Design and construction of a floating seedbed for rice seedling cultivation in flood prone lowland areas

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Abstract: Frequent flooding and land scarcity pose significant challenges to rice seedling production in flood-prone regions. This study investigates floating seedbeds as a climate-resilient solution, evaluating three compositions: water hyacinth only (T1); water hyacinth and soil (T2); soil only (T3). Seedling growth was assessed based on height, root depth, stem thickness, and stem size. The results indicate that T2 (water hyacinth and soil) achieved the best overall growth, producing the tallest seedlings (35.76 cm), largest stem size (10.16 cm), and optimal root depth (5.04 cm). T1 supported strong root elongation and thicker stems, while T3 had the lowest growth performance due to limited buoyancy and nutrient distribution. These findings demonstrate that integrating soil with water hyacinth enhances nutrient retention and structural stability, optimizing seedling development. Floating seedbeds provide a sustainable, low-cost alternative for rice production in flood-prone areas. Future research should focus on scaling up implementation and evaluating long-term viability to strengthen food security and climate adaptation strategies.

Keywords: rice seedling, floating seedbed, flood adaptation, lowland agriculture, climate resilience

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1 Introduction

Bangladesh is an agrarian country with gradually decreasing cultivable land and increasing population (Yeasmin et al., 2020). Rice is an important staple food for almost two-thirds of the world's population, making it a vital worldwide resource (Asma et al., 2023), due to its affordability and nutritional value (Hirzel et al., 2020). It is cultivated on 163 million hectares worldwide, with 90% of production concentrated in Asia (Verma et al., 2018). In Bangladesh, rice occupies 75% of agricultural land, contributing 28% to the national Gross Domestic Product (Chowhan et al., 2017). Rice (*Oryza sativa* L.) is Bangladesh's staple meal, accounting for 67.5% of daily calorie intake with a per capita consumption of 144.5 kg year^{-1}. Boro (winter) is the most productive of the three rice seasons, accounting for around 40% of planted area and 55% of overall yield. Aus (pre-monsoon) is the smallest, accounting for

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just about 10% of the land and 7% of production. The Aman (monsoon) rice crop has the highest planted area (~50%) and the second highest production volume (~38%) (Saha et al., 2021).

Japan International Cooperation Agency (2021) emphasizes that the most important factor in achieving desirable traits such as taste, nutrition, and productivity in rice cultivation is the quality of rice seeds. High-quality seeds contribute significantly to improving yield and overall rice production efficiency (Japan International Cooperation Agency, 2021). Seedbed preparation is a critical stage in rice cultivation, influencing seedling quality and crop productivity. Proper land preparation, including tillage, soil conditioning, and transplanting, is essential for ensuring high yields (Okeke and Oluka, 2017). Traditionally, rice seedlings are grown in puddled soil before transplantation (Dilipkumar et al., 2022). Rice seedlings should be transplanted between two and three weeks old. Rice yield was found to be considerably affected by seedling age at transplant (Ramadhani et al., 2018). In general, fewer than 25 days is the ideal seedling age for rice that has been mechanically transplanted (Liu et al., 2017). In one instance, studies on transplanting age have indicated that rice seedlings transplanted earlier (8 - 16 days) resulted in increased grain yield (Reuben et al., 2016). The coastal region of Bangladesh is susceptible to saline intrusion (Sharifuzzaman and Islam, 2024). Soil salinity in Bangladesh’s southern coastal districts, covering 2.83 million hectares or 20% of the country’s land and 30% of its cultivable area, poses a major threat to agriculture and livelihoods (Shawkhatuzamman et al., 2023).

Flooding is the most frequent of these calamities and has a significant impact on Bangladesh's rice crop. Therefore, identifying places that flood regularly and rice paddies affected by flooding is crucial for preventing floods, minimizing property damage, and guaranteeing Bangladesh's food security. Bangladesh's low-lying areas frequently experience flooding (Singha et al., 2020). Flooding also alters soil nutrient dynamics, affecting the uptake of iron (Fe), zinc (Zn), and cadmium (Cd), essential for plant growth (Xu et al., 2024). To reduce the high risk of submergence, seedling preparation on a floating seedbed is an alternative method. Farmers can use the flooding period to prepare seedlings and increase planting time by using a floating system (Ria et al., 2020). Floating agriculture is the cultivation of crops on floating beds created from water hyacinth, bamboo, and other organic materials that are easily available as river debris (Sarker et al., 2025). However, challenges such as labor intensity, technical expertise, and material availability still constrain wider adoption in wetland communities (Kabir et al., 2022).

Floating agriculture presents a viable climate-adaptive solution for seedling production in flood-prone areas. This method, locally known as "Vasoman Chash," has been practiced for centuries in southern and southwestern Bangladesh, where farmers construct floating platforms from water hyacinth and bamboo to grow crops on water surfaces (Al Mamun et al., 2021). Despite being invasive, water hyacinth is a beneficial bioresource (Laguna-Estrada et al., 2024). It enhanced structure, nutrient retention, and insect suppression when processed or combined with soil; these characteristics help buoyancy, aeration, and nutrient supply in floating nursery platforms (Kassa et al., 2025). By utilizing locally available resources, this system minimizes input costs while enhancing resilience to extreme weather conditions (Kabir et al., 2022). The nutritional quality of floating beds has a major impact on plant growth, development, and production (Al-Imran et al., 2023). Lindiana et al. (2016) suggests that floating seedbeds composed of decomposed aquatic weed biomass improve nutrient availability and seedling health. Additionally, lightweight floating bed designs have been shown to support early seedling growth and improved transplanting success (Ramadhani et al., 2018).

