



Productivity Evaluation of Aloe Vera with Tree-based Agroforestry Systems in the Charland Ecosystem of Bangladesh

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Abstract: Aloe vera (*Aloe barbadensis* Mill.) offers both economic and therapeutic benefits in Bangladesh, thereby enhancing farmers' profits and addressing the growing demand for natural health products. Its integration into woody perennials can increase both income and productivity. However, research on the productivity evaluation of aloe vera in association with trees in different agroforestry systems in charland is limited, underscoring the need for further study. Therefore, an experiment was conducted from July 2022 to October 2024 in Char Kalibari under Sadar Upazila of Mymensingh District, Bangladesh, to evaluate the growth, yield, and economic productivity of aloe vera with tree-based agroforestry systems. A single-factor randomized complete block design with four treatments and three replications was employed, resulting in a total of 12 plots, each measuring 16 m². The treatments consisted of T₀, representing aloe vera sole cropping (control), T₁ = aloe vera with *Swietenia macrophylla* agroforestry, T₂ = aloe vera with *Mangifera indica* agroforestry, and T₃ = aloe vera with *Psidium guajava* agroforestry. Aloe vera suckers were transplanted into the interspaces, where the trees were permanently grown at a spacing of 2 m × 2 m. Findings revealed that aloe vera in sole cropping had significant growth and the highest fresh leaf yield (39.6 t ha⁻¹) compared to agroforestry treatments. Among the agroforestry combinations, the aloe vera-*Swietenia macrophylla* performed better than others, while the aloe vera-*Psidium guajava* showed the lowest growth and yield. From an economic point of view, the aloe vera-*Mangifera indica* agroforestry system provided the highest net income (664579 Tk ha⁻¹), benefit-cost ratio (1.81), and land equivalent ratio (1.69), making it the most profitable agroforestry combination. Correlation analyses revealed strong positive relationships between yield and key yield-contributing characters, including plant height, leaf number, leaf length and diameter, and individual leaf weight. In summary, the limited negative impact of tree components on the aloe vera plant emphasizes the viability of its cultivation in agroforestry systems in the Charland ecosystems to meet national demand.

Keywords: Medicinal plant; Agroforestry systems; Crop yield; Tree income, Economic analysis

INTRODUCTION

Bangladesh is home to approximately 6,500 plant species, of which 722 have medicinal values and about 700 are utilized for therapeutic purposes. Notably, 255 species are used in traditional Ayurvedic and Unani systems of medicine (Ahmed, 2022). Medicinal plant resources form a significant part of Bangladesh's pharmaceutical landscape (Shahidullah and Haque, 2010). Approximately one-fourth

of the country's pharmaceutical drugs are derived from these medicinal plants (Faisal, 2019), with their total market value estimated at US\$24.71 million (BFTI, 2016; Faisal, 2019). Owing to the rising global demand, researchers are increasingly focusing on the cultivation of medicinal plants in cultivated and uncultivated areas (Subrat, 2002). Despite their significant economic and ecological potential, medicinal plants remain underutilized in mainstream agricultural systems in Bangladesh. Currently, only 20% of

domestic demand for medicinal plants is met through local production, while the remaining 80% is imported. Integrating medicinal species into agroforestry systems presents a promising opportunity to enhance biodiversity, meet rising market demands, and diversify farmers' incomes.

Agroforestry is a sustainable land-use system combining trees, crops, and sometimes livestock, providing multiple benefits such as increased farm productivity, improved soil fertility, and valuable environmental services (Jose, 2009; Reed et al., 2017). Additionally, agroforestry advances sustainability through carbon sequestration and storage (Khan et al., 2021; Raj, 2017), promotes biodiversity (Udawatta et al., 2021), and enhances resource resilience (Biswas et al., 2022). Furthermore, agroforestry improves household food security (Nawaz et al., 2012; Yasin et al., 2018), elevates farmers' socioeconomic status (Ali et al., 2024; Duffy et al., 2021), supports smallholder livelihoods (van Noordwijk et al., 2023), contributes to national economic development (Gao et al. 2014; Gold and Garrett, 2009), and mitigates climate change impacts (Singh et al., 2017).

