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Research Article

Selection of Different Trees/Shrubs Species for Rehabilitation of Degraded Lands in Wag-Lasta Area, Northeastern Ethiopia

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ABSTRACT

Due to human and livestock population pressure, land degradation is the main problem in many part of Ethiopia. To avert the situation, tree and shrub species selection on degraded lands are valuable tool for ecological restoration. Therefore, the aim of this study was to select the best performing tree and shrub species in three agro-ecological zones of Waglasta area, Ethiopia. The experiment was conducted in randomized block design with three replications in highland, mid altitude, and lowland sites. For total experimental setup 21 (seven for lowland, eight for mid altitude and six for highland) tree and shrub species were used. Growth and survival rate data were collected every 3 months interval for one year and every 6 months up to the end of the experiment. The result indicated that L. pallid (2.52 ± 0.19 m) at lowland site, *Acacia senegal* (1.32±0.23 m) at mid altitude and *Acacia decurrens* (4.0 ± 0.46 m) at highland site had shown better performance in height. Similarly, *Moringa stenopetala* at lowland, *Jatropha carcus* at mid altitude and *Acacia saligna* at highland site had shown 8.63 ± 2.37 cm, 3.1 ± 0.2 cm and 7.06 ± 0.75 cm performance in root collar diameter, respectively. However, the survival rate was higher for A. *senegal* (43 ± 7%) and M. *stenoptella* (44 ± 17%) at lowland site, A. *senegal* (98 ± 2%) at mid altitude and A. *saligna* (63.9 ± 20.0%) at highland site. Therefore, to restore degraded lands and to support the on-going land rehabilitation programs of Wag-lasta area, we recommend A. *senegal* and M. *stenoptella* for lowland site, A. *senegal* for mid altitude areas and A. *saligna* for highland site of Lalibela, Abergele and Sekota and similar agro-climatic zones. However, additional studies regarding soil nutrient dynamics, fostering effect and tree nursing should be integrated to develop sound ecological restoration strategies in the growth corridor as well as in the region.

Keywords: Rehabilitation; Tree/Shrub species; Selection

INTRODUCTION

Land degradation is both a natural and human-induced process [1], which diminish the capacity of land resources to perform essential functions and services [2]. Land degradation is a global-scale, ongoing, and the relentless problem that poses a major long-term challenge to humans in terms of its adverse impact on biomass productivity, food security, biodiversity and environmental sustainability [3]. Land degradation is the broad term that includes soil erosion degradation (acidification, fertility depletion, hard setting), biological degradation (reduction of total biomass and carbon and decline of biodiversity) and ground water depletion.

In Ethiopia, land degradation has become a serious problem affecting all spheres of social, economic and political life of the population [4]. It is one of the major challenges to agricultural development and food security of the country. A large portion of the agricultural land, which is mainly located in the highland part of the country, is affected by severe to moderate land degradation [2].

Particularly, Amhara region is extremely affected by land degradation. In terms of soil erosion, 29% experience high erosion rates (51–200 t/ha per year), 31% experiences moderate erosion rates (16–50 t/ha per year), 10% experiences very high erosion rates (>200 t/ha per year) and the remaining 30% experiences low erosion rates (<16 t/ha per year) [5]. The leading factor of land degradation in the region is deforestation, soil erosion, growth of human and livestock population, overgrazing, and mismanagement of land. For instance, accelerated growth of human and livestock population coupled with per capital demand for goods and services, land degradation has gone beyond the limits of reversal, and the problems are expanding at large. Although, the trend of land rehabilitation is becoming an increasingly significant tool to manage, conserve, and repair the worlds degraded ecosystems. Hence, rehabilitation of degraded ecosystems are critical tools for protection of the remaining natural resource.

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Therefore, restoring degraded lands through afforestation pointed out as crucial step to return the productive potential of a land, and its related benefit to meet their economic, social and environmental potentials. However, previous reforestation programs attempting to counteract the effects of deforestation have failed mainly due to lack of knowledge on site–species matching [6]. Thus, an appropriate tree/shrub species selection for different agro-ecologies is a sound step to assist the rehabilitation of the degraded lands. Therefore, the focus of this research was to select the best performing trees or/and shrubs species on the degraded lands of Wag-Lasta area.

