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Evaluation of *Pangasius* pond sediment potentials in vegetable production as rooftop Bag Gardening

S. Monira*, M. M. Haque, M. M. Ali and M. Y. Prodhan[1]
Department of Aquaculture, Bangladesh Agricultural University, Mymensingh-2202, [1]Department of Biochemistry and Molecular Biology, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh, *E-mail: smonykaafroje@yahoo.com

Abstract

An experimental research was carried out to assess the potential of *Pangasius* pond sediment (PPS) on the performance of yield and yield quality attributes of vegetable crop (BARI's tomato variety) grown in bag gardening system on rooftop under integrated aquaculture-horticulture approach. For this purpose, PPS chemical analysis, recording of plant morphological parameters and biochemical analysis of yield were performed. The plants were grown in 100% PPