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Efficacy of Different Organic Manures and Inorganic Fertilizers in Culture and Propagation of Fresh Water Ornamental Aquatic Plant Fanwort, *Cabomba carolininana*

Sachin Onkar Khairnar,* Vaneet Inder Kaur

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ABSTRACT

A trial was conducted to evaluate the efficacy of different organic manures and inorganic fertilizers to assess the growth performance of *Cabomba caroliniana* for 180 days in the agro-climatic conditions of Punjab. There were total six treatments containing azolla compost, vermicompost, poultry manure, cattle manure, Urea : SSP and DAP in triplicate. At the start of an experiment, one plant (10.5 cm ± 0.35) was planted per earthen pot (3.5 L capacity). Results illustrated that, the inorganic substrates in T_5 and T_6 had the significant influence ($p<0.01$) on plant length and biomass in *C. caroliniana*, whereas the number of runners and leaf length : Leaf width (LL: LW) ratio showed no significant difference. In all the treatments, stems showed fine, longitudinal striations which dark green from top and light green from below and the coloration of the submerged leaves was also similar to that of the stem, might be due to the presence of elevated levels of chlorophyll pigmentation. These discrepancies in qualitative trait may perhaps have happened due to the genetic makeup of these plants, as they were kept under analogous conditions. The presence of higher percentage of nitrogen and phosphorus in T_5 accelerated 08.63-15.34 % higher plant growth compare to T_6 and T_3. In conclusion, urea: SSP @ 0.2% with soil : Sand mixture (2:1) helps to increase plant length, biomass and produced good leaf quality of *C. caroliniana* under controlled conditions.

Keywords *Cabomba*, Manures, Fertilizer, Growth performance, Fanwort.

INTRODUCTION

Biodiversity of aquatic and semi-aquatic plants constitutes an integral component of any aquatic ecosystem. They serve as a source of food and shelter for the aquatic fauna, thus forming the base of aquatic wildlife conservation practices (Saini *et al.* 2010). Export of ornamental aquatic plant began in Brazil in the 1930s (Khairnar *et al.* 2020). Aquatic plants have been widely used in traditional landscape practices. The aesthetics of aquatic plants were appreciated in ancient literature which has continued for decades and a similar trend can be recognized even today where the incorporation of aquatic plants is considered as a scenic superlative to a man-made aquascape (Yakandawala *et al.* 2013). In addition to outdoor planting, incorporation of aquatic plants in aquariums together with ornamental fish is also popular. This global trend

Sachin Onkar Khairnar,* Vaneet Inder Kaur
Department of Aquaculture, College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana 141004, Punjab, India
Email: sachinkhairnar5983@gmail.com
*Corresponding author

Table 1. Chemical composition of growing media (soil, manures and fertilizers) used during the study.

Growing media	Organic carbon (%)	Available nitrogen (%)	Available phosphorus (%)	Available potassium (%)
Soil	3.2	0.08	0.033	0.15
Sand	2.8	0.01	0.034	0.11
Azolla compost	4.8	0.34	0.187	0.14
Poultry compost	9.4	1.26	3.945	0.65
Cattle compost	7.1	0.83	0.522	0.24
Urea	--	46	0	0
Single super phosphate	--	0	16	0
Di-ammonium phosphate	--	18	46	0

has made aquatic plants an important element of high demand. As a result many commercially important species of aquatic plants viz., *Bacopa monnieri*, *Cabomba caroliniana*, *Ceratophyllum demersum*, *Crytocornebecketti*, *Hydrilla verticilliata*, *Hygrophila difformis*, *Ludwegiarepens*, *Vallisneria spiralis* have been traded through various routes during the past few decades.