MATERIALS AND METHODS

Site description

The experimentation was conducted in Amhara region of Waghemira and Semen wollo, in three agro-ecologies namely; lowland, mid-altitude, and highland. The lowland site is located at Abergele, which ranges in altitude from 1150-2500 m.a.sl (Figure 1). The mean annual temperature and rainfall varies from 23°C to 43°C, 250 to 750 mm, respectively. Also the district's agro-ecology can be classified as lowland [7]. Mid altitude site is located at Sekota (Woleh), the altitude of the district range from 1340 to 2200 m.a.sl. The rainfall patter is unimodal with erratic and uneven distribution. But mean annual rainfall ranges between 350 to 700 mm, and the mean annual temperature varied from 16°C to 27°C [8]. The highland is located at Lalibela; Altitude of the site is 2129 m.a.sl. Lalibela area has two rainy seasons from June to September and from March to April. The annual rainfall varies from 500 to 1000 mm, Lalibela area is characterized by mean annual temperature of 24.5°C and relative humidity is 52.9% [9].

Experimental design and management

Treatments were laid out in Randomized Complete Block Design (RCBD) with three replications. The space between blocks and plots were 3 m and 2 m, respectively. The size Plot was 12 m × 10 m for lowland, 10 m × 8 m for mid altitude and 6 m × 6 m for the highland site. The spacing between trees in a plot was 2.5 m × 2 m (lowland), 2 m × 2 m (mid altitude) and 1.5 m × 2 m (highland). For the total experimental set up 21 treatments (6 for the lowland, 8 for mid-altitude and 7 for highland) were used (Table 1). In a plot, 25 trees for lowland, 16 trees for mid-altitude and 12 trees for highland were planted. Water harvesting structures (half-

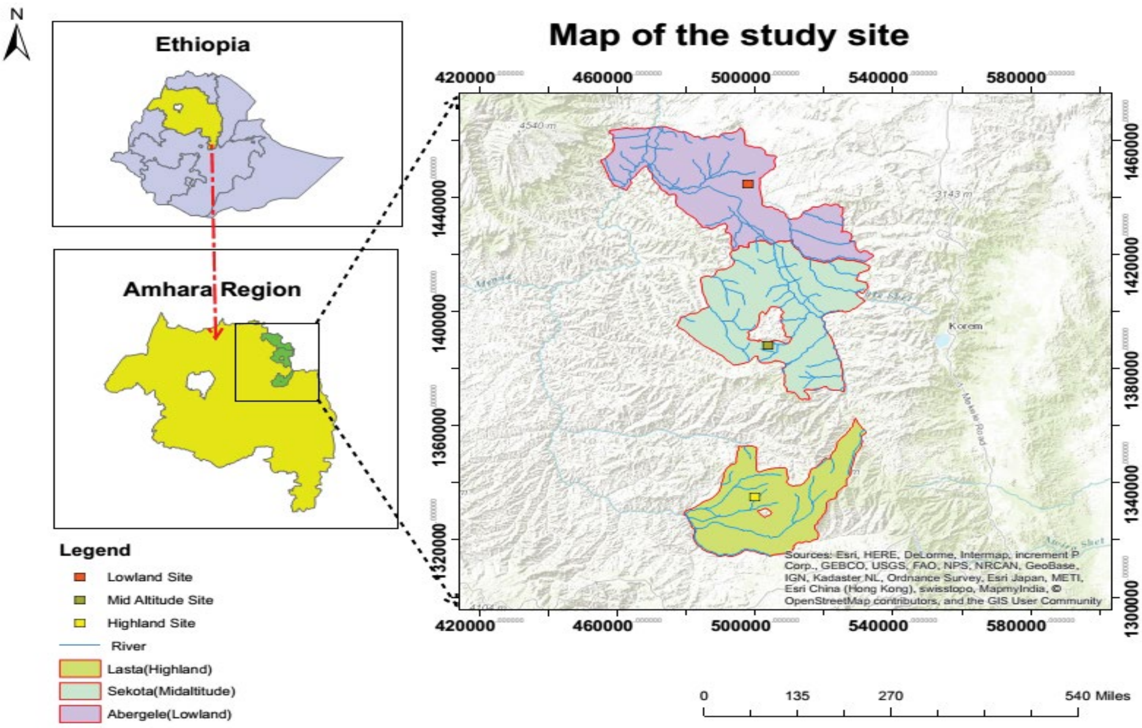

Figure 1: Map of the study area.

