***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 Kuttanadduring kharif season from June-July and August to September 2023 to evaluate the efficacy of open water culture with respect to yield and economics of amaranthus cultivation against hydroponics with and without water hyacinth as medium. The experiment was laid out in Completely Randomized Design (CRD), comprising of six treatments with four replications. The treatments were $T_1$: Open water culture without medium, $T_2$: Open water culture with medium, $T_3$: Hydroponics without medium, $T_4$: Hydroponics with medium, $T_5$: Land cultivation with a bed of water hyacinth alone as medium and $T_6$: Control: soil culture-KAU-POP recommended dose of nutrients.The data revealed significant difference 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 $T_6$ (Control-soilculture-KAU-POP recommended dose of nutrients) followed by $T_5$ (Land cultivation with a bed of water hyacinth alone as medium). Highest leaf area index was with $T_6$, which was on par with $T_5$. The yield of the total harvest was significantly higher in $T_6$, which was on par with $T_5$, which proves the efficacy of water hyacinth as a growing medium for amaranthus cultivation. The lowest yield and growth attributes were recorded by $T_1$ (Open water culture without medium) and $T_3$ (Hydroponics without medium).


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




## INTRODUCTION

*Amaranthus sp*. (Amaranthacea) is one of the leafy vegetables that is in great demand in India and across the globe.Out of common leafy vegetables consumed by the people all over the 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 where below sea level farming is followed which has achieved the status of Globally Important Agricultural Heritage System (GIAHS) surrounded by a large network of backwaters connected with the mighty Vembanad lake the Kuttanad ecosystem is limited in land for growing vegetables. The major crops are rice grown in the vast padasekharams (paddy fields) in theagroecosystem(FAO, 2013). The discharge of fertilizers and agrochemicals into the water bodies, due to the heavy use in these paddy fields result in enormous growth of water hyacinth(*Pontederia crassipes*). The aquatic weed is a major threat in the water bodies hindering navigation, reducing the water quality for other aquatic organisms, promoting breeding of mosquito and directly affecting the much popular back water tourism of Kuttanad. The potential of using water hyacinth as a media for growing crops as in the floating cultivation system practiced in Bangladesh and other countries (Haq *et al*, 2016) can be adopted in 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 solution for a brief period of time in artificial environments. Deep water culture is a method of hydroponics which is a non-circulating system in which the plants are always submerged in the nutrient solution that supplies nutrients directly to the plant roots (Saaid *et al*, 2013). Many commercial and specialty crops like tomato, cucumber, eggplants, leafy vegetables, strawberries and so on, can be grown using this technology. Water hyacinth which is a good source of nutrients and can be used as media for growing vegetables in floating cultivation for flood resilience as well as land as a low-cost option in Kuttanad. Hence, considering the scope, need and practical utility an experiment was taken with the objective to evaluate the efficacy of open water culture with respect to yield of amaranthus against hydroponics and soil cultivation with and without water hyacinth as medium.

## MATERIALS AND METHODS

Present study was conducted at farmer's field in North Kuttand during 2023, where Arun variety of amaranthus was evaluated in different media namely, open water culture, Hoagland nutrient solution in deep water hydroponics, water hyacinth as media, soil supplemented with nutrients consecutively as two trials. The experiment consisted of six treatments and four

replications. The treatments were $T_1$: Open water culture without medium; $T_2$: Open water culture with medium; $T_3$: Hydroponics without medium; $T_4$: Hydroponics with medium; $T_5$: Land cultivation with water hyacinth bed alone as medium; $T_6$-Control: soil culture of nutrients. The amaranthus seedlingswere transplanted at15 Days after sowing, with a spacing of 15 cm x 15 cmin styriform board ($T_1$& $T_3$), water hyacinth bed (30 cm thickness) ($T_2$& $T_4$), and soil bed (30 cm thickness) ($T_6$), each with a size 1x1 $m^2$. The growthmedium used for the study is water hyacinth bed in $T_2$, $T_4$ and $T_5$ and water in $T_1$, Hoaglandnutrient solution in $T_3$ and soil with manures and fertilizers [namely Urea (46% N), Rajphos (20% $P_2O_5$) and Muriate of potash (60% $K_2O$)]in $T_6$.In $T_3$ and $T_4$, 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,root characteristics were recorded at 15, 30 and at harvest(45 DAT). Vegetative yield of amaranthus was recorded at harvest. The data obtained from the experiment was subjected to statistical analysis using GRAPES.