This study evaluates the effectiveness of floating seedbeds for rice seedling development in flood-prone areas by comparing three different compositions: water hyacinth alone, water hyacinth mixed with soil, and soil supported by plastic bottles. The study focuses on creating and building floating seedbeds, assessing seedling growth metrics (height, root depth, stem thickness, and leaf count), and determining their suitability as a climate-resilient method. Overall, the study seeks to increase sustainable rice agriculture, climate adaptability, and food security in flood-affected areas (Siaga et al., 2019).

2 Materials and methods

2.1 Site selection

The effectiveness of a floating bed system largely depends on selecting a suitable site with favorable environmental conditions. Key factors considered for site selection included water quality, ease of handling, maximum sunlight exposure, and minimal disruption from wind and water currents. A pond adjacent to the university mosque in Sylhet city, Bangladesh, was chosen as the experimental site due to its calm water conditions and accessibility. The study was conducted from June to September 2021. The geographical coordinates of the site are 24°54'39.1"N, 91°54'10.0"E, and the floating structure was placed along the north bank of the pond to ensure stability.

2.2 Raw materials

The floating seedbed structure was constructed using Bangladeshi available materials to ensure cost effectiveness and sustainability. The primary materials included bamboo, steel wire, plastic bottles, jute sacks, and water hyacinth. Bamboo is a lightweight but robust natural material with great tensile strength, flexibility, and environmental sustainability. Steel wire has higher tensile strength and longevity, and it can bear heavy loads and mechanical stress. Jute sack, formed from natural jute fibers, is praised for being biodegradable, breathable, and inexpensive, but it deteriorates faster when exposed to damp. Poultry manure, obtained from a Bangladeshi poultry farm, was incorporated as an organic supplement to enhance soil fertility. Additionally, rice seeds (BRRI dhan71) were selected for cultivation, sourced from the Bangladesh Rice Research Institute, Gazipur. Water hyacinth and supplementary chemical fertilizers were collected from nearby locations.

2.3 Design of floating structure

Prior to construction, the floating seedbed was designed using AutoCAD software to ensure precise dimensions and structural integrity (Figure 1). The design consisted of three experimental plots, each measuring 1.5 m in length, 0.75 m in width, 0.75 m in height from water surface and 1.0 m in height from the soil surface under the water.

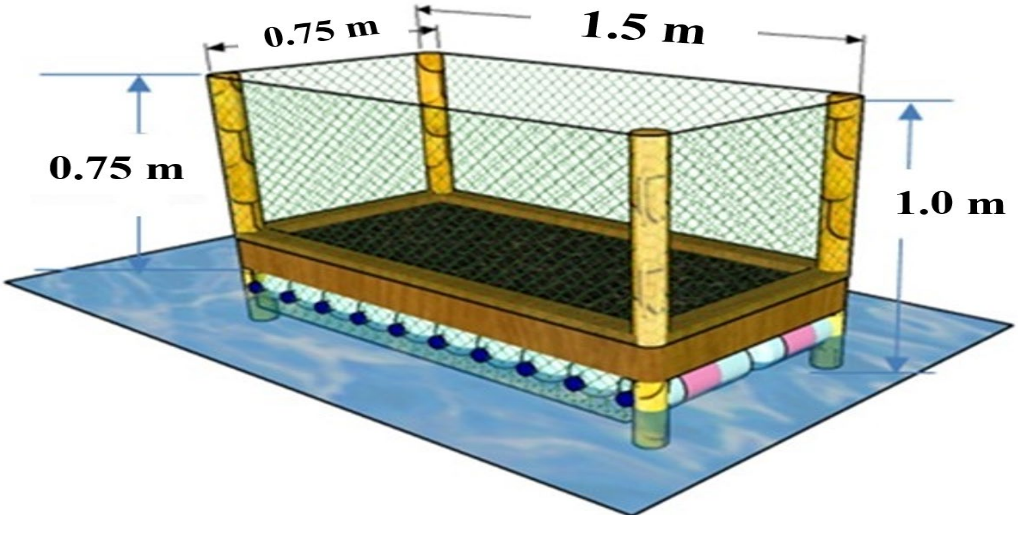

Figure 1 Design of the floating bed structure

The composition of the floating beds varied as follows:

- Plot 1: Constructed using a single layer of water hyacinth.

- Plot 2: Comprised a base layer of water hyacinth, topped with a soil layer.
- Plot 3: Contained only soil and was supported by plastic bottles to provide buoyancy.

The floating structure was enclosed using bamboo and netting to maintain stability.

2.4 Construction of floating structure

The construction process involved assembling a rectangular frame using bamboo poles, which were bound together with steel wire for reinforcement (Figure 2). The framework was then enclosed with a net to secure the floating bed components.

- Plot 1: A 0.8 m water hyacinth was placed directly inside the enclosed frame.
- Plot 2: A base layer of 0.5 m of water hyacinth was laid, followed by a 0.3 m layer of soil to create a mixed medium, forming the cross-sectional structure of the floating seedbed (Figure 3). The floating bed structure after seedling establishment is shown in (Figure 4).
- Plot 3: A 0.8 m soil layer was used, with plastic bottles incorporated to maintain flotation.