Among medicinal plants, Aloe vera (*Aloe barbadensis* Miller) of the family Liliaceae has become increasingly popular in Bangladesh due to its wide range of applications in the cosmetics, pharmaceuticals, and food industries (Grindlay and Reynolds, 1986; Eshun and He, 2004; Boudreau and Beland, 2006; Saccu et al., 2001). Traditional, rural people use aloe vera for treating various physical ailments, including coughs, colds, fevers, headaches, burns, tooth pain, dysentery, and digestive disorders (Foster et al., 2011). It is also consumed as “sarbat”, which keeps the stomach cool and relieves constipation. The annual national demand for fresh aloe vera leaves is approximately 13,000 tons, yet large-scale commercial cultivation remains limited. Only selective areas in the districts of Natore, Bogra, and Naogaon have adopted commercial cultivation as sole cropping and are meeting 70-80% of the current demand. Therefore, alternative land-use strategies are necessary to expand aloe vera production. One promising avenue is the charland ecosystem, where agroforestry practices could enhance medicinal plant production and meet the country's national demand.

Charlands— riverine floodplains formed by silt deposition— cover approximately 0.83 million hectares in Bangladesh, 90% of which are suitable for cultivation and home to over 6.5 million people (Ahmad, 2022). Charlands are often home to marginalized communities and hold significant potential for agroforestry systems that can improve productivity while maintaining environmental sustainability. The literature shows that traditional agroforestry in the charland primarily involves fruit and timber trees combined with seasonal crops; overall productivity remains low. The integration of high-value medicinal plants— aloe vera into these systems can increase land-use efficiency, enhance farmer income, and promote ecological resilience. Agroforestry trees in charland can improve microclimates, supply food, fodder, fuelwood, and timber, and create more favourable growing conditions for arable crops. Furthermore, integrating aloe vera medicinal

plants with tree components offers a promising option for charland farmers in Bangladesh, as it enhances farm production, increases income, and boosts economic productivity.

Several studies have validated the successful integration of medicinal and aromatic plants with agroforestry tree species (Madhavi et al., 2012; Kumar et al., 2017). Research has also demonstrated that MAPs can be effectively intercropped between rows of fruit trees (Pawar et al., 2006; Swain and Patro, 2007). In the context of Bangladesh, however, research on the integration of medicinal plants into agroforestry systems, especially charland areas, remains limited. Existing studies have mostly focused on the inclusion of medicinal plants, including aloe vera, within agroforestry systems in plain land ecosystems (Bari and Rahim, 2010; Khatun et al., 2010; Bari and Rahim, 2012; Aktar et al., 2019), leaving a knowledge gap regarding the viability and productivity of aloe vera-tree crop agroforestry systems in charland ecosystems. Therefore, it is necessary to assess the growth, yield and economic productivity of aloe vera with tree-based agroforestry systems in Bangladesh's charlands. Such research can offer new insights into sustainable land use, contribute to national herbal resource security, and provide livelihood options for vulnerable communities.

MATERIALS AND METHODS

Experimental Location and Geographical Description

A field experiment was carried out at Char Kalibari under Sadar Upazila of Mymensingh district, from July 2022 to October 2024. Mymensingh district is situated between 24°38'3" north latitude and 90°16'4" east longitude. The total area of this district is 4394.57 km². The experimental site is located between 24°45' to 25°40" north latitude and 90°24'4" to 90°24'44" east longitude (Wikipedia, 2025, and Figure 1). The area of this Char is about 257 ha of which cultivated land is 175 ha, wetland 10 ha, fallow land 40 ha, homestead 23 ha and the rest 9 ha is forest area. There are 2350 people in total, with 1238 men and 1112 women (Char Ishwardia Union Parishad, 2024).

Physiography of the Experimental Site

Char Kalibari is one of the charland located along the Old Brahmaputra River floodplain Agro-ecological zone-9 includes the charland, which has a terrain that is medium-high land above flood level. Recent and older alluvial sediments from low areas of the former Brahmaputra floodplain are primarily responsible for the soil formation in this region. Dark grey floodplain soil that is non-calcareous, predominantly medium-textured (loam and silt loam), with variations ranging from clay loam to sandy loam and clay content between 10–33% (Islam et al., 2003). The study area has a subtropical climate. High temperatures and lots of rainfall from April-September and little from October-March are its defining characteristics. Except for winter, the relative humidity is consistently high throughout the year.

Tree and Crop Materials

A four-year-old established plantation scheme of *Swietenia macrophylla* and orchards of *Mangifera indica* and *Psidium*

guajava tree species were selected as test tree components, and a local variety of *Aloe barbadensis* was used as crop material for the study.