Among the commercially important varieties of aquatic plants, plant belonging to the family Cabombaceae is more as attractive compared to other plants and adds much more aesthetic value of the aquarium outlook. The aquatic plant belonging tofamily Cabombaceae includes two genera : *Brasenia* represented solely by *B. schreberi* and *Cabomba* represented by five species—*C. aquatica*, *C. caroliniana*, *C. furcata*, *C. haynesii* and *C. palaeformis*. All of these species are available throughout the world and are quite similar and difficult to separate. *C. caroliniana* is native to the south-eastern United States of America and South America (Hanlon 1990). It is one of the fastest growing amphibious plants that produce both submersed and emergent growth. It spreads largely through activities related to the aquarium trade. Its stem is smooth, fleshy and branchy about 1.5 m long; the leaves are fan-shaped arranged in opposite pairson short stalks and resemble a bottle brush; flower has white petals and float on water surface (Wilson *et al.* 2013). Due to this shape of its leaves vegetation of this plant looks very fragile, delicate and attractive. The plant spreads most often through vegetative means, primarily through stem fragments and rhizomes (Washington State Department of Ecology 2008).

In India, ornamental aquatic plants is an upcoming enterprise and have great potential in aquarium fish industry, as secondary source of income beside ornamental fish trade (Khairnar and Kaur 2018). Although the trade of ornamental aquatic plants is dependent upon wild collection, this activity can be developed into small scale enterprise to furnish the needs of hobbyists and traders by setting up an ornamental aquatic plant nursery. Thus for the sustainable growth of this trade, it is necessary to strengthen the culture and propagation techniques for commercially important species. For successful propagation and better growth of aquarium plants, there rises a need to understand the requirement of different substrate (soil and either manure or fertilizer). Organic manures are derived from animals, plants and microorganisms and many varieties of manures are easily available in local market at affordable price. Growth promoting enzymes present in organic manures make them useful for improvement of soil fertility and productivity (Usmani *et al*. 2019). Inorganic fertilizers consist of most essential elements like nitrogen, phosphorus and potassium which influences vegetative and reproductive phase of plant growth. Compared to inorganic fertilizers the organic fertilizer have lowered nutrient content, solubility and nutrient release rates are typically low than inorganic fertilizers and therefore inorganic fertilizers are more preferred than organic fertilizers (Attarde *et al.* 2012). In this perspective, efforts were being made to culture and propagate the ornamental aquatic plant fanwort, *C. carolininana* with different organic and inorganic substrate to assess its growth performance and propagation in confined conditions.

MATERIALS AND METHODS

The experiment was performed with *C. caroliniana* at Ornamental Fish and Aquatic Plant Unit, College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana (Punjab), India

Table 2. Quantitative traits (Growth parameters) of amazon sword plant at the end of experiment. *Values (mean ± SE) with same superscripts in a row do not differ significantly (p ≤ 0.05).

Treat-ments	Growth parameters SL	RL	PL	Runners	No. of leaves	LH	LW	Biomass
T_1	$16.33^{a} \pm 2.03$	$4.57^{a} \pm 0.26$	$20.90^{a} \pm 2.17$	$1.33^{a} \pm 0.33$	$5.33^{a} \pm 1.33$	$15.63^{a} \pm 0.74$	$3.36^{a} \pm 0.29$	$41.67^{a} \pm 2.85$
T_2	$17.67^{ab} \pm 1.76$	$4.70^{a} \pm 0.17$	$22.37^{ab} \pm 2.66$	$1.33^{a} \pm 0.33$	$6.33^{a} \pm 0.88$	$16.93^{ab} \pm 0.48$	$3.77^{a} \pm 0.15$	$44.33^{a} \pm 2.91$
T_3	$20.00^{b} \pm 1.15$	$4.73^{a} \pm 0.23$	$24.73^{b} \pm 1.36$	$2.00^{b} \pm 0.58$	$9.00^{b} \pm 2.08$	$17.57^{b} \pm 0.29$	$4.27^{b} \pm 0.24$	$51.33^{b} \pm 2.40$
T_4	$22.33^{c} \pm 0.66$	$5.30^{b} \pm 0.15$	$27.63^{c} \pm 0.90$	$2.00^{b} \pm 0.58$	$9.33^{b} \pm 2.02$	$18.16^{bc} \pm 0.49$	$4.27^{b} \pm 0.24$	$53.66^{b} \pm 2.60$
T_5	$28.96^{d} \pm 1.68$	$5.26^{b} \pm 0.19$	$34.23^{d} \pm 1.88$	$2.33^{c} \pm 0.33$	$12.33^{c} \pm 1.85$	$18.31^{c} \pm 0.35$	$5.02^{c} \pm 0.16$	$65.33^{c} \pm 2.90$
T_6	$28.50^{d} \pm 1.80$	$5.23^{b} \pm 0.14$	$33.73^{d} \pm 2.28$	$2.00^{b} \pm 0.00$	$10.66^{bc} \pm 0.33$	$18.24^{c} \pm 0.23$	$4.97^{c} \pm 0.21$	$64.66^{c} \pm 1.33$

