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COMPARATIVE EFFICACY OF MANURES AND FERTILIZERS ON GROWTH PERFORMANCE OF AMAZON SWORD PLANT, *ECHINODORUS BLEHERI*

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ABSTRACT : An experiment was conducted to evaluate the efficacy of different manures and fertilizers to assess growth efficiency and propagation rate of *Echinodorus bleheri* and health status of different substrates using three replicates per treatment (azolla compost, vermicompost, poultry manure, cattle manure, Urea : SSP and DAP)for 180 days in agro-climatic conditions of Punjab. Initially, single plant (8cm ± 0.12) was planted per earthen pot (3.5 L capacity). Results showed that, the inorganic substrates in T_5 and T_6 had the significant influence (P<0.01) on length, number of leaf and biomass in *E. bleheri*. Maximum plant length, number of leaves and biomass were recorded in T_5, followed by T_6. However, number of runners and leaf length: leaf width (LL: LW) ratio showed no significant difference.All the treatments showed erect branching habit with bright green coloured shoots; while leaves were pear green in colour. The TPC was highest in T_2 due to the presence of high levels of organic matter and its buffering capacity while lowest in T_5. The presence of higher percentage of nitrogen and phosphorous in T_5accelerated 10.31-23.88% 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 amazon sword plant under controlled conditions.

Key words : Sword plant, manures, fertilizer, growth performance, microbial variation.

INTRODUCTION

Numerous fascinating and attractive aquatic plants are grown in aquaria for ornamental purpose and maintaining water quality. They absorb nutrients, resulting in their less availability for algae, hence making algal blooms less likely. Like any other plant, aquatic plants also fixes inorganic carbon (CO_2) into organic carbon through photosynthesis and release oxygen into the water medium, which is important for fish and other aquatic organisms that depend on dissolved oxygen to survive. In addition, aquatic plants provide food, shed, shelter and breeding places to fishes being reared together with plants (Madsen and Cedergreen, 2002; Khairnar *et al*, 2018).

Aquarium plants are produced in sophisticated plant nurseries in Europe, India, Indonesia, Malaysia, Singapore, Sri Lanka and Thailand (Winkelmann *et al*, 2006; Brunel, 2009) and such propagation has developed into a multimillion-dollar industry. In Europe alone, more than 30 specialized nurseries serve mainly the European market (Lehtonen and Falck, 2011). It has been secondary source of income beside ornamental fish trade for aquari-um enterprises (Lehtonen and Arevalo, 2005). In India, aquarium plant cultivation is an upcoming enterprise, which has not progressed to the level of its counterpart *i.e.* the ornamental fish trade (Swain *et al*, 2010). The supply is mainly dependent upon wild collection and may lead to ecological imbalance due to overexploitation along with non-availability of desirable species (Khairnar and Kaur, 2018). Hence, for the sustainable development of thistrade, it is essential to strengthen the culture and propagation techniques and set up a small scale backyard ornamental aquatic plant nursery in large numbers to cater the needs of amateurs and traders in domestic market.

Aquatic plants propagate mainly by sexual propagation via seeds, or asexually, by vegetative propagation (Shibayama and Kadono, 2007). The most imported aquatic plant that are used in aquarium industry are *Cabombaca roliniana*, *Echinodorus bleheri, Hygrophila polysperma*, *Vallisneria spiralis*,

Vallisneria americana, *Najas marina* and *Hygrophila difformis*. *Echinodorus bleheri* commonly known as amazon sword plant of the Alismataceae family is the economically most important among the ornamental underwater aquatic plants (Brunel, 2009). Due to its high aquatic ornamental value, demand for high-quality, disease-free, amazon sword plant is steadily increasing (Dissanayake *et al*, 2007). For successful propagation, there rises a need to know the optimum requirement of different substrate (soil and either manure or fertilizer) used for plant growth. Therefore, the present study was designed to examine the comparative efficacy of manures and fertilizers on growth performance ofamazon swordplant, *E. bleheri*.

MATERIALS AND METHODS

The experiment was conducted at College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana (Punjab), India (30.54°N latitude and 75.48°E longitude) for the period of 6 months (June-November 2017). Freshwater ornamental aquatic plant amazon sword plant, *E. bleheri* was obtained domestic ornamental fish market in Kurla, Mumbai, Maharashtra. Theidentification of plant was carried out by using thedistinguishing characters (Reimer, 1984; Fassett, 1997).Six treatments such as azolla compost (T_1), vermi compost (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 amazon sword plant in triplicate (Table 1). Initially, single plant (8cm ± 0.12) was planted per earthen pot of 3.5 litre 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 physicochemical analyses like temperature (°C), pH, specific conductivity (µS/cm), dissolved oxygen (mg/L), Carbon dioxide (mg/ L), total alkalinity (mg/L), total hardness (mg/L), ammonia (mg/L), nitrate (mg/L), nitrite (mg/L) were determined as per the standard methods (APHA, 2005). 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 ANOVAfor qualitative and quantitative charactersand followed by Duncan's multiple comparison to find out the difference between treatments.