Once assembled, the floating structure was carefully positioned on the pond surface to prevent excessive movement due to wind or water currents.

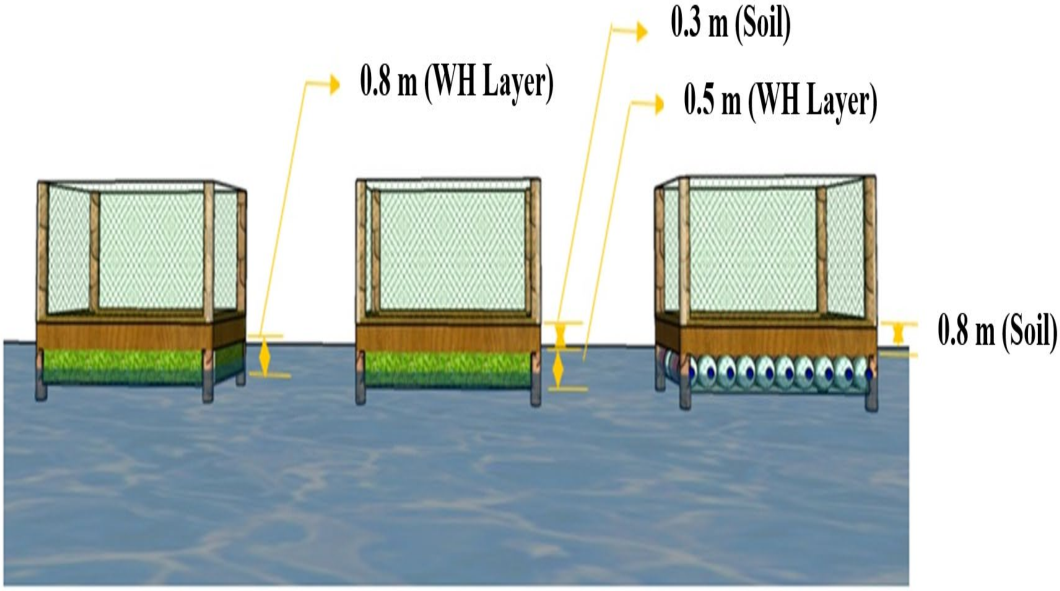

Figure 2 Construction process of the floating bed using bamboo and netting

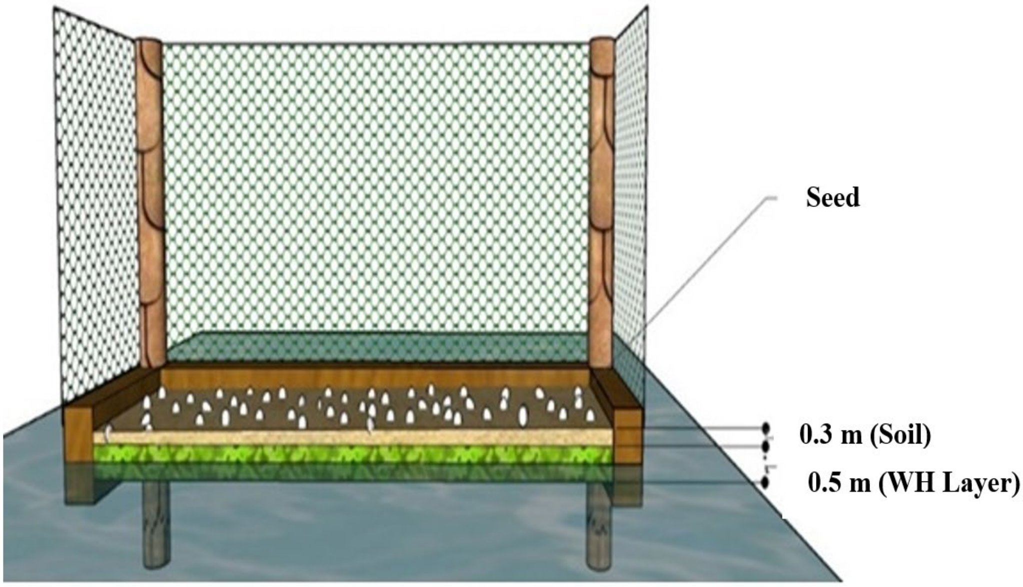

Figure 3 Cross-section of the floating seedbed

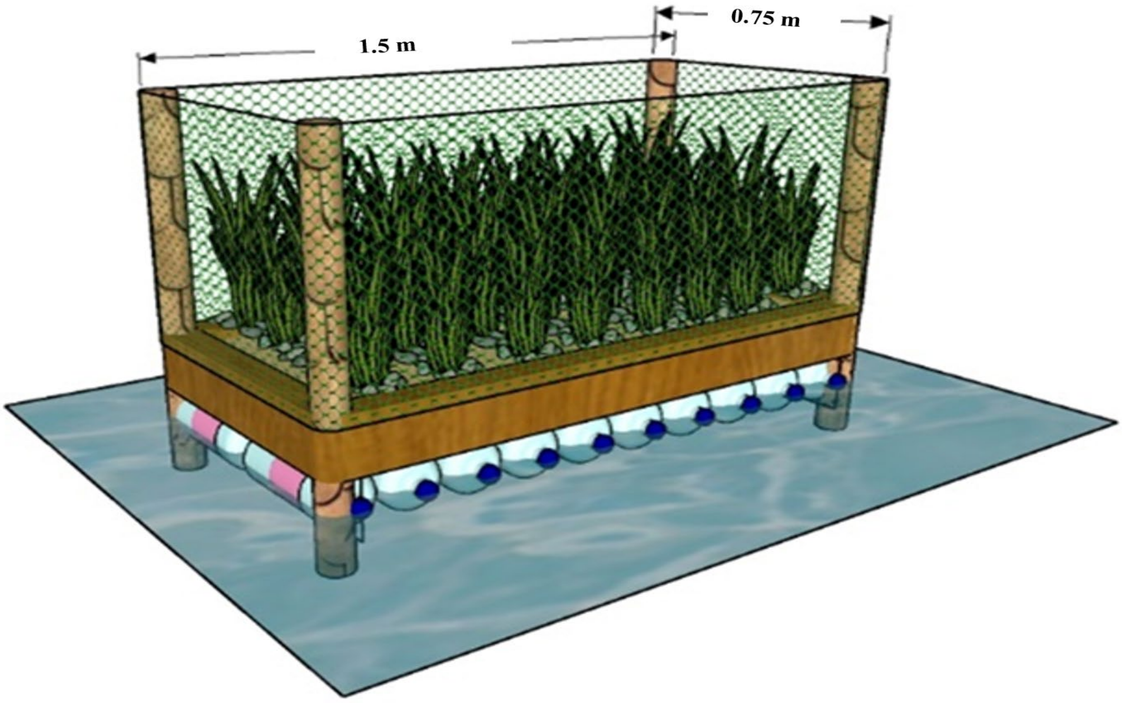

Figure 4 Floating bed structure after seedling establishment

2.5 Soil selection and preparation

Rice cultivation requires optimal soil conditions for proper seedling growth. While various soil types are used for rice production, loamy and clayey loam soils are considered ideal. For this study, sandy loam soil was collected from a hillock near the Faculty of Agricultural Engineering and Technology (AET), Bangladesh. The mechanical examination indicated that the experimental soil was sandy loam (65% sand, 25% silt, 10% clay), which offered sufficient aeration and moisture-holding capacity for seedling growth. The latitude and longitude of the experimental site is 24°54'39.1"N, 91°54'10.0"E.

The soil preparation process involved:

1. Breaking clumps using a shovel and thoroughly mixing 11.32 kg of poultry manure to enhance fertility.

2. Covering the prepared soil with a polythene sheet and allowing it to decompose for six days.

3. Pulverizing the soil further to eliminate clods and adding water to accelerate fermentation.

2.6 Water hyacinth preparation

Fresh water hyacinth was collected from the pond and allowed to decompose for 60 days before use in the floating beds. This decomposition process helped enhance its nutrient content and structural stability as a growing medium.

Initially, water hyacinth was gathered from the pond. It was left in the prepared structures for 60 days to decompose.

2.7 Plot preparation and treatments

After preparing the water hyacinth and the soil, the water hyacinth was placed in the first plot. The second plot was prepared using a mixture of water hyacinth and soil. Finally, the third plot was created using only soil, with two-liter plastic bottles incorporated for floating purposes. After preparing the soil and water hyacinth, the floating plots were established as follows:

T1= Rice Seedling production in plot 1 (Water Hyacinth media);

T2= Rice Seedling production in plot 2 (Mixture of Water Hyacinth and soil media);

T3= Rice Seedling production in plot 3 (Soil media).

2.8 Plant material

In this study high yielding variety of rice (*Oryza sativa*) BRRI dhan71 was cultivated. The variety was released by Bangladesh Rice Research Institute (Gazipur, Bangladesh) in 2014. The Coordinates for this site 23°59′29.3″N, 90°24′25.2″E. Its approximate yield rate was 5-6 tons per hector

(Digital Herbarium of Crop Plants (2020), Establishment of Digital Herbarium of Crop Plants by Department of Crop Botany, BSMRAU). BRRI dhan71 was created through a single cross between IR55423-01 and IRRI148 in order to create a drought tolerant rice variety (Kader et al., 2020).

2.9 Seed sowing

A total of 360 grams of BRRI dhan71 seeds were used for the experiment, with 120 grams allocated per plot. The seeds were broadcasted evenly and lightly covered with topsoil to promote germination.

2.10 Irrigation management

Watering was conducted according to the seedlings' requirements. A one-liter bottle was used to ensure equal distribution of water across all plots. The water was sourced from the pond where the floating beds were placed to maintain consistency in growing conditions.

2.11 Collection of crop data

Data Collection:

To evaluate seedling growth performance, five plants were randomly selected from each plot, and the following parameters were recorded:

- Number of leaves (NoL)
- Seedling height (SH) (cm)
- Stem size (SS) (cm)
- Stem thickness (ST) (mm)
- Root depth (RD) (cm)

A stainless-steel scale was used for measuring seedling height and root depth, while a slide caliper was used for stem thickness measurements.

2.12 Statistical analysis

The collected data were analyzed using Statistix 10 software. The Randomized Complete Block Design (RCBD) was employed to assess variations in seedling growth across different treatments. Yield performance was statistically compared using Analysis of Variance (ANOVA), and significant differences were determined based on p-values at a 5% significance level.