(30.54°N latitude and 75.48°E longitude) for the period of 4 months. Freshwater ornamental aquatic plant fanwort, *C. caroliniana* was obtained domestic ornamental fish market in Kurla, Mumbai, Maharashtra. The identification of plant was carried out by using the distinguishing characters (Reimer 1984).

Six treatments such as azolla compost (T_1), vermicompost (T_2), poultry manure (T_3), cattle manure (T_4), Urea (46.0.0) : SSP (0 : 16 : 0) (T_5) and DAP (18 : 46 : 0) (T_6) were used as organic and inorganic substrate for growing *C. caroliniana* in triplicate (Table 1). Initially, single plant (8cm ± 0.12) was planted per earthen pot of 3.5 liter capacity. The pot was filled with 1 kg of soil and sand (2:1) supplemented @ 2% (T_1-T_4) manures and 0.2% (T_5-T_6) fertilizer as per experiment design which was thoroughly mixed and then remaining space was filled by 1 kg sand and top-up with small stones (pebbles) to avoid the loss of media.

For qualitative traits the plants were examined visually for differences in nature of branch and leaves, color of leaves, stem and shape of leaves, while for quantitative traits vegetative characters such as shoot length (SL), root length (RL), shoot length/root length ratio, plant length (PL), leaf length (LL), leaf width (LW), leaf length/leaf width (LL/LW) ratio were recorded.

Water samples were collected for physico-chemical analyses like temperature (°C), pH, specific conductivity (µS cm^{-1}), dissolved oxygen (mg L^{-1}), carbon dioxide (mg L^{-1}), total alkalinity (mg L^{-1}), total hardness (mg L^{-1}), ammonia (mg L^{-1}), nitrate (mg L^{-1}), nitrite (mg L^{-1}) were determined as per the standard methods (Carranzo 2012).

Statistical analysis of the data was performed with a statistical package (SPSS 20.0, SPSS Inc., Richmond, CA, USA).Values was presented as means ± standard error of the mean. Data for the growth parameters were tested for homogeneity of variances and then possible differences were tested using one-way ANOVA for qualitative and quantitative characters and followed by Duncan's multiple comparison to find out the difference between treatments.

RESULTS AND DISCUSSION

Earlier studies have reported that, ornamental aquatic plants grow better under restricted conditions.The positive influence of compostand manures has been observed on the growth of several aquatic plants viz., in *Cabomba caroliniana* (Gurav 2011, Khairnar *et al.* 2020), *Vallisneria spiralis* (Shelar *et al.* 2012), *Hygrophila difformis* (Khairnar and Kaur 2018) and *Elatine gratioloides* (Khairnar *et al.* 2018), while influence of fertilizers on growth of *Microcystis aeru gino*sa (Huang *et al.* 2014), *Cabomba caroliniana* (Khairnar and Kaur 2018) and *Elodea nuttallii* (Huang *et al.* 2017) has also been illustrated. Even though, the independent investigations probing into the effects of organic manures and inorganic fertilizers on growth of ornamental aquatic plants have produced variant results. Still, the work on comparative effectiveness of both organic manures and inorganic fertilizers on growth performance of ornamental aquatic plants is not reported altogether.