## RESULT AND DISCUSSION

### Growth attributes

The plant height recorded at 15, 30 and 45 DAT ofamaranthus for both trials are presented in Table 1. The data revealed that the treatments caused significant variation in plant height at all growth stages. At 15 DAT, in first trial, plant height was significantlyhigher (21.79 cm) with $T_6$ (Control- soilculture-KAU-POP recommended dose of nutrients) and the treatment $T_5$ (18.75 cm) ranked next and was on par with $T_2$ (17.06 cm). $T_6$ (52.98cm & 77.80 cm) followed by $T_5$ (50.04cm & 74.91 cm) recorded more plant height at 30 and 45 DAT respectively. The lowest plant height was recorded with $T_1$ (Open water culture without medium) followed by $T_3$ (Hydroponics without medium).

Number of leaves per plant at all growth stages was significantly influenced by different treatments (Table 2). Thetreatment $T_6$ (Control-soil culture-KAU-POP recommended dose of nutrients) showed significantly maximum number of leaves and it was on par with $T_5$ in both trials in all growth stages and minimum number of leaves was formed in $T_1$.

The treatments had significant effect on the leaf area index in all growth stages (Table 3). The LAI was found highest in $T_6$ which was on par with $T_5$ in all growth stages in first and second trial.

Significant variation was observed among different treatments in respect of stem girth (Table 4).

**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 |

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

| 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 |

Maximum stem girth was obtained in treatment $T_6$.The root length varied significantly bydifferent treatments (Table 4). The higher root length was recorded in $T_6$ (control: soil culture-KAU-POP-recommended dose of nutrients).

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 $T_5$ largeamount of nutrients released from the decomposing water hyacinth also resulted in higher plant height (Vidya & Girish, 2014).The increased number of leaves may have resulted from more nutrients being availablein $T_6$, which improved the crop's ability to absorb nutrients because N enhanced theeffectiveness of leaves' photosynthesis.Higher availability of N which resulted inincreased length and width as well as leaf area in amaranthus. This are in conformity with the findings of Makinde (2015). Theincreased stem diameter might be attributed to more nutrients 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 nutrientavailability and better soil structure favor the root growth in amaranthus as observed in $T_6$.

**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 (Table 6), higher in $T_6$ (Control- soil culture-KAU-POP recommended dose of nutrients) which was on par with $T_5$ (Land cultivation with a bed of water hyacinth alone as medium). The increase in yield in $T_6$ might be due to the increased levels of inorganic fertilizer, which resulted in better availability and uptake of nutrients by plants that stimulates plant vegetative growth (Nyankanga*et al*,2012).Increase in yield in treatment $T_5$ can be explained by the release of the 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 growing medium $T_2$, followed by the $T_4$ ranked next in amaranthus yield. Improvement of yield in vegetablesgrowing in water hyacinth medium has been reported also by Baran*et al.* (2022).

Lower yield was recorded by $T_1$ (Open water culture without medium) and $T_3$ (Hydroponics without medium), which might be due to the presence of water in the root zone throughout the growth period of plants that resulted in anaerobic condition preventing root growth and nutrient uptake. Also, in $T_2$ (Open water culture with medium) and $T_4$ (Hydroponics with medium),the water hyacinth bed of 30 cm thickness lost water content soon and reduced to a thin layer of medium soon, resulting in water stagnation in the root zone.

**Table 6. Effect of water hyacinth medium on yield (kg ha$^{-1}$)**

| Treatments | Yield (kg ha$^{-1}$) | |
|---|---|---|
| | **Trial 1** | **Trial 2** |
| $T_1$ | 1195 | 1215 |
| $T_2$ | 8245 | 7602.5 |
| $T_3$ | 1810 | 1715 |
| $T_4$ | 3777.5 | 3635 |
| $T_5$ | 16820 | 16042 |
| $T_6$ | 17210 | 17135 |
| **SEm (±)** | 624.1 | 422.93 |
| **CD (0.05)** | 1854.27 | 1256.63 |

## 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 and reduced cost of cultivation is an added advantage. Hence, water hyacinth can be used as an effective medium for growing amaranthus at a lower cost in Kuttanad ecosystem.

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