3 Results and discussion

The growth of rice seedlings varied significantly across the three floating bed treatments. Figure 5 presents the maximum seedling height recorded in each plot. Seedlings in Plot 2 (T2: water hyacinth + soil) exhibited the highest growth, reaching an average height of 35.76 cm, followed by Plot 1 (T1: water hyacinth only) with 34.9 cm. In contrast, Plot 3 (T3: soil only) had the lowest seedling height at 27.23 cm. The improved growth in T2 can be attributed to the enhanced nutrient availability from the soil-water hyacinth combination, which facilitated better root development and nutrient uptake.

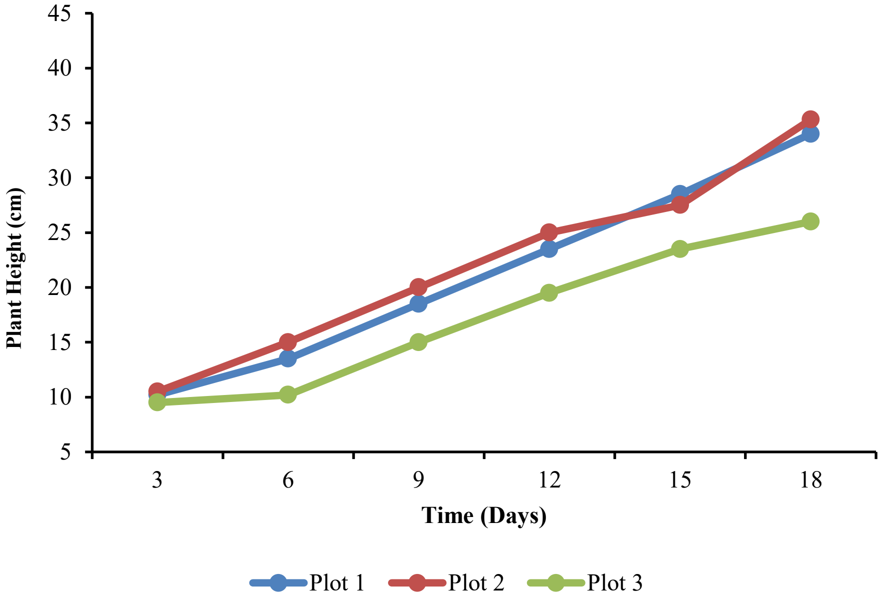

Figure 5 Growth rate of rice seedlings in different plots

The depth of seedling roots was also influenced by the choice of growth medium (Figure 6). Plot 1 (T1: water hyacinth only) exhibited the deepest root penetration at 5 cm, followed by Plot 2 (T2: water hyacinth + soil) at 3.95 cm. The shallowest roots were observed in Plot 3 (T3: soil only) with 3.3 cm. The floating nature of the water hyacinth medium likely promoted greater root elongation by reducing resistance to root penetration.

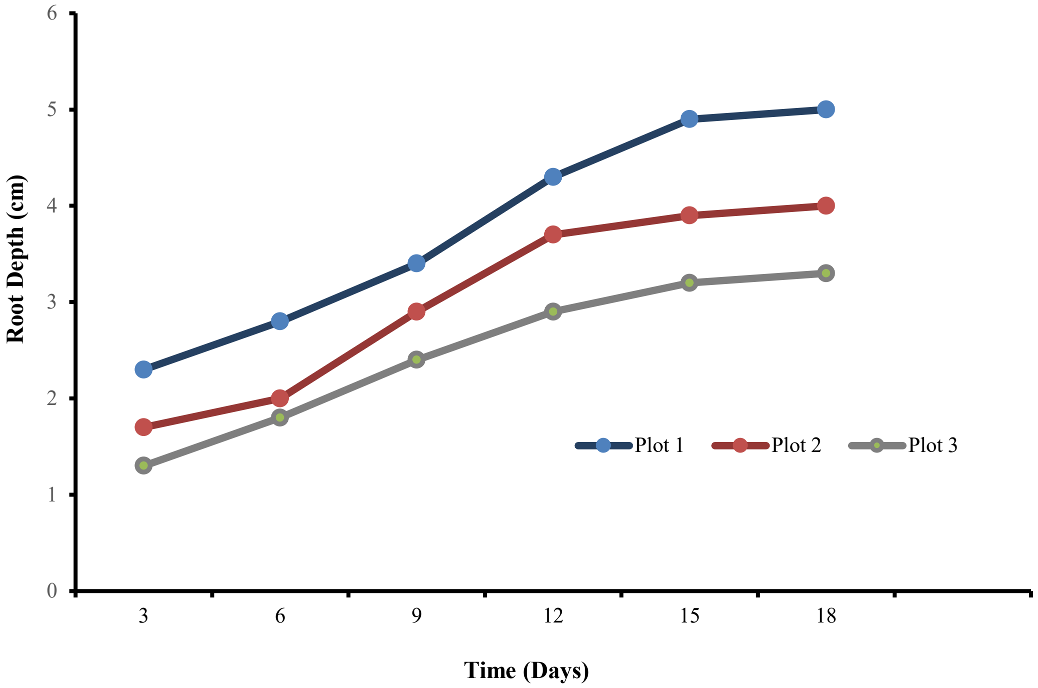

Figure 6 Root depth variation in different floating bed treatments

A Randomized Complete Block Design (RCBD) was used to analyze the seedling growth parameters, including height, root depth, stem size, stem thickness, and number of leaves. The results of Analysis of Variance (ANOVA) are presented in Tables 1 through 5. In the statistical analysis, T1, T2, and T3 represent plot 1, 2, and 3, respectively. The null hypothesis represents no difference in seedling parameters among three plots.

