

Original Research Article

Efficacy of water hyacinth as growing media for *Amaranthus* in open water culture, hydroponics and land cultivation in Kuttanad Ecosystem

Abstract

A field experiment was conducted in farmer's field in north Kuttanad during the kharif season during June-July 2023 and repeated consecutively during August-September 2023 to evaluate the efficacy of open water culture with respect to yield and growth attributes of amaranthus cultivation against deep water culture hydroponics with and without water hyacinth as medium. The experiment was laid out in a Randomized Design (CRD), comprising six treatments with four replications. The treatments were T₁: Open water culture without medium, T₂: Open water culture with medium, T₃: Hydroponics without medium, T₄: Hydroponics with medium, T₅: Land cultivation with a bed of water hyacinth alone as medium and T₆: Control: soil culture-KAU-POP recommended dose of nutrients. The data revealed significant differences in plant height, number of leaves, leaf length and width, leaf area index, stem girth, root length and yield. Maximum plant height was recorded in T₆ (Control- soil culture-Kerala Agricultural University (KAU) -POP recommended dose of nutrients) followed by T₅ (Land cultivation with a bed of water hyacinth alone as medium). Highest leaf area index, stem girth and root length were in T₆, but was on par with T₅. The yield of the total harvest was significantly higher in T₆, but was on par with T₅, which proves the efficacy of water hyacinth as a growing medium for amaranthus cultivation. The lowest yield and growth attributes were recorded by T₁ (Open water culture without medium) and T₃ (Hydroponics without medium).

Key words: Flood resilience, Water hyacinth, Kuttanad, *Amaranthus*, Deep water culture, Hydroponics