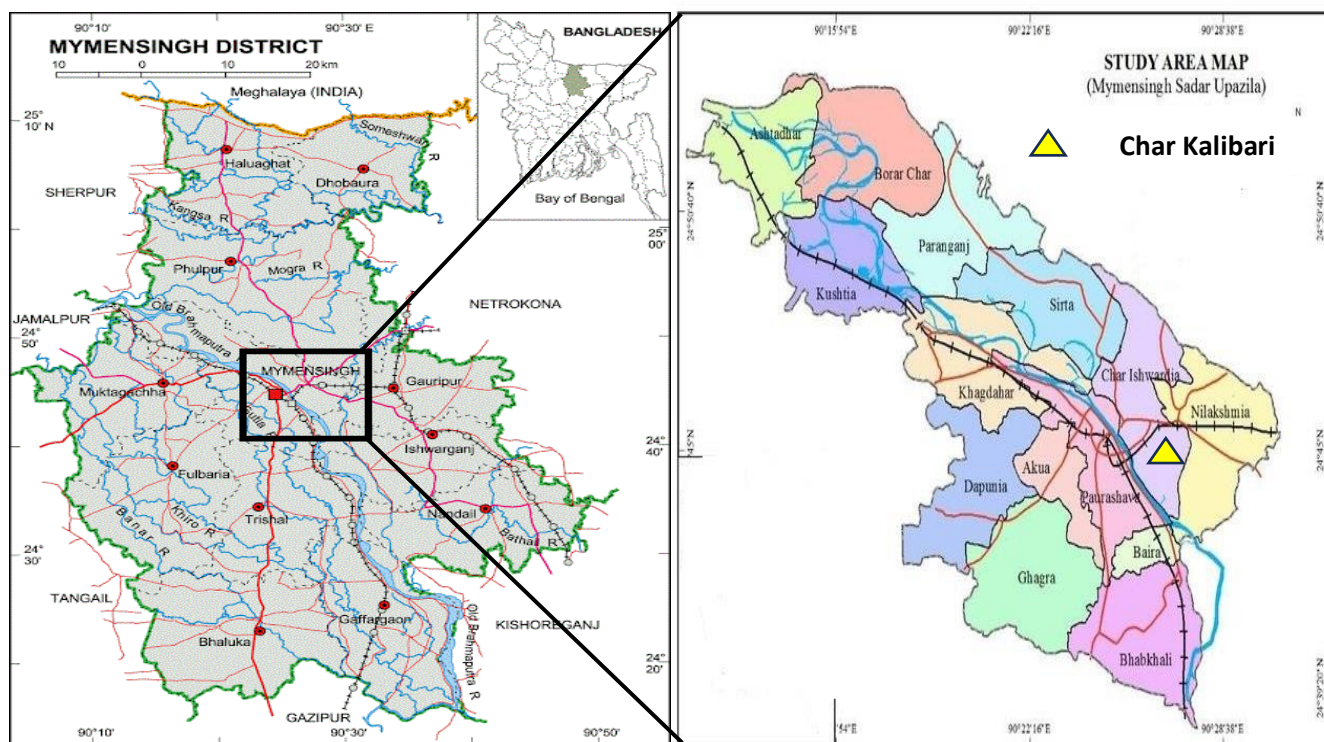


Figure 1. Location of Mymensingh district (left) and study area map showing Char Kalibari (right) (Source: Rakib et al., 2017 and <https://bdmaps.blogspot.com/2011/09/mymensingh-district.html>)

Experimental Design and Treatments

The field experiment was followed in Randomized Complete Block Design (RCBD) with four treatments and three replications. The treatments were T_0 = sole aloe vera cropping (i.e. control), T_1 = aloe vera-*Swietenia macrophylla* agroforestry, T_2 = aloe vera-*Mangifera indica* agroforestry, and T_3 = aloe vera-*Psidium guajava* agroforestry. The size of each plot was $4\text{ m} \times 4\text{ m} = 16\text{ m}^2$ and a total number of plots was 12. *Swietenia macrophylla*, *Mangifera indica*, and *Psidium guajava* tree species were grown permanently maintaining spacing $2\text{ m} \times 2\text{ m}$.