The ANOVA results (Table 1) indicate that seedling height varied significantly across treatments ($p = 0.0344$). The highest mean seedling height was recorded in T2, while T3 exhibited the lowest values. The critical value for comparison of seedlings height is 6.2235.

Table 1 Randomized complete block analysis of variance (ANOVA) for seedling height

Source	Degree of Freedom (DF)	Sum of Square (SS)	Mean Square (MS)	F (Variation)	P (Probability Value)
Replication	3	6.847	3.4233		
Treatment	3	132.347	66.1733	8.78	0.0344*
Error	4	30.147	7.5367		
Total	8	169.34			
Grand Mean	32.633				
CV	8.41				

Note: *Significant at 5% level ($p < 0.05$).

Table 2 summarizes the statistical analysis for root depth. A significant variation was found ($p = 0.0353$), confirming that different media influenced root penetration. The critical value for comparison of root depth is 1.2156.

Both stem thickness and stem size exhibited significant differences among treatments ($p = 0.0019$ and $p = 0.0002$, respectively), as shown in Tables 3 and 4. T2 produced the largest stem size, while T1 resulted in the thickest stems. The critical value for comparison of stem thickness is 0.269.

Table 2 Randomized complete block ANOVA for root depth

Source	Degree of Freedom (DF)	Sum of Square (SS)	Mean Square (MS)	F (Variation)	P (Probability Value)
Replication	3	1.36842	0.68421		
Treatment	3	4.97309	2.48654	8.65	0.0353*
Error	4	1.15018	0.28754		
Total	8	7.49169			
Grand Mean	4.0811				
CV	13.14				

Note: *Significant at 5% level ($p < 0.05$).

Table 3 Randomized complete block ANOVA for stem thickness

Source	Degree of Freedom (DF)	Sum of Square (SS)	Mean Square (MS)	F (Variation)	P (Probability Value)
Replication	3	0.40222	0.20111		
Treatment	3	1.25149	0.62574	44.45	0.0019*
Error	4	0.05631	0.01408		
Total	8	1.71002			
Grand Mean	2.5444				

Note: *Significant at 5% level ($p < 0.05$).

The value of P shows that the result was significant, so the null hypothesis was rejected. There was significant difference in terms of stem thickness among different beds as shown in Table 3. The critical value for comparison of stem thickness is 0.269 and 0.4207 for Stem Size respectively.

Table 4 Randomized complete block ANOVA for stem size

Source	Degree of Freedom (DF)	Sum of Square (SS)	Mean square (MS)	F(Variation)	P (Probability)
Replication	3	1.6822	0.84111		
Treatment	3	10.1089	5.05444	146.74	0.0002*
Error	4	0.1378	0.03444		
Total	8	11.9289			
Grand Mean	9.2111				
CV	2.01				

Note: *Significant at 5% level ($p < 0.05$).

Unlike the other parameters, the number of leaves did not show a statistically significant difference among treatments ($p = 0.1284$), suggesting that leaf production was less influenced by the growth medium (Table 5). The critical value for comparison of no of leaves is 0.6669.

Table 5 Randomized complete block ANOVA for the number of leaves

Source	Degree of Freedom (DF)	Sum of Square (SS)	Mean Square (MS)	F (Variation)	P (Probability Value)
Replication	3	0.17309	0.08654		
Treatment	3	0.61976	0.30988	3.58	0.1284*
Error	4	0.34618	0.08654		
Total	8	1.13902			
Grand Mean	3.8144				
CV	7.71				

Note: *Significant at 5% level ($p < 0.05$).

Table 6 presents the Least Significant Difference (LSD) all-pairwise comparisons for each growth parameter, providing a more detailed statistical analysis of treatment effects. These results further reinforce the significant influence of the floating bed composition on seedling performance, particularly in parameters like stem thickness and seedling height.

In floating seedbeds, water hyacinth and soil (T2) greatly enhanced stem strength, root development, and seedling growth. Since soil improves water retention and root anchoring (Sindhu et al., 2010) and water hyacinth provides nutrients through decomposition (Haque, 2006), T2 is the best medium for establishing rice seedlings in flood-prone areas.

Table 6 LSD all-pairwise comparisons test of all parameters for treatments

Treatment	Height (cm)	Root depth (cm)	Stem size (cm)	Stem thickness (mm)	No. of leaf
T1	34.9 (A)	3.9667 (AB)	9.733 (B)	2.9767 (A)	4 (A)
T2	35.767 (A)	5.0433 (A)	10.167 (A)	2.59 (B)	4 (A)
T3	27.233 (B)	3.2333 (B)	7.733 (C)	2.0667 (C)	3.4433 (A)
% of CV value	8.41	13.14	2.01	4.66	7.71
Level of significance	NS	NS	S	S	NS

Note: NS = Not Significant, S = Significant

This study identifies floating seedbeds as a sustainable alternative to traditional seedling production in flood-prone areas. Water hyacinth-based platforms have already been utilized effectively in Bangladesh for crop cultivation (Hossain, 2014; Islam and Atkins, 2007), providing cost-effective solutions made from locally available materials such as water hyacinth and bamboo (Al Mamun et al., 2021). However, problems remain, such as the limited longevity of floating structures, which necessitate frequent repair (Kabir et al., 2022), and the localized availability of materials, both of which may hamper widespread implementation.