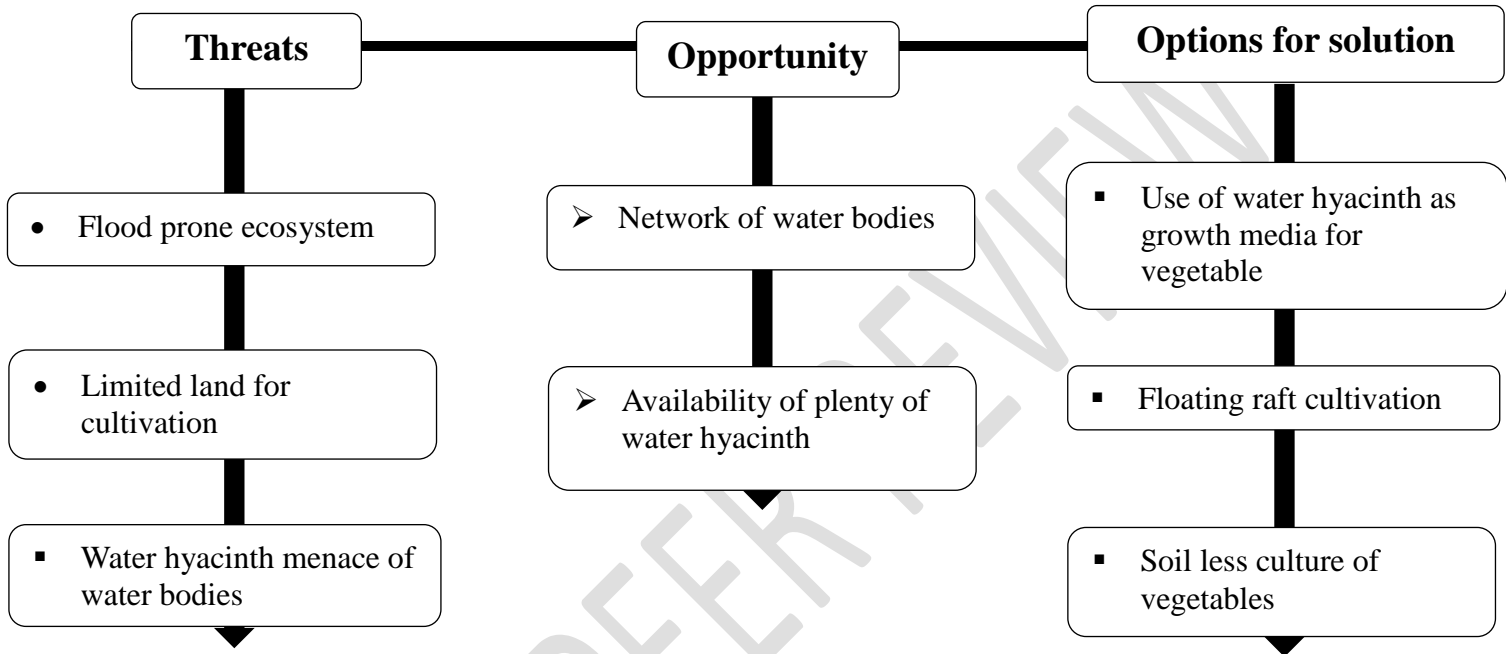
INTRODUCTION

Amaranthus sp. (Amaranthaceae) is one of the leafy vegetables that is in great demand in India and across the globe. Among a variety of leafy vegetables consumed by people all over India, amaranthus is the most common one (Akbugro *et al*, 2007). In Kerala also, amaranthus is the most common and commercially grown leafy vegetable and is cultivated in nearly 2169 ha area (GoK, 2023) Kuttanad is a unique wetland ecosystem in Kerala where below-sea level farming is followed, which has achieved the status of a Globally Important Agricultural Heritage System (GIAHS) (FAO, 2013). Surrounded by a large network of backwaters connected with the mighty Vembanad Lake, the Kuttanad ecosystem has limited land for growing vegetables. The major

crop is rice, grown in the vast padasekharams (paddy fields) in the agroecosystem. The discharge of fertilizers and agrochemicals into the water bodies, due to their heavy use in these paddy fields results in enormous growth of water hyacinth (*Pontederia crassipes*). The aquatic weed is a major threat to the water bodies hindering navigation, reducing the water quality for other aquatic organisms, promoting mosquito breeding and directly affecting the much popular back water tourism of Kuttanad (Simpson *et al*, 2020). The potential of using water hyacinth as a medium for growing crops, as in the floating cultivation system practiced in Bangladesh and other countries (Haq *et al*, 2016) can be adopted in the water bodies of Kuttanad. It has received a lot of attention as an environment-friendly and productivity-enhancing option for climate change adaptation.

Hydroponics is the process of growing plants without the use of soil or solid growing media, utilizing just water or nutrient-rich solutions for a brief period of time in artificial environments. Many commercial and specialty crops like tomato, cucumber, eggplants, leafy vegetables, strawberries etc., can be grown using this technology. Deep water culture is a method of hydroponics, which is a non-circulating system in which the plants are always submerged in a nutrient solution that supplies nutrients directly to the plant roots (Saaid *et al*, 2013). Water hyacinth, which is a good source of nutrients can be used as a media for growing vegetables in floating cultivation for flood resilience in aquatic bodies (Alam and Chowdhury, 2018) and as a media in the land as well as a low-cost media option in Kuttanad. Hence, considering the scope, need and practical utility, an experiment was taken with the objective of evaluating the efficacy of open water culture with respect to the yield of amaranthus against hydroponics and soil cultivation with and without water hyacinth as a medium. The experiment included the evaluation of floating raft with and without water hyacinth media in open water bodies, deep water culture method of hydroponics with and with and without water hyacinth media, land cultivation with water hyacinth alone as media and conventional soil cultivation with organic and inorganic nutrition for amaranthus cultivation.