Table 3. Qualitative traits of amazon sword plant at the end of the experiment. E-erect, lg-light green, g-green, dg-dark green, pv-pinnately veined.

Treat-ments	Qualitative traits: Nature of the branch	Color of the stem	Color of the leaves	Shape of the leaves
Control (T_0)	e	lg	pg	pv
T_1	e	lg	pg	pv
T_2	e	g	pg	pv
T_3	e	lg	pg	pv
T_4	e	lg	pg	pv
T_5	e	lg	pg	pv
T_6	e	lg	pg	pv

In the beginning of experiment, no significant differences were observed in plant biomass and total plant length among all the treatments ($p > 0.05$). The results revealed that, the inorganic substrate containing high levels of nitrogen and phosphorus had the significant effect on growth parameters especially, plant biomass and plant length in *C. caroliniana* ($p<0.01$). The maximum plant biomass and plant length was observed in the treatment containing urea and single super phosphate (1:1), followed by di-ammonium phosphate (Table 2). However, number of runners showed no significant difference between the treatments. In all the treatments, stems showed fine, longitudinal striations which dark green from top and light green from below (Reimer 1984) and the coloration of the submerged leaves was also similar to that of the stem, might be due to the presence of elevated levels of chlorophyll pigmentation (Table 3). These discrepancies in qualitative trait may perhaps have happened due to the genetic makeup of these plants, as they were kept under analogous conditions. Previous studies have shown that, successful attempts have being made for rearing ornamental aquatic plant by using different manures and fertilizers separately to improve the plant biomass, plant length and also produced good leaf quality (Shelar *et al.* 2012, Huang *et al.* 2014, Huang *et al.* 2017, Khairnar *et al.* 2018).

In the present study, the temperature varied between 27.5 to 31.5°C, pH was around 7.5, while specific conductivity of water showed gradual drop after first two weeks in all the treatments (Table 4). Owing

Table 4. Physico-chemical and microbial parameters during the study. *Values (mean ± SE) with same superscripts in a row do not differ significantly ($p \leq 0.05$).

Parameter	Treatments: T_1	T_2	T_3	T_4	T_5	T_6
Temp (°C)	$30.77^a±0.36$	$30.78^a±0.32$	$30.69^a±0.37$	$30.63^a±0.40$	$30.76^a±0.36$	$30.72^a±0.36$
pH	$7.52^b±0.03$	$7.41^a±0.01$	$7.49^b±0.02$	$7.61^c±0.03$	$7.43^a±0.02$	$7.48^{bc}±0.02$
Conductivity (ms)	$1.07^b± 0.03$	$1.04^b± 0.03$	$1.10^c± 0.02$	$1.12^c± 0.04$	$0.99^a± 0.01$	$0.98^a± 0.02$
DO (mg L^{-1})	$6.12^a±0.35$	$6.15^a±0.62$	$6.18^a±0.48$	$6.26^a±0.59$	$6.22^a±0.84$	$6.20^a±0.66$
Free Co_2 (mg L^{-1})	Nil	Nil	Nil	Nil	Nil	Nil
Total hardness (mg L^{-1})	$213.57^a±2.66$	$215.76^a±2.37$	$233.33^c±1.50$	$235.00^c±1.71$	$221.76^b±2.10$	$236.33^c±3.50$
Total alkalinity (mg L^{-1})	$235.32^a±0.94$	$244.49^b±1.09$	$237.14^a±2.71$	$238.94^a±1.44$	$266.56^c±1.23$	$236.14^a±2.92$
Ammonia-nitrogen (mg L^{-1})	$0.04^a ± 0.01$	$0.06^b± 0.02$	$0.11^c± 0.05$	$0.06^b± 0.03$	$0.08b^c± 0.02$	$0.11^c± 0.05$
Nitrate-nitrogen (mg L^{-1})	$0.02^a± 0.01$	0.02a± 0.01	$0.04^b± 0.01$	$0.02^a± 0.01$	$0.03^{ab}± 0.01$	$0.04^b± 0.01$
Nitrite-nitrogen (mg L^{-1})	$0.01^a± 0.01$	$0.01^a± 0.01$	$0.02^b± 0.01$	$0.01^a± 0.01$	$0.01^a ± 0.01$	$0.02^b± 0.01$
Total plate count in substrate(CFU × 10^{-8} g^{-1})	$2.97^b± 0.02$	$3.88^d± 0.03$	$3.21^c± 0.05$	$3.18^c± 0.03$	$2.74^a ± 0.02$	$2.71^a± 0.04$