Land Preparation, Sucker Transplanting and Crop Management

The land was first opened on 20 July 2022 and then on 01 September 2023 using a spade and a plough. All the crop residues, weeds and stubble were removed to obtain a desirable tilth of soil for planting aloe vera sucker. The manure and fertilizers such as FYM 10 t ha^{-1} , Urea 65 kg ha^{-1} , Triple superphosphate 250 kg ha^{-1} , Muriate of potash 50 kg ha^{-1} , and Gypsum 120 kg ha^{-1} were applied during the final land preparation. An additional 65 kg ha^{-1} urea was applied 20 days after transplanting. Aloe vera suckers were collected from Laxmipur Kholabaria Union (Local Administrative Unit) under Sadar Upazila of Natore district. Before planting, the suckers were cleaned by removing dead

leaves and trimming a portion of the roots. The suckers were planted on 31 July 2022 and 10 September 2023, maintaining a row to row 60 cm and plant to plant spacing 40 cm . Gap filling was performed one week after transplanting using uniform suckers from the same nursery. The experimental plots were kept weed-free through frequent manual weeding. Irrigation was provided as needed using a hose pipe and watering can. No major pest or disease outbreaks were observed. However, mealybugs, anthracnose, and leaf spot diseases were occasionally identified in the field. Leaf spot was effectively controlled by spraying the recommended fungicide Mancozeb. Termite infestations were managed through the application of light irrigation.

Sampling, Harvesting, and Data Collection

Five aloe vera plants from each treatment were randomly selected and marked with sample cards to record the data on plant height (cm), leaves per plant (no.), leaf length (cm), leaf width (cm), individual leaf weight (g), fresh and dry leaf weight (g plant^{-1}), fresh and dry leaf yield (kg ha^{-1}). The leaves of aloe vera were harvested twice during the experimental period. First harvest from July to September 2023 and second from July to September 2024. Four harvests were done in each duration at 20-day intervals, and the necessary information was recorded. Plot-by-plot fresh leaf yields were recorded and expressed as t ha^{-1} . The growth and yield parameters, tree height, and tree volume of the

Swietenia macrophylla, *Mangifera indica*, and *Psidium guajava* were determined. The height and diameter at breast height (DBH) of trees were measured before planting and after harvesting of aloe vera. The tree height was measured (in meters) using a graduated bamboo pole. The bole girth, bole DBH, and basal girth of the trees were measured using a measuring tape and expressed in meters. The volume of the standing trees was estimated using a formula developed by Husch et al. (2003): $V = \frac{\pi}{4} \times D^2 \times H \times F$. Where V = bole volume, D = diameter at breast height (DBH, m), H = tree height (m), and F = form factor.

Also, the fruits per tree (no.), fruit yield (kg ha⁻¹), and income (Tk ha⁻¹) of *Mangifera indica* and *Psidium guajava* were recorded during harvesting, and yield per hectare was subsequently calculated.

Economic Profitability Analysis

The economic profitability of aloe vera-tree crop agroforestry systems was computed per hectare using the total cost of cultivation, gross income, net income (Tk ha⁻¹), benefit-cost ratio (BCR), and land equivalent ratio (LER). The following formula was used to calculate the overall cost of production: Total cost of production (TC) = Input cost + Overhead cost. The total income of an agroforestry systems was calculated by adding crop income and income from tree products: Total income = Crop income + Income from tree products. All farm expenditures were subtracted from total income to arrive at the net return: Net income = Total income – Total costs. The benefit-cost ratio refers to net income as compared to the cost of production (Islam et al., 2004; Hasan et al., 2020b).

$$BCR = \frac{\text{Net income}}{\text{Total cost of production}}$$

LER is the ratio of each tree and crop species' relative yield in an agroforestry system to the yield of the same tree and crop species in a monoculture during the same period (Mead and Wiley, 1980; Hasan et al., 2020a). It was calculated as follows in agroforestry situations:

$$LER = \frac{C_i}{C_s} + \frac{T_i}{T_s}$$

Where C_i represents crop yield when intercropping, C_s represents crop yield when sole cropping, T_i represents tree yield when intercropping, and T_s represents tree yield when sole cropping.

Data Statistical Analysis

The collected data were gathered and analyzed by the stated design to test the statistical significance of experimental findings. The data collected over two consecutive years were analyzed using a linear mixed model (LMM) to interpretation for both fixed and random effects across years and treatments. Statistical analysis was performed using the lme4 package in R software (R Core Team, version 4.3.3). Pairwise comparisons among treatment means were conducted using Tukey's Honest Significant Difference (HSD) test by the multcompView package in R Studio programming (Posit Team, 2024).