CONCEPTUAL FRAME WORK



MATERIALS AND METHODS

Present study was conducted in farmer's field in North Kuttand during 2023, where the Arun variety of amaranthus was evaluated in different media namely, open water culture in the aquatic body, Hoagland nutrient solution in deep water hydroponics, water hyacinth as media in hydroponics, floating raft in open water culture and for land cultivation and along with soil supplemented with nutrients. The trials were carried out during kharif season in June-July and repeated consecutively in August-September 2023. The experiment consisted of six treatments and four replications. The treatments were T₁: open water culture without medium; T₂: open water culture with medium; T₃: hydroponics without medium; T₄: hydroponics with medium; T₅: land cultivation with water hyacinth bed alone as medium; and T₆-Control: soil culture- Kerala Agricultural University(KAU)-package of practices (POP)recommended dose of nutrients. The amaranthus seedlings were transplanted 15 days after sowing, with a spacing of 15 cm x 15 cm in styrofoam board (T₁& T₃), water hyacinth bed (30 cm thickness) (T₂& T₄), and soil bed (30 cm thickness) (T₆), each with a planting area of 1x1 m². The growth medium used for the study is water hyacinth beds in T₂, T₄ and T₅ and water in T₁, Hoagland nutrient solution in T₃ and soil with manures and fertilizers [N: P₂O₅: K₂O @ 50: 50: 50 Kg ha⁻¹, namely, Urea (46% N), Rajphos (20% P₂O₅) and Muriate of potash (60% K₂O)] in T₆. In T₃ and T₄, deep water hydroponics with and without water hyacinth medium in Hoagland nutrient solution was tried. The observations on plant height, number of leaves, length and width of leaf, stem girth, and root characteristics were recorded at 15, 30 and at harvest [45 days after transplant(DAT)]. The vegetative yield of amaranthus was recorded at harvest. The data obtained from the experiment was subjected to statistical analysis using GRAPES(Gopinath *et al.*, 2020).

RESULT AND DISCUSSION

Growth attributes

The plant height recorded at 15, 30 and 45 DAT of amaranthus for both trials is presented in Table 1. The data revealed that the treatments caused significant variation in plant height at all growth stages. At 15 DAT, in the first trial, plant height was significantly higher (21.79 cm) with T₆ (Control- soil culture- Kerala Agricultural University (KAU)-package of practices (POP)recommended dose of nutrients) and the treatment T₅ (18.75 cm) ranked next and was on

par with T₂ (17.06 cm). At 30 and 45 DAT, T₆ followed by T₅ recorded more plant height in both first and second trials. The shortest plant height was recorded with T₁ (open water culture without medium), followed by T₃ (hydroponics without medium). Number of leaves plant⁻¹ at all growth stages was significantly influenced by different treatments (Table 2). The treatment T₆ (control-soil culture-Kerala Agricultural University (KAU)-package of practices (POP) recommended dose of nutrients) showed a significantly maximum number of leaves and it was on par with T₅ in both trials in all growth stages and the minimum number of leaves was formed in T₁. The treatments had a significant effect on the leaf area index in all growth stages (Table 3). The LAI was found to be highest in T₆, which was on par with T₅ in all growth stages both first and second trials. Significant variation was observed among different treatments with respect to stem girth (Table 4). Maximum stem girth was obtained in treatment T₆. The root length also varied significantly between different treatments (Table 4). The higher root length was recorded in T₆ (control: soil culture-KAU-POP-recommended dose of nutrients) followed by T₅ (land cultivation with water hyacinth bed alone as medium) and least root length was recorded in T₁ (Open water culture without medium) and T₃ (Hydroponics without medium).

Table 1. Effect of water hyacinth medium on plant height (cm)

Treatments	Plant height (cm)					
	Trial 1			Trial 2		
	15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT
T ₁	10.56	13.02	15.24	11.23	13.33	15.17
T ₂	17.06	23.69	42.43	17.24	27.32	42.08
T ₃	13.22	14.51	16.52	13.75	15.43	15.81
T ₄	11.29	18.73	32.47	11.76	19.82	31.07
T ₅	18.75	50.05	74.91	17.25	38.98	63.12
T ₆	21.79	52.98	77.80	24.25	46.68	65.37
SEm (±)	0.586	0.719	1.068	0.416	1.34	1.56
CD (0.05)	1.74	2.16	3.21	1.24	4.02	4.65

Treatments	Number of leaves					
	Trial 1			Trial 2		
	15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45DAT
T ₁	4.6	8.17	9.41	4.50	8.6	9.33
T ₂	5.75	10.37	13.54	6.50	10.31	13.26
T ₃	5.10	8.19	9.49	5.95	8.36	9.46
T ₄	5.28	9.44	12.23	5.70	9.85	12.23
T ₅	7.45	11.34	14.51	6.60	11.15	14.45
T ₆	7.48	11.48	14.89	6.68	11.23	14.55
SEm (±)	0.282	0.259	0.279	0.235	0.222	0.335
CD (0.05)	0.84	0.78	0.84	0.69	0.66	1.01