Table 1: Length treatment set up in three agro-ecologies.

S. No	Highland (Lalibela)	Mid altitude (Sekota)	Lowland (Abergele)
1	*Acacia abyssinica*	*Susbania seculeta*	*Susbania seculeta*
2	*Acacia decurrens*	*Acacia senegal*	*Acacia albida*
3	*Acacia melanoxylon*	*Cordia africana*	*Acacia senegal*
4	*Acacia saligna*	*Gravilea robusta*	*Luecaena pallida*
5	*Chamaecytisus palmensis*	*Jatrofa carcus*	*Leucaena leucocephala*
6	*E. viminalis*	*Melia azandarchata*	*Moringa stenoptella*
		Moringa stenoptella	*Susbania sesban*
		Sesbania sesban	

moon), which recommended in our mandate area, was constructed following the contours.

Data collected

Growth (Height and Root collar diameter) and survival data were collected every 3 months interval for 21 months and every 6 months interval since 21-month period up to the end of the experimentation.

Data analysis

Data analysis was performed by using SPSS statistical analytical software version 22 for comparison of among treatments with height, root collar diameter, and survival rate.

RESULTS AND DISCUSSION

Lowland site (Abergele)

The growth and survival rate data of Abergele trial had shown significant difference across months and treatments in height, root collar diameter and survival rate at $p<0.05$. The performances of all species except survival rate were increasing with increasing growing months. The mean comparison result indicated that *L. pallid* and *M. stenoptella* had shown significant growth in height (2.52 ± 0.19 m) at 45 months (Figure 2), and root collar diameter (8.63 ± 2.37 cm) at 39 months (Table 2), respectively. This may be due to the difference in growth strategy of the plants. *A. Senegal* and *M. stenoptella w*ere scored relatively highest (43 ± 7% and 44 ± 17%) survival rate **at** the end of the experimentation (Table 3). This result is relatively lower than the finding of Haile and Bayu 10], who found 83.3% survival rate for *M. stenoptella* and 52.08% for *A. Senegal* in similar location. However, *L. leucocephala, S. seculeta*, and *S. sesban* were not survived after 27 month lifetime. Particularly, poor survival and growth response was observed on *L. leucocephala, S. seculeta, and S. sesban.* probably due to longer period of dry season which extends from 9 to 10 months, and also lifetime of the species and need of special treatment like pruning, looping, and coppice. Specificaly, *L. leucocephala* does not tolerate very dry and acidic soil [11].

Mid-altitude (Sekota /Woleh)

The performance of tree/shrubs in this site was significant across months. The trends in height (Figure 3) and root collar diameter (RCD) (Figure 4) were increased with increasing months. The highest growth in height was recorded for *A. senegal* (1.32 ± 0.23 m) and the lower height was obtained for *M. stenopetala* (0.15 ± 0.15 m) at the end of the trial. This might be due to nitrogen fixing ability of the species helps to perform in degraded soil [12]. Similarly, the RCD was higher *for J. carcus* (3.1 ± 0.2 cm) and the lower value was recorded for *G. robusta* (0.5 ± 0.3 cm). The performance of A.

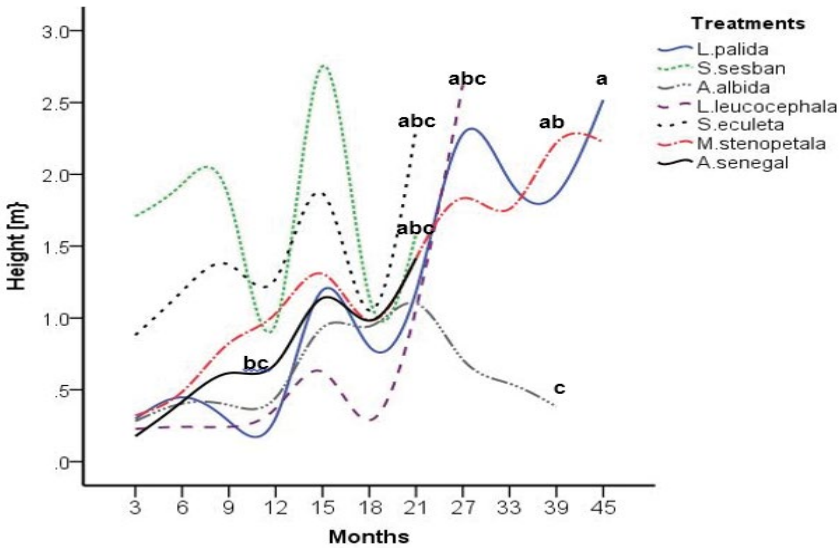

Figure 2: Growth performance of tree/shrub species in height (m) across months at Abergele. Means with similar letters are not significantly different at ($p<0.05$). Means with similar letters are not significantly different at ($p<0.05$).