RESULTS AND DISCUSSIONS

Performance of aloe vera growth and yield in aloe vera with tree-based agroforestry systems

The results indicated that the growth characteristics of aloe vera, such as plant height, leaves per plant (no.), leaf length and width, were significantly affected by different tree species at a 0.1% level of probability (p<0.001) (Table 1). Based on the pooled value, the highest plant height (44.3 cm) of aloe vera was observed in the sole aloe vera cropping treatment (T₀), which was significantly greater than in the other treatments. Among the tree species, the longest aloe vera plant (36.7 cm) was observed at T₁ treatment (aloe vera-*Swietenia macrophylla* agroforestry), which was statistically similar to T₂ (aloe vera-*Mangifera indica* agroforestry) (35.1 cm) treatment. On the contrary, the smallest aloe vera plant (30.8 cm) was recorded under T₂ (aloe vera-*Psidium guajava* agroforestry) treatment. The results indicated that the highest number of leaves per plant (13.42) was recorded in the treatment T₀ (sole aloe vera cropping). Among the agroforestry treatments, the greatest number of leaves per plant (11.60) was found under the treatment of Aloe vera-*Swietenia macrophylla* agroforestry, which was statistically similar to the T₂ treatment (aloe vera-*Mangifera indica* agroforestry) (11.47). The lowest number of leaves per plant (8.32) was recorded at T₃ (aloe vera-*Psidium guajava* agroforestry) treatment. However, the highest leaf length and width (34.6 and 5.47 cm, respectively) of aloe vera plants were observed in the sole aloe vera cropping (T₀). The analyzed data indicated that among the three treatments, the highest leaf length and width (30.6 and 4.71 cm, respectively) were recorded in the T₁ treatment, statistically similar to the T₂ treatments (29.8 and 4.54 cm, respectively). The shortest leaf length and width (25.1 and 3.79 cm, respectively) of aloe vera plants were obtained in the treatment T₃, where aloe vera plant was intercropped with *Psidium guajava* tree species. The yield and yield attributes of aloe vera, such as individual leaf weight, fresh and dry leaf weight per plant, fresh and dry leaf yield, were significantly affected by the treatments (p<0.001) (Table 1). The heaviest leaves (70.9 g) were recorded in the control treatment (T₀). The pooled values indicated that among the tree species treatments, T₁ showed a relatively higher leaf weight (64.7 g), which was statistically similar to T₂ (63.7 g). The lightest leaves (52.3 g) were found in the T₃ treatment. Significant differences were observed in the fresh and dry leaf weight of aloe vera among treatments. The treatment T₀ (Sole aloe vera cropping) exhibited the highest fresh and dry leaf weights per plant (951 and 38.0 g, respectively), which were statistically higher than the other treatments. The treatment T₁ had the maximum amount of fresh leaf weight per plant of 751 g, followed by T₂ (731 g). The maximum amount of dry leaf weight (30.7 g) per aloe vera plant was obtained by the T₂ treatment, which was statistically similar to the T₁ treatment. On the contrary, the lowest (436 and 20.9 g, respectively) fresh and dry leaf weight of the aloe vera plant was obtained in the T₃ treatment. Table 1 shows that the fresh and dry leaf yield of aloe vera plants per hectare exhibited the highest (39.6 and 1.58 t ha⁻¹) in the T₀ treatment, i.e., sole

aloe vera cropping. Among the tree species treatments, the highest fresh leaf yield (31.3 t ha⁻¹) was obtained at the T₁ treatment, which was statistically similar to the treatment T₂. The maximum dry leaf yield (1.28 t ha⁻¹) was reported in the T₂ treatment, followed by the T₁ treatment. While the lowest fresh and dry leaf yield (18.2 and 0.87 t ha⁻¹) of aloe vera was obtained at T₃ treatment, i.e., aloe vera-*Psidium guajava* agroforestry. The result was in line with that by Bari and Rahim (2012), who reported that the highest yield (31.10 t

ha⁻¹) of aloe vera was recorded under a sole cropping system, which was followed by (22.48 t ha⁻¹) coconut+lemon+aloe vera-based multistoried agroforestry (MAF). While the lowest yield of aloe vera (18.53 t ha⁻¹) was recorded in the coconut+guava+aloe vera-based MAF. Khatun et al. (2010) also observed that the growth, yield attributes, and yield of aloe vera were significantly influenced and performed better under guava-lemon agroforestry systems than sissou-lemon agroforestry systems.

