saligna* canopy. As a result, this could be due to high shading conditions (close canopy of *A. saligna*) and unfavorable soil conditions under the canopy. It can be generally concluded that, the indigenous woody species diversity, herbaceous cover and biomass production was significantly affected under the canopy of *A. saligna* tree stand. Less light for photosynthesis and competition from tree roots for soil nutrients could be the main causes of the decline in herbaceous biomass and indigenous woody species diversity under the canopy of *A. saligna*. Increases in diversity of woody plants, herbaceous cover and biomass production are all present in canopy a gap, which suggests that *A. saligna* is receiving intense canopy management. Further studies should be needed on the soil seed bank and carbon stock potential under the canopy of *A. saligna* tree stand.

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Competing Interests: The authors declared that they have no conflict of interest.

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