to photosynthesis, dissolved oxygen levels were found to be increased in all the treatments and there was no significant difference among the treatments ($p > 0.05$). Most of the aquatic plants supplement free dissolved carbon dioxide (CO_2) with bicarbonate (Maberly and Gontero 2017), however; they are more readily able to assimilate dissolved CO_2. During the trial free CO_2 was found to be absent, while water hardness and alkalinity ranged from 213.57–236.33 mg L^{-1} and 232.40–266.56 mg L^{-1} respectively in all the treatments. Overall, water quality parameters showed a positive effect of manures and fertilizers on growth performance *C. caroliniana.* The results of present study showed that all the values of hardness and alkalinity were found within the range. The optimum values of hardness ($CaCO_3$) and alkalinity for aquaculture ranges from 40 to 250 mg L^{-1} and 60 to 300 mg L^{-1} respectively (Boyd *et al.* 2016).

At the beginning of experimental trial, the soil and growing media analysis was carried out, while microbial variation in substrate was analyzed at the end of an experiment and later the readings were matched with the initial soil sample. The total plate count (TPC) of bacterial population in substrate was highest without having significant difference in microbial population in T_2, which did not show significant influence on plant growth may be due to the presence of high levels of organic matter and its buffering capacity. Total plate count showed no significant difference ($p>0.05$), but presence of higher amount of nutrients like nitrogen and phosphorus in T_5 and T_6 might have encouraged higher plant growth compared to other treatments. In aquatic ecosystem, sediments contain active bacterial communities that consume molecules excreted by plant roots, including organic molecules (amino acids, sugars and organic acids) and gasses (O_2, N_2 and CO_2) (Gougoulias *et al.* 2017). In return, microbial processes, like organic matter mineralization, phosphorus solubilization and nitrogen fixation, provide nutrients for the plants (Marques *et al.* 2019). Moreover, the plant-attached with bacterial communities are different than the bacterial communities in surrounding environments (Fagorzi *et al.* 2019).

CONCLUSION

In the present study, the application of Urea: SSP and DAP illustrated better results during comparative evaluation of qualitative and quantitative traits of freshwater ornamental aquatic plant *C. caroliniana*. The presence of higher percentage of essential nutrient like nitrogen and phosphorus in Urea : SSP accelerated higher plant growth compare to DAP and poultry manure.In conclusion we suggest that Urea: SSP @ 0.2% with soil: Sand mixture (2:1) helps to increase plant length, biomass and produced good leaf quality under controlled conditions.

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REFERENCES

Attarde SB, Narkhede SB, Patil RP, Ingle ST (2012) Effect of organic and inorganic fertilizers on the growth and nutrient content of *Abelmoschus esculentus*. *Int J Cur Res* 4 (10) : 137—140.

Boyd CE, Tucker CS, Somridhivej B (2016) Alkalinity and hardness: Critical but elusive concepts in aquaculture. *J World Aquac Soc* 47 (1) : 6—41.

Carranzo IV (2012) Standard methods for examination of water and wastewater. In Anales De Hidrología Médica, Universidad Complutense de Madrid.