Table 1. Effects of trees on the growth and yield of aloe vera in aloe vera with tree-based agroforestry systems

Treatments	Plant height (cm)	Leaves per plant (no.)	Leaf length (cm)	Leaf width (cm)	Individual leaf weight (g)	Fresh leaf weight (g plant ⁻¹)	Dry leaf weight (g plant ⁻¹)	Fresh leaf yield (t ha ⁻¹)	Dry leaf yield (t ha ⁻¹)
T ₀	44.3a	13.42a	34.6a	5.47a	70.9a	951a	38.0a	39.6a	1.58a
T ₁	36.7b	11.60b	30.6b	4.71b	64.7b	751b	29.6b	31.3b	1.23b
T ₂	35.1b	11.47b	29.8b	4.54b	63.7b	731b	30.7b	30.4b	1.28b
T ₃	30.8c	8.32c	25.1c	3.79c	52.3c	436c	20.9c	18.2c	0.87c
Level of sig.	***	***	***	***	***	***	***	***	***
CV (%)	14.18	17.49	12.45	15.31	11.20	26.76	21.60	26.76	21.60

Note: Means in a column followed by different letters are significantly different according to Tukey’s honest significant difference (HSD); T₀ = sole aloe vera cropping (control), T₁ = aloe vera-*Swietenia macrophylla* agroforestry, T₂ = aloe vera-*Mangifera indica* agroforestry, and T₃ = aloe vera-*Psidium guajava* agroforestry; CV = Coefficient of variation; sig = significance; *** = significant at 0.1% level of probability.

Growth performance of *Swietenia macrophylla*, *Mangifera indica*, and *Psidium guajava* in aloe vera with tree-based agroforestry systems

The growth parameters, such as tree height, bole GBH and DBH, and basal area (BA) of *Swietenia macrophylla*, *Mangifera indica*, and *Psidium guajava* were estimated and found to vary significantly with the advancement of age (Table 2). The result showed that the highest (6.0 m) tree height was recorded in (T₁) aloe vera-*Swietenia macrophylla* agroforestry, followed by (4.34 m) in (T₃) aloe vera-*Psidium guajava* agroforestry, while the lowest (3.68 m) tree height was observed in (T₂) aloe vera-*Mangifera indica* agroforestry. The highest GBH (27.50 cm) was found in the

aloe vera-*Swietenia macrophylla* agroforestry (T₁), whereas the lowest GBH (23.34 cm) was recorded in the aloe vera-*Psidium guajava* agroforestry, which was statistically similar to the aloe vera-*Mangifera indica* agroforestry (T₃). The maximum (8.75 cm) DBH was noted in (T₁) aloe vera-*Swietenia macrophylla* agroforestry, and the minimum DBH was recorded in (T₃) aloe vera-*Psidium guajava* agroforestry. The largest basal area (48.09 cm²) was recorded in the aloe vera-*Swietenia macrophylla* agroforestry (T₁), followed by (38.26 cm²) in the aloe vera-*Psidium guajava* agroforestry (T₃), whereas the smallest (33.63 cm²) basal area was observed in the (T₂) aloe vera-*Mangifera indica* agroforestry treatment.

Table 2. Effect of aloe vera with tree-based agroforestry systems on growth parameters of tree species

Treatments	Tree height (cm)	Girth at breast height (cm)	Diameter at breast height (cm)	Basal area (cm ²)
T ₁	6.00a	27.50a	8.75a	48.09a
T ₂	3.68c	23.48b	7.48b	33.63c
T ₃	4.34b	23.34b	7.43b	38.26b
Level of significance	*	*	*	*
CV (%)	3.37	3.83	3.81	2.28

Note: Means in a column followed by different letters are significantly different according to Tukey’s honest significant difference (HSD); T₁ = aloe vera-*Swietenia macrophylla* agroforestry, T₂ = aloe vera-*Mangifera indica* agroforestry, and T₃ = aloe vera-*Psidium guajava* agroforestry; CV = Coefficient of variation; sig = significance; * = significant at 5% level of probability.

Economic profitability analysis of aloe vera with tree-based agroforestry systems

Among the four treatments, the highest costs of production (821817 Tk ha⁻¹) were calculated in the (T₃) aloe vera-*Psidium guajava* agroforestry, and the lowest costs of production (787241 Tk ha⁻¹) were recorded in the (T₀) aloe vera sole cropping, i.e., control. The maximum total income (1484037 Tk ha⁻¹) was obtained in aloe vera-*Mangifera indica* agroforestry (T₂), followed by (1386000 Tk ha⁻¹) from sole aloe vera cropping (T₀), whereas the lowest (1089655