For rice seedling production in flood-prone locations, floating seedbeds offer a climate-resilient solution; nevertheless, their adoption necessitates policy assistance, farmer training, and incentives (Saha, 2010). The combination of water hyacinth and soil (T2) was the most successful treatment, increasing stem stability, root anchoring, and seedling height. T2 is the best medium for seedling establishment because it releases nutrients from decaying water hyacinth (Haque, 2006) and improves soil water retention (Sindhu et al., 2010). Floating seedbeds can help improve rice farming in flood-prone areas by decreasing delays and increasing food security. Such systems, which are already utilized in Bangladesh for vegetables and seedlings (Hossain, 2014; Islam and Atkins, 2007), can be built inexpensively using indigenous materials such as water hyacinth and bamboo (Al Mamun et al., 2021). However, difficulties such as limited durability and maintenance requirements provide obstacles (Kabir et al., 2022). Scalable designs, policy backing, farmer training, and awareness programs will be required for widespread adoption (Saha, 2010).

4 Conclusions

Floating seedbeds are a viable option for rice seedling cultivation in lowland and flood-prone areas. They keep seedlings above water, minimizing flooding and promoting better germination and growth. This approach boosts seed germination, seedling vigor, and survival rates. Floating seedbeds are usually created from Bangladeshi accessible materials like bamboo, banana stems, straw, and water hyacinth, making them cost-effective and sustainable. For successful implementation, high-quality seeds should be utilized, as well as correct spacing and water levels. The seedbed's buoyancy must be monitored on a regular basis. To ensure successful adoption, farmers should be trained in seedbed construction and management. This strategy promotes timely transplanting and consistent crop establishment. It also improves climate resilience in places that experience frequent flooding. However, scaling up adoption requires further research on economic feasibility, long-term sustainability, and material optimization. Future studies should focus on integrating floating agriculture into existing farming systems, providing technical support to smallholder farmers, and developing policies to promote widespread implementation. By addressing these factors, floating seedbeds could become a widely adopted adaptation strategy for ensuring sustainable rice production in flood-prone areas.

References

Al Mamun, M. R., A. A. R. Nabil, S. A. Fairuz, M. S. Hossen, M. J. A. Soeb, and S. Shammi. 2021. Integration of vertical floating bed for red amaranth cultivation in low land areas of Bangladesh. *AIMS Agriculture & Food*, 6(4): 969-987.

Al-Imran, M., S. Mitra, M. A. Rahman, and S. K. Das. 2023. Effect of different macrophytes on crop cultivation under floating agriculture system for climate change adaptation in Bangladesh. *Aquatic Botany*, 189: 103699.

Asma, J., D. Subrahmanyam, and D. Krishnaveni. 2023. The global lifeline: a staple crop sustaining Two-Thirds of the world's population. *Agriculture Archives*, 2(3): 15–18.

Chowhan, S., M. R. Haider, A. Hasan, M. I. Hoqe, M. Kamruzzaman, and R. Gupta. 2017. Comparative on-farm performance of five modern rice varieties with two local cultivars. *Journal of Bioscience and Agriculture Research*, 13(1): 1074–1086.

Digital Herbarium of Crop Plants. 2020. Establishment of digital herbarium and herbal museum for crop plant by Department of Crop Botany, BSMRAU. Available from: https://dhcrop.bsmrau.net/brri-dhan-71/?doing_wp_cron=1733059896.4146449565887451171875. Accessed 17 November 2021.

Dilipkumar, M., M. S. S. Mohamad-Ghazali, E. S. Shari, N. L. Chuen, B. S. Chauhan, and T. S. Chuah. 2022. Integrated use of the stale seedbed technique with preemergence herbicides to control weedy rice in wet-seeded rice. *Weed Technology*, 36(3): 373–378.

Haque, S. A. 2006. Salinity problems and crop production in coastal regions of Bangladesh. *Pakistan Journal of Botany*, 38(5): 1359-1365.

Hirzel, J., M. Paredes, V. Becerra, and G. Donoso. 2020. Response of direct seeded rice to increasing rates of nitrogen, phosphorus, and potassium in two paddy rice soils. *Chilean Journal of Agricultural Research*, 80(2): 263-273.

Hossain, M. A. 2014. Floating cultivation: An indigenous technology for adapting to waterlogging situations towards sustainable livelihood security in the low-lying areas of Bangladesh. *Journal of Bioscience and Agriculture Research*, 1(1): 54–58.

Islam, T., and P. Atkins. 2007. Indigenous floating cultivation: A sustainable agricultural practice in the wetlands of Bangladesh. *Development in Practice*, 17(1): 130–136.

Japan International Cooperation Agency. 2021. The role of quality rice seeds in enhancing productivity. Available at: https://www.jica.go.jp/english/overseas/nepal/information/press/2021/press211203.html. Accessed 12 January 2025.

Kabir, K. H., S. Sarker, M. N. Uddin, H. R. Leggette, U. A. Schneider, D. Darr, and A. Knierim. 2022. Furthering climate-smart farming with the introduction of floating agriculture in Bangladeshi wetlands: Successes and limitations of an innovation transfer. *Journal of Environmental Management*, 323: 116258.

Kader, M. A., T. L. Aditya, R. R. Majumder, T. K. Hore, and M. E. Haq. 2020. Early maturing drought-tolerant rice variety BRRI dhan71 suitable for drought-prone environments in Bangladesh. *International Journal of Plant and Soil Science,* 32(12): 1–11.