Table 2: Growth performance of tree/shrub species in root collar diameter (cm) across months at Abergele.

Treatments	Months						
	6	12	18	27	33	39	45
	Mean ± _SE	Mean ± _SE	Mean ± _SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
A. albida	0.23 ± 0.09^{df}	0.4 ± 0.1^{c}	0.9 ± 0.39^{ab}	1.13 ± 0.73^{c}	0.73 ± 0.73^{c}	0.43 ± 0.43^{b}	d
A. senegal	0.47 ± 0.12^{d}	1.1 ± 0.35^{bc}	0.03 ± 0.79^{b}	Nd	Nd	Nd	Nd
L. leucocephala	0.37 ± 0.07^{ce}	0.53 ± 0.07^{c}	0.23 ± 0.19^{b}	2.77 ± 0.33^{ab}	d	d	d
L. palida	0.6 ± 0.06^{cd}	0.6 ± 0.1^{c}	1.17 ± 0.28^{a}	3.43 ± 0.32^{b}	2.87 ± 0.48^{b}	2.1 ± 1.06^{b}	3.7 ± 0.44^{b}
M. stenopetala	1.53 ± 0.09^{b}	2.83 ± 0.41^{a}	0.57 ± 1.12^{ab}	5.97 ± 0.97^{a}	5.27 ± 0.18^{a}	8.63 ± 2.37^{a}	7.87 ± 0.72^{a}
S. eculeta	1.23 ± 0.13^{b}	1.53 ± 0.12^{b}	1.3 ± 0.48^{a}	d	d	d	d
S. sesban	1.7 ± 0.17^{a}	1.97 ± 0.2^{b}	1.43 ± 1.4^{a}	d	d	d	d

Means in columns with similar letters are not significantly different at ($p<0.05$), Nd; No Data, d; Died Out, SE: Standard Error of Mean

Table 3: Growth performance of tree/shrub species in Survival rate (%) across months at Abergele.

Treatments	Months						
	6	12	18	27	33	39	45
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
A.albida	96 ± 2^{a}	77 ± 3^{a}	74 ± 6^{ab}	48 ± 6^{a}	16 ± 16^{b}	16 ± 16^{ab}	4 ± 4^{c}
A.senegal	79 ± 3^{b}	72 ± 6^{a}	76 ± 4^{a}	57 ± 13^{a}	43 ± 22^{a}	43 ± 22^{a}	43 ± 7^{ab}
L.leucocephala	64 ± 15^{b}	45 ± 12^{b}	35 ± 5^{d}	19 ± 4^{b}	8 ± 8^{b}	8 ± 5^{b}	8 ± 2^{c}
L.palida	87 ± 3^{a}	72 ± 7^{a}	60 ± 0^{bc}	53 ± 5^{a}	52 ± 6^{a}	33 ± 12^{a}	23 ± 9^{bc}
M.stenopetala	83 ± 3^{ab}	73 ± 6^{a}	72 ± 5^{ab}	64 ± 7^{a}	59 ± 10^{a}	47 ± 14^{a}	44 ± 17^{a}
S.eculeta	99 ± 1^{a}	48 ± 10^{b}	40 ± 10^{cd}	d	d	d	d
S.sesban	96 ± 4^{a}	45 ± 7^{b}	41 ± 10^{cd}	d	d	d	d

Means in columns with similar letters are not significantly different at ($p<0.05$), Nd: No Data, d: Dry Out, SE: Standard Error of Mean