Tk ha⁻¹) income was obtained in aloe vera-*Psidium guajava* agroforestry (T₃) (Table 7). Thus, the highest net profit of 664579 Tk ha⁻¹ was recorded in the aloe vera-*Mangifera indica* agroforestry (T₂). In contrast, the lowest net profit of 267838 Tk ha⁻¹ was found in the aloe vera-*Psidium guajava* agroforestry (T₃). However, the highest BCR (1.81) was recorded in (T₂) aloe vera-*Mangifera indica* agroforestry, followed by (1.76) in (T₀) sole aloe vera cropping, and the lowest (1.33) in (T₃) aloe vera-*Psidium guajava* agroforestry. Accordingly, the highest LER (1.69) was recorded in (T₂)

aloe vera-*Mangifera indica* agroforestry, whereas the lowest (1.33) LER was obtained in (T₃) aloe vera-*Psidium guajava* agroforestry. This result is supported by Bari and Rahim (2012), who reported that the highest benefit-cost ratio of 3.54 was recorded from coconut, guava, and aloe vera-based MAF, followed by coconut, lemon, and aloe vera-based

MAF. In contrast, the lowest benefit-cost ratio of 1.65 was obtained in aloe vera sole cropping systems. Al Amin et al. (2021) found that the benefit-cost ratio of mango-potato agroforestry systems was 2.14, which was higher than growing potatoes as a sole crop (1.78).

Table 3. Economic performances of various aloe vera-tree crop agroforestry systems

Treatments	Gross Returns (US\$ ha ⁻¹)			Costs (US\$ ha ⁻¹)	Net Profit (US\$ ha ⁻¹)	BCR	LER
	Crops	Tree	Total Income				
T ₀	11404	0	11404	6477	4926	1.76	-
T ₁	9013	928	9942	6403	3539	1.55	1.61
T ₂	8754	3456	12210	6742	5468	1.81	1.69
T ₃	5241	3724	8965	6762	2204	1.33	1.35

Note: T₀ = aloe vera sole cropping (control), T₁ = aloe vera-*Swietenia macrophylla* agroforestry, T₂ = aloe vera-*Mangifera indica* agroforestry, and T₃ = aloe vera-*Psidium guajava* agroforestry.