Fagorzi C, Del Duca S, Venturi S, Chiellini C, Bacci G, Fani R, Tassi F (2019) Bacterial communities from extreme environments: Vulcano Island. *Diversity* 11 (8): 140.

Gougoulias C, Clark JM, Shaw LJ (2017) The role of soil microbes in the global carbon cycle : Tracking the below ground microbial processing of plant-derived carbon for manipulating carbon dynamics in agricultural systems. *J Sci Food Agric* 94 (12) : 2362—2371.

Gurav A, Dhaker HS, Bhalekar M (2011) Effect of different organic manures and light on the growth of Cabomba. LAP- Lambert Academic Publishing, pp 184.

Hanlon C(1990) A Florida native - Cabomba (Fanwort). *Aquatics* 12 : 4—6.

Huang W, Bi Y, Hu Z (2014) Effects of fertilizer-urea on growth, photosynthetic activity and microcystins production of *Microcystis aeruginosa* isolated from Dianchi lake. *Bull Environ Contam Toxicol* 92 (5) : 514—519.

Huang W, Shao H, Li W, Jiang H, Chen Y (2017) Effects of urea on growth and photosynthetic metabolism of two aquatic plants *Cabomba caroliniana*. A Gray and *Elodea nuttallii* Planch. H. St. John. *Aquat Bot* 140 : 69—77.

Khairnar SO, Kaur VI (2018) Quantitative and qualitative differences in morphological traits of freshwater ornamental aquatic plant water wisteria, *Hygrophila difformis* under different organic substrate. *J Entomol Zool Stud* 6 (1) : 1664—1667.

Khairnar SO, Kaur VI, Pandey A, Sharma S (2018) Morphological evaluation of freshwater ornamental aquatic plant waterwort, Elatine gratioloides A. Cunn under Different Organic Substrate. *Adv Res* 13 (6) : 1—7.

Khairnar SO, Mandal A, Tyagi A, Sharma S (2020) Comparative efficacy of manures and fertilizers on growth performance of amazon sword plant, *Echinodorus bleheri*. *J Exp Zool India* 23 (S1) : 725—729.

Maberly SC, Gontero B (2017) Ecological imperatives for aquatic CO_2-concentrating mechanisms. *J Exp Bot* 68 (14) : 3797—3814.

Marques JM, Mateus JR, da Silva TF, Couto CRDA, Blank AF, Seldin L (2019) Nitrogen fixing and phosphate mineralizing bacterial communities in sweet potato rhizosphere show a genotype-dependent distribution. Diversity 11 (12) : 231.

Riemer DN (1984) Introduction to freshwater vegetation, AVI Publishing Company, West Port, USA, pp 207.

Saini DC, Singh SK, Rai K (2010) Biodiversity of aquatic and semi-aquatic plants of Uttar Pradesh. Uttar Pradesh State Biodiversity Board, pp 479.

Shelar GS, Dhaker HS, Pathan DI, Shirdhankar MM (2012) Effect of different organic manures on the growth of screw vallisneria, *Vallisneria spiralis* Linne 1753. *J Aquac Res Dev* 3 (1) : 1—4.

Usmani Z, Kumar V, Gupta P, Gupta G, Rani R, Chandra A (2019) Enhanced soil fertility, plant growth promotion and microbial enzymatic activities of vermicomposted fly ash. *Sci Rep* 9 (1) : 1—16.

Washington State Department of Ecology (2008) Technical information about *Cabomba caroliniana* (Fanwort). Non-Native Freshwater Plant, USA.

Wilson CE, Darbyshire SJ, Jones R (2013) The biology of invasive alien plants in Canada. 7. *Cabomba caroliniana* A. Gray. *Can J Pl Sci* 87 (3) : 615—638.

Yakandawala D, Yakandawala K, Sathurusinghe A, Gunasekara S (2013) Is the blooming ornamental aquatic plant industry a threat to the aquatic ecosystems of Sri Lanka ? *The Srilanka Forester* 35 (1) : 104.