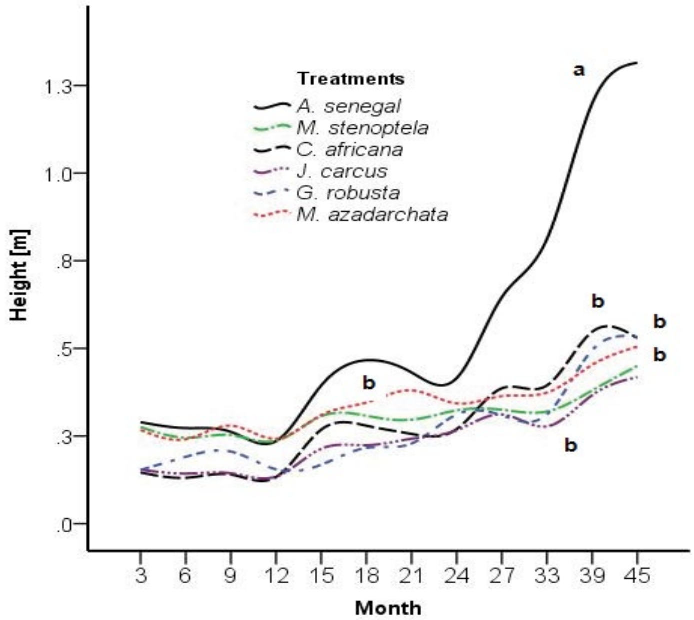

Figure 3: Growth performance of tree/shrub species in height [m] across months at Woleh. Means with similar letters are not significantly different at ($p<0.05$).

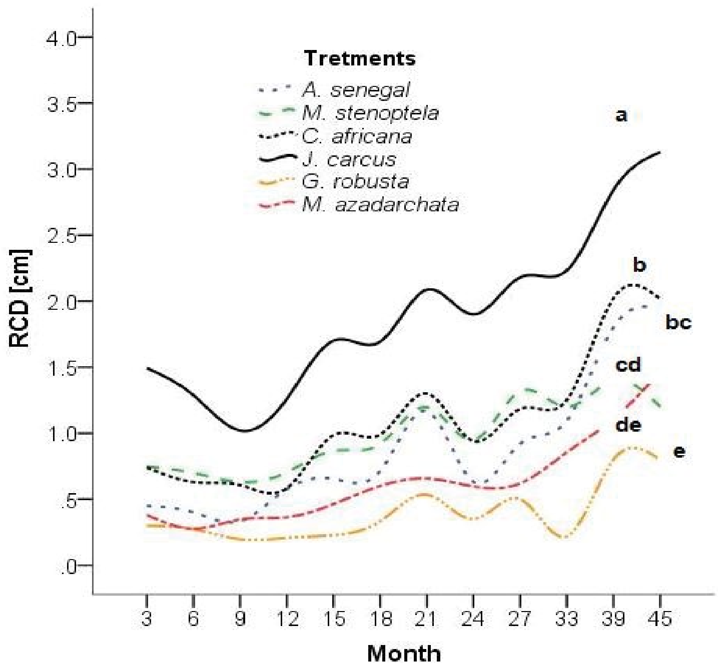

Figure 4: Growth performance of tree/shrub species in root collar diameter (RCD) across months at Woleh. Means with similar letters are not significantly different at ($p<0.05$).

senegal was higher in survival rate and lower for *M. stenopetala* at the end of the experimentation 98 ± 2% and 4 ± 4%, respectively. This probably due to *A. senegal* is one of the species which classified as drought avoider [6], and there was drainage problem during rainy season, which affect the survival ability of *M. stenopetala*. Along with *M. stenopetala* does not grow well on waterlogged or swampy areas [13].

Highland site (Lalibela)

The performance of tree/shrubs in growth and survival rate was significant across months ($p<0.05$). Significantly higher plant height was obtained for *A. decurrence* (4.0 ± 0.46 m) and the lower height was recorded for *A. melanoxylon* (2.30 ± 0.1 m) at the end of the experiment. This result is relatively lower with the result of Kindu et al. [14], who found 6.89 m and 3.90 m height growth at 36 months on *A. decurrence* and *A. melanoxylon*, respectively. However, *C. palmensis* was not survived after 21 months. Similarly, the survival rate was decreasing with increasing growing months. The higher survival rate was recorded for *A. saligna* (63.9 ± 20.0%) and the lower survival rate was recorded for *A. decurrence* (16.7 ± 4.8%) at the end of the experimentation. except for *A. decurrence*, there was no significance difference in survival rate among *A. saligna*, *A. melanoxylon*, *A. abyssinica* and *E. viminalis* at ($p<0.05$) (Figure 5). In addition, the root collar diameter (RCD) performance of tree/shrubs was increased with increasing growing months (Table 4). The higher RCD value was found for *A. saligna* (7.06 ± 0.75 cm) and lower value was obtained under *A. melanoxylon* (4.18 ± 0.27 cm) at 45 months lifetime (Table 5). This result is similar with