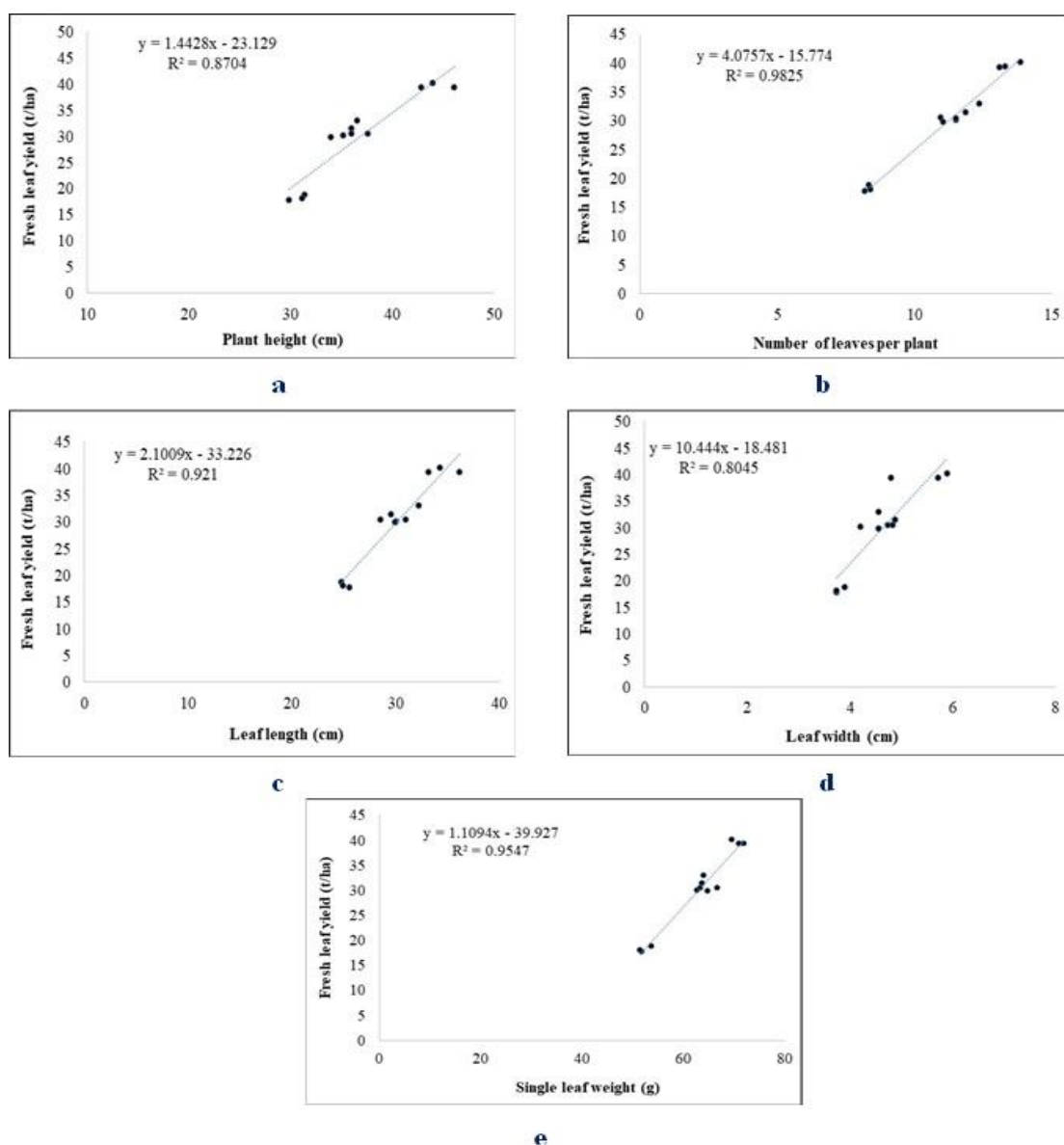


Figure 2. Scatter chart a-e, relationship between fresh leaf yield and plant height (a); fresh leaf yield and number of leaves per plant (b); fresh leaf yield and leaf length (c); fresh leaf yield and leaf width (d); fresh leaf yield and single leaf weight (e)

Relationship between yield contributing characters and yield of aloe vera in aloe vera-tree crop agroforestry systems

The scatter chart showed that the fresh leaf yield (t/ha) of aloe vera was positively correlated with the plant height (cm), leaves per plant (no.), leaf length and width, and single leaf weight (Figure 2). Figure 2 (a) shows that a strong positive relationship exists between plant height (cm) and the fresh leaf yield (t ha⁻¹) of aloe vera, with the value of r being 0.932 and $R^2 = 0.87$. A positive correlation regression result was noted for the number of leaves per plant and the fresh leaf yield (t ha⁻¹) of aloe vera. The value of correlation regression, $R^2 = 0.98$, $r = 0.99$, was highly positive (Figure 2 (b)). According to results, the leaf length and leaf width were positively correlated with the fresh leaf yield (t ha⁻¹) of aloe vera plant, with the value of R^2 being 0.92, $r = 0.95$, and R^2 was 0.80, $r = 0.89$ (Figure 2 (c-d)). From correlation regression analysis, it was shown that the single leaf weight of aloe vera had a strong positive relationship with the fresh leaf yield (t ha⁻¹) in aloe vera-tree crop agroforestry systems (Figure 2 (e)). The value of correlation regression, $R^2 = 0.95$, $r = 0.97$ that was a highly positive correlation.

CONCLUSION

This study evaluated the productivity and economic viability of aloe vera-based agroforestry systems incorporating *Swietenia macrophylla*, *Mangifera indica*, and *Psidium guajava* in the charland ecosystem of Mymensingh, Bangladesh. The findings demonstrated that aloe vera sole cropping produced the highest growth and yield performance. However, among the tree-based systems, intercropping with *Mangifera indica* and *Swietenia macrophylla* led to significantly better aloe vera growth and yield compared to *Psidium guajava*, which performed the poorest. Tree growth attributes, including height, DBH, and basal area, were also influenced by intercropping. *Swietenia macrophylla* showed the most robust growth, indicating a high degree of compatibility with aloe vera. Economically, the aloe vera–*Mangifera indica* system yielded the highest total income (Tk ha⁻¹), net profit, benefit-cost ratio (1.81), and land equivalent ratio (1.69), highlighting its superior land-use efficiency and financial return. Overall, integrating aloe vera with *Mangifera indica* in charland areas offers a viable strategy to enhance land productivity, reduce reliance on medicinal plant imports, and improve rural livelihoods while promoting biodiversity. This system presents a promising model for sustainable land use in underutilized riverine ecosystems. Further long-term studies are recommended to assess its ecological resilience and broader environmental impacts under changing climatic conditions.

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Conflicts of Interest

The authors declared there are no conflicts of interest.

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