Table 2. Effect of water hyacinth medium on number of leaves

The application of manures and inorganic fertilizer resulted in higher availability of nutrients, which increased photosynthetic activity and translocation of photosynthates, leading to higher plant height, as reported by Kushare *et al*, (2010). Meanwhile, in T₅, a large amount of nutrients released from the decomposing water hyacinth also resulted in higher plant height (Vidya & Girish, 2014). The increased number of leaves might have resulted from more nutrients especially N being available in T₆, which improved the crop's ability to absorb nutrients because N enhanced the effectiveness of leaves' photosynthesis. Higher availability of N resulted in increased length and width as well as leaf area in amaranthus as in conformity with the findings of Makinde (2015). Similarly, the increased stem diameter also can be attributed to more nutrients being available in the soil, which improved the absorption of nutrients by the crop that enhanced the photosynthetic efficiency of leaves (Charachimwe *et al*, 2018). Chowdhury *et al*, (2017) reported that improved nutrient availability and better soil structure favor root growth in amaranthus as observed in T₆.

The reduced growth attributes found in the case of treatments T₁ (Open water culture without medium) and T₃ (Hydroponics without medium) happened because of the presence of water in continuous submergence around the root zone that created an anaerobic condition resulting in poor root growth leading to stunted plant growth. Similarly, in T₂ (Open water

culture with medium) and T₄ (Hydroponics with medium), the water hyacinth bed of 30 cm thickness lost water content quickly and reduced to a thin layer of medium soon, resulting in water stagnation in the root zone. Also reduced root and plant growth were observed for these treatments.

Table 3. Effect of water hyacinth medium on leaf area index.

Treatments	Leaf area index (cm)					
	Trial 1			Trial 2		
	15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT
T ₁	0.07	0.311	0.521	0.07	0.29	0.54
T ₂	0.196	0.742	1.78	0.20	0.79	1.83
T ₃	0.098	0.308	0.55	0.120	0.30	0.60
T ₄	0.117	0.490	1.13	0.16	0.59	1.17
T ₅	0.804	2.12	3.69	0.54	1.67	3.65
T ₆	0.863	2.19	3.83	0.61	1.84	3.92
SEm (±)	0.044	0.067	0.074	0.023	0.067	0.125
CD (0.05)	0.132	0.20	0.218	0.068	0.20	0.38

Table 4. Effect of water hyacinth medium on stem girth (cm)

Treatments	Stem girth (cm)					
	Trial 1			Trial 2		
	15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT
T ₁	0.107	0.31	0.39	0.107	0.348	0.38
T ₂	0.165	0.65	1.05	0.17	0.60	1.03
T ₃	0.113	0.34	0.42	0.12	0.365	0.44
T ₄	0.113	0.42	0.57	0.13	0.402	0.60
T ₅	0.312	1.07	1.26	0.51	1.09	1.33
T ₆	0.515	1.08	1.29	0.62	1.10	1.39
SEm (±)	0.016	0.045	0.04	0.02	0.024	0.041
CD (0.05)	0.049	0.14	0.12	0.06	0.072	0.12

Table 5. Effect of water hyacinth medium on root length (cm)

Treatments	Root length (cm)					
	Trial 1			Trial 2		
	15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT
T ₁	4.29	5.65	6.89	4.08	5.65	6.24
T ₂	4.69	8.40	12.05	4.14	7.85	11.77
T ₃	4.33	5.45	7.15	4.11	5.16	6.85
T ₄	4.46	7.33	10.32	4.1	7.41	10.45
T ₅	5.33	10.17	13.84	4.84	9.09	13.68
T ₆	6.47	10.91	14.31	6.02	10.21	15.76
SEm (±)	0.244	0.24	0.184	0.204	0.204	0.231
CD (0.05)	0.73	0.71	0.55	0.61	0.61	0.69

Yield (Kg ha⁻¹)

Total yield was significantly influenced by the treatments (Fig. 1), higher (17210 kg ha⁻¹ & 17135 kg ha⁻¹) in T₆ (control-soil culture-KAU-POP recommended dose of nutrients), which was on par (16820 kg ha⁻¹ & 16042 kg ha⁻¹) with T₅ (land cultivation with a bed of water hyacinth alone as medium). The increase in yield in T₆ is due to the increased levels of inorganic fertilizer, which resulted in better availability and uptake of nutrients by plants that stimulated plant vegetative growth (Nyankanga *et al.*, 2012). The increase in yield in treatment T₅ can be explained by the release of considerable amount of nutrients to the plants, especially N and P from the water hyacinth, which resulted in better photosynthesis, plant growth and yield (Kamanu *et al.*, 2012). The treatments with water hyacinth as the growing medium T₂, followed by T₄, ranked next in amaranthus yield. Improvement of yield in vegetables growing in water hyacinth medium has also been reported by Baran *et al.* (2022).