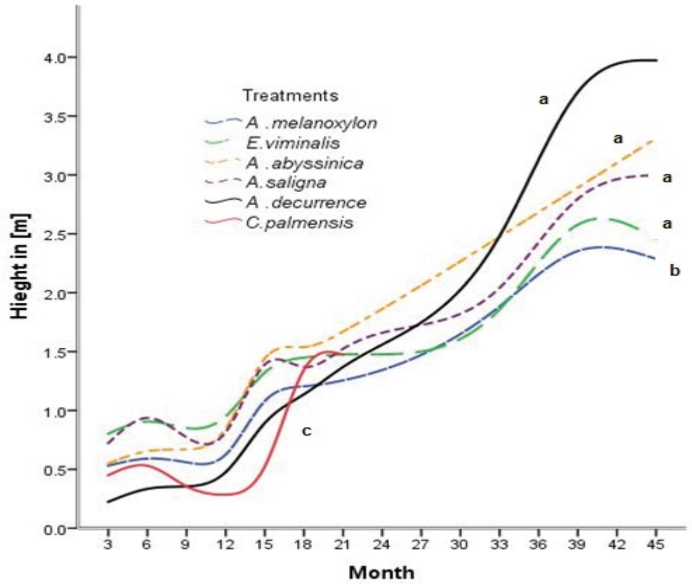

Figure 5: Survival rate (%) performance of tree/shrub species in across months at Lalibela. Means with similar letters are not significantly different at ($p<0.05$).

Table 4: Survival rate performance of tree/shrub species in percent across months.

Treatments	Months						
	6	12	18	24	33	39	45
	Mean ± _SE	Mean ± _SE	Mean ± _SE	Mean ± _SE	Mean ± _SE	Mean ± _SE	Mean ± _SE
A. senegal	100 ± 0^{a}	100 ± 0^{a}	98 ± 2^{a}	98 ± 2^{a}	98 ± 2^{a}	98 ± 2^{a}	98 ± 2^{a}
C. africana	100 ± 0^{a}	83 ± 14^{a}	85 ± 12^{a}	81 ± 13^{a}	73 ± 9^{a}	69 ± 16^{abc}	67 ± 15^{ab}
G. robusta	85 ± 8^{a}	83 ± 6^{a}	56 ± 17^{a}	47 ± 34^{a}	27 ± 27^{b}	17 ± 17^{bc}	11 ± 15^{b}
J. carcus	100 ± 0^{a}	88 ± 10^{a}	85 ± 12^{a}	85 ± 12^{a}	85 ± 12^{a}	83 ± 10^{ab}	76 ± 2^{ab}
M. azadarchata	100 ± 0^{a}	98 ± 2^{a}	94 ± 4^{a}	81 ± 10^{a}	56 ± 28^{ab}	56 ± 28^{abc}	46 ± 23^{ab}
M. stenoptela	83 ± 9^{a}	75 ± 10^{a}	64 ± 4^{a}	48 ± 15^{a}	4 ± 4^{c}	4 ± 4^{c}	4 ± 4^{b}

Means in columns with similar letters are not significantly different at ($p<0.05$), Nd: No Data, D: Dry Out, SE: Standard Error of the Mean.