RESULTS AND DISCUSSION

While the idea that ornamental aquatic plants grow better under confined conditions is generally accepted, the positive influence of manures on the growth of aquatic plant have been reported in *Cabomba caroliniana* (Gurav, 2011), *Vallisneria spiralis* (Shelar *et al*, 2012), *Hygrophila difformis* (Khairnar and Kaur, 2018) and *Elatinegra tioloides* (Khairnar *et al*, 2018), while influence of fertilizers on growth of *Microcystis aeruginosa* (Huang *et al*, 2014), *Cabomba caroliniana* and *Elodea nuttallii* (Huang *et al*, 2016) has also been illustrated.

One-way ANOVA shows that, at the commencement of an experiment there was no significant differences inthe plant biomass and total length among all treatments ($P>0.05$). Results illustrate that, the inorganic substrates which contain high levels of nitrogen and phosphorous had the significant influence ($P<0.01$) on plant length, number of leaf and biomass in *E. bleheri*. Maximum plant

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	3.1	0.07	0.035	0.14
Sand	2.8	0.02	0.037	0.09
Azolla compost	4.8	0.34	0.187	0.14
Vermi compost	5.5	0.49	0.241	0.18
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

Table 2 : Quantitative traits (growth parameters) of amazon sword plant at the end of experiment.

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

*Values (mean ± S.E.) with same superscripts in a row do not differ significantly (P ≤ 0.05).

Table 3 : Qualitative traits of amazon sword plant at the end of the experiment.

Treatments	Qualitative traits			
	Nature of the branch	Colour of the stem	Colour 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

Note: E-erect, lg-light green, g-green, dg-dark green, pv-pinnately veined.

coloured shoots. (Table 3). The light green colouration in stem was might be due to chlorophyll pigment concentration; while leaves were pear green in colour (Wilson, 1941). This divergence in qualitative traits may possibly have occurred due to the genetic makeup of these plants, as they were kept under identical conditions. Best owing to previous research studies, manures and fertilizers helps to improve the plant biomass, plant length and also produced good leaf quality.

The physico-chemical parameters of soil and growing media were checked initially, while microbial variation in substrate was studied at the end of the experiment and compared with the initial soil sample. The total plate count (TPC) of bacterial population in substrate was highest

Table 4 : Physico-chemical and microbial parameters during the study.

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)	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)	Nil	Nil	Nil	Nil	Nil	Nil
Total hardness (mg/L)	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)	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)	0.04^{a} ± 0.01	0.06^{b}± 0.02	0.11^{c}± 0.05	0.06^{b}± 0.03	0.08^{bc}± 0.02	0.11^{c}± 0.05
Nitrate-nitrogen (mg/L)	0.02^{a}± 0.01	0.02^{a}± 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)	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 x 10^{-8}/g)	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

*Values (mean ± S.E.) with same superscripts in a row do not differ significantly (P ≤ 0.05).

length, number of leaves and biomass were recorded in combination of Urea: SSP treatment, followed by DAP treatment (Table 2). However, number of runners and leaf length: leaf width (LL: LW) ratio showed no significant difference between the treatments. All the treatments showed erect branching habit with bright green

(Brown, 1995; Chaoui *et al*, 2003) without having significant difference in microbial population in T_2, which did not showsignificant influence on plant growthmay be due to the presence of high levels of organic matter and its buffering capacity. Without having any significant difference (P>0.05) in TPC, but presence of higher

amount of nutrients like nitrogen and phosphorus in T_5 and T_6 could influence higher plant growth compares to any other treatments employed during the study period. Several researchers have already cited that in aquatic system, 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) (Moriarty *et al*, 1986, Pollard and Moriarty, 1991). In return, microbial processes, including organic matter mineralization (Smith *et al*, 1984), phosphorous solubilization (Wigand and Stevenson, 1997) and nitrogen fixation, provide nutrients for the plants. Also, plant-attached bacterial communities are different than the bacterial communities in surrounding environments (Crump and Koch, 2008).

In the current study, the temperature varied between 28.5 to 31.5°C, pH was around 7.5, while specific conductivity of water showed gradualdrop after first five weeks in all the treatments (Table 4). Due to photosynthesis, dissolved oxygen levelswere 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 CO_2 with bicarbonate (Spence and Maberly, 1985), however; they are more readily able to assimilate dissolved CO_2.During present study, free carbon dioxide was found to be absent throughout the experiment, while water hardness and alkalinity ranged from 213.57×236.33 mg/L and 232.40×266.56mg/L, respectively in all the treatments. Overall, water quality parameters showed a positive effect of manures and fertilizers on growth performance *E. bleheri*.

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 amazon sword plant. The presence of higher percentage of essential nutrient like nitrogen and phosphorous in Urea: SSP accelerated 10.31-23.88% 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 of amazon sword plant under controlled conditions.

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