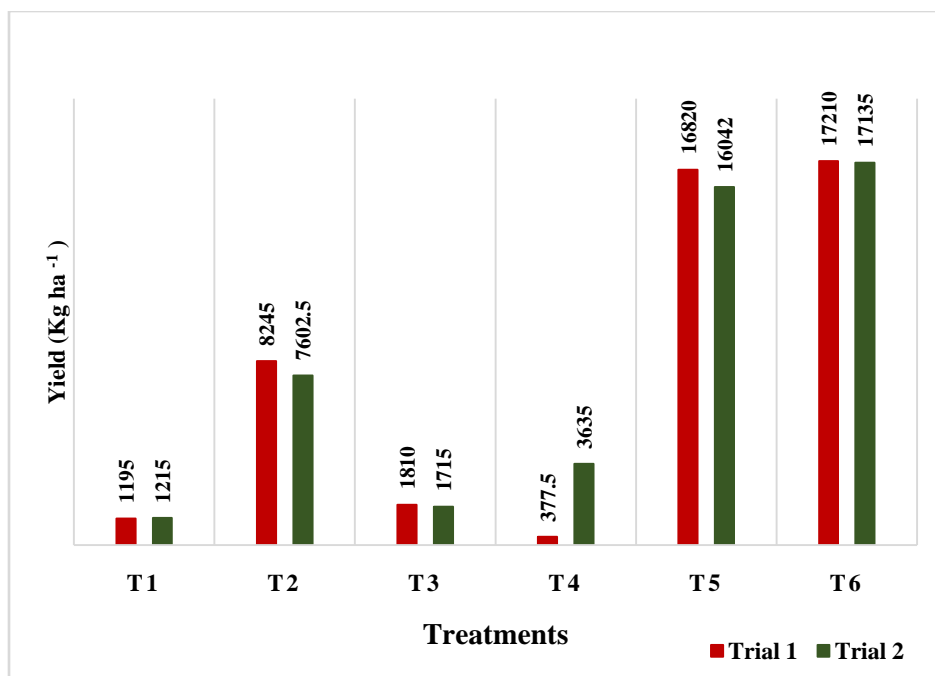


Fig 1: Effect of water hyacinth medium on yield (kg ha⁻¹)

Lower yields were recorded by T₁ (open water culture without medium) and T₃ (hydroponics without medium), which might be due to the presence of water in the root zone throughout the growth period of plants, which resulted in an anaerobic condition preventing proper root growth and nutrient uptake. Also, in T₂ (open water culture with medium) and T₄ (Hydroponics with medium), the water hyacinth bed of 30 cm thickness lost water content quickly and reduced to a thin layer of medium soon, resulting in water stagnation in the root zone. This has caused poor root growth leading to a reduction in overall growth and yield. Significant yield loss due to anaerobic condition in the root zone due to flooding condition has been reported by, Lin *et al.* (2021) in rice crop.

CONCLUSION

From this experiment, it can be concluded that water hyacinth can be used as an effective medium for the cultivation of amaranthus as it is rich in nutrients and found to be as effective as cultivation in soil with POP recommended dose of nutrients with regards to yield and growth

attributes. Hence, water hyacinth can be used as an effective medium for growing amaranthus at a reduced cost of production which is an added advantage as it is available in plenty in Kuttanad ecosystem. Also, the deep-water hydroponics (in both Hoagland nutrient solution as well as in open water body) was not found effective for growing amaranthus with or without water hyacinth as growing media. However, future works with waterhyacinth media for rafts of a higher thickness may be tried to test the efficacy for flood resilience in Kuttanad ecosystem.

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