Kassa, Y., A. Amare, T. Nega, T. Alem, M. Gedefaw, B. Chala, B. Freyer, B. Waldmann, T. Fentie, T. Mulu, T. Adgo, G. Ayalew, M. Adugna, and D. Tibebe. 2025. Water hyacinth conversion to biochar for soil nutrient enhancement in improving agricultural product. *Scientific Reports*, 15(1): 1820.

Laguna-Estrada, M. I., J. E. Ruiz-Nieto, A. R. Lopez-Nuñez, J. G. Ramírez-Pimentel, J. C. Raya-Pérez, and C. L. Aguirre-Mancilla. 2024. Biomass of Eichhornia crassipes as an Alternative Substrate for the Formation of Lettuce Seedlings. *AgriEngineering*, 6(3): 2612-2622.

Lindiana, L. B., K. Herlindas, I. W. Laily, and S. M. Erna. 2016. Rice cultivation images by local farmers in pemulutan district, ogan ilir, south sumatra. *Journal of Suboptimal Lands*, 5(2): 153–158.

Liu, Q., X. Zhou, J. Li, and C. Xin. 2017. Effects of seedling age and cultivation density on agronomic characteristics and grain yield of mechanically transplanted rice. *Scientific Reports*, 7(1): 1-10.

Okeke, C. G., and S. I. Oluka. 2017. A survey of rice production and processing in South East Nigeria. *Nigerian Journal of Technology*, 36(1): 227–234.

Ramadhani, F., B. Lakitan, and M. Hasmeda. 2018. Decaying Utricularia-biomass versus soil-based substrate for production of high-quality pre-transplanted rice seedlings using floating seedbeds. *Australian Journal of Crop Science*, 12(12): 1983–1988.

Reuben, P., Z. Katambara, F. C. Kahimba, H. F. Mahoo, W. B. Mbungu, F. Mhenga, and M. Maugo. 2016. Influence of transplanting age on paddy yield under the system of rice intensification. *Agricultural Sciences*, 7(3): 154-163.

Ria, R. P., B. B. Lakitan, and Z. P. Negara. 2020. Effects of water table, population density, and transplanting time on vegetative growth of black sticky rice at floating seedbed method. *Jurnal Lahan Suboptimal: Journal of Suboptimal Lands*, 9(2): 167–174.

Saha, I., A. Durand-Morat, L. L. Nalley, M. J. Alam, and R. Nayga. 2021. Rice quality and its impacts on food security and sustainability in Bangladesh. *PLoS One*, 16(12): e0261118.

Saha, S. K. 2010. Soilless cultivation for landless people: An alternative livelihood practice through indigenous hydroponic agriculture in flood-prone Bangladesh. Beppu, Japan: Ritsumeikan Asia Pacific University.

Sarker, M. R., N. D. Kundu, M. H. K. Sujan, M. Salman, A. M. McKenzie, M. M. Islam, M. A. Rahman, M. T. Uddin, H. Bhandari, and M. A. R. Sarkar. 2025. River Waste to Goldmine: A tale of floating agriculture in vulnerable southern regions of Bangladesh. *Food and Energy Security*, 14(2): e70062.

Sharifuzzaman, M., and M. R. Islam. 2024. Impacts of salinity intrusion on agriculture in the coastal region of Bangladesh. *Journal of Coastal Conservation*, 28(6): 79.

Shawkhatuzamman, M., S. R. Roy, M. Z. Alam, P. Majumder, N. J. Anka, and A. K. Hasan. 2023. Soil salinity management practices in coastal area of Bangladesh: a review. *Research in Agriculture Livestock and Fisheries*, 10(1): 1–7.

Siaga, E., B. Lakitan, H. Hasbi, S. M. Bernas, L. I. Widuri, and K. Kartika. 2019. Floating seedbed for preparing rice seedlings under unpredictable flooding occurrence at tropical riparian wetland. *Bulgarian Journal of Agricultural Science*, 25(2):326-336.

Sindhu, P. V., C. G. Thomas, and C. T. Abraham. 2010. Seedbed manipulations for weed management in wet-seeded rice. *Indian Journal of Weed Science*, 42(3-4): 173–179.

Singha, M., J. Dong, S. Sarmah, N. You, Y. Zhou, G. Zhang, R. Doughty, and X. Xiao. 2020. Identifying floods and flood-affected paddy rice fields in Bangladesh based on Sentinel-1 imagery and Google Earth Engine. *ISPRS Journal of Photogrammetry and Remote Sensing*, 166: 278–293.

Verma, G. S., Verma, V. K., Verma, D. K., & Singh, R. K. 2018. Integrated Weed Management Practices in Zero-Till Direct-Seeded Rice. In *Agronomic Rice Practices and Postharvest Processing,* pp. 287-308.

Xu, Y., H. Lambers, J. Feng, Y. Tu, Z. Peng, and J. Huang. 2024. The role of arbuscular mycorrhizal fungi in micronutrient homeostasis and cadmium uptake and transfer in rice under different flooding intensities. *Ecotoxicology and Environmental Safety*, 284: 116978.

Yeasmin, H., S. B. Sanawar, S. Sharmin, and M. A. Islam. 2020. Efficient use of agricultural land in Bangladesh: Strategies for optimization. *Bangladesh Journal of Agricultural Economics*, 41(1): 35-45.