Table 5: Growth performance of tree/shrub species in root collar diameter (cm) across months

Treatments	Months					
	6	12	18	33	39	45
A. abyssinica	0.59 ± 0.08^{ab}	0.91 ± 0.10^{ab}	1.67 ± 0.08^{a}	4.01 ± 0.13^{a}	4.47 ± 0.48^{a}	6.11 ± 0.76^{a}
A. decurrence	0.31 ± 0.01^{b}	0.53 ± 0.09^{bc}	0.56 ± 0.20^{bc}	3.31 ± 0.75^{a}	4.38 ± 0.59^{a}	6.55 ± 1.90^{a}
A. melanoxylon	0.65 ± 0.14^{ab}	0.80 ± 0.12^{abc}	1.08 ± 0.21^{ab}	2.80 ± 0.24^{a}	3.44 ± 0.20^{a}	4.18 ± 0.27^{a}
A. saligna	1.15 ± 0.23^{a}	1.37 ± 0.21^{a}	1.55 ± 0.19^{a}	4.06 ± 0.38^{a}	5.04 ± 0.27^{a}	7.06 ± 0.75^{a}
C. palmensis	0.30 ± 0.00^{b}	0.65 ± 0.00^{c}	0.35 ± 00^{c}	d	d	d
E. viminalis	0.71 ± 0.05^{ab}	1.22 ± 0.05^{ab}	1.05 ± 0.11^{ab}	2.54 ± 0.11^{a}	3.54 ± 0.11^{a}	4.24 ± 0.33^{a}

Means in columns with similar letters are not significantly different at ($p<0.05$), Nd: No Data, d: Dry Out, SE: Standard Error of the Mean.

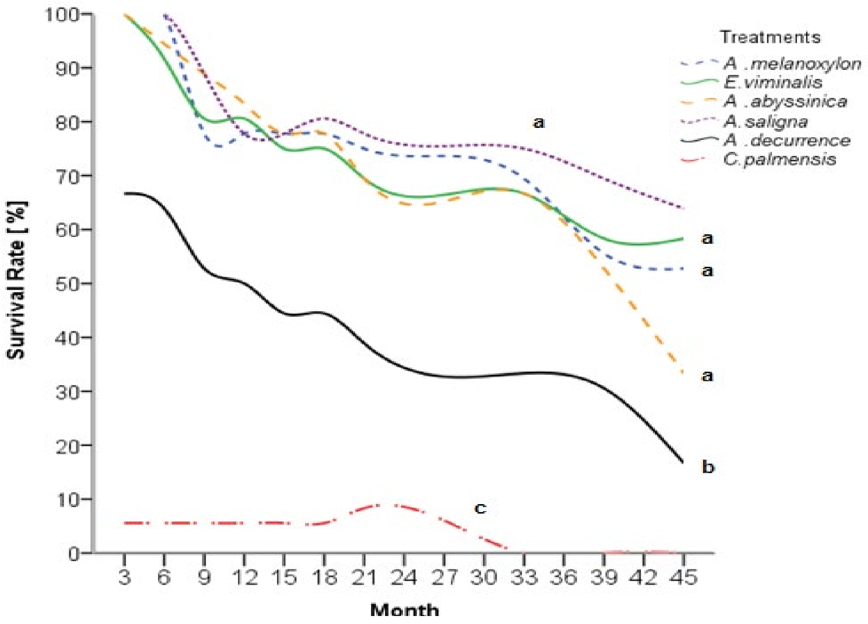

Figure 6: Growth performance of tree/shrub species in height (m) across months at Lalibela. Means with similar letters are not significantly different at (p<0.05).

the value were found by Tesfaye et al. [15], who found higher root collar diameter for *A. saligna* in the central highlands of Ethiopia. However, all treatments did not show any significant difference (p<0.05) in RCD at the end of the experiment (Figure 6).

CONCLUSION AND RECOMMENDATIONS

Across agroecological zones, the performance of tree and shrub species were varied in hieght, root collar diameter and survival rate. In the lowland site, better performances observed for *L. palida* and *M. stenoptella* in height and RCD, also *A. senegal* and *M. stenoptella* in survival rate. Similarly, in the mid altitude, *A. senegal* in height and survival rate, and *J. carcus* in RCD, had shown good performances. Also in the highland sites, relatively higher performances were observed for *A. deccurence* in height, *A. saligna* in RCD and survival rate at the end of the experimentation. Therefore, to restore degraded lands and to support the on-going land rehabilitation programmes of wag-lasta area, we recommend *A. senegal* and *M. stenoptella* for lowland site, *A. senegal* for mid altitude areas and *A. saligna* for highland site of lalibela, abergele and sekota and similar agroclimatic zones. However, additional studies regarding soil nutrient dynamics, fostering effect and tree nursing should be integrated to develop sound ecological restoration strategies in the growth corridor as well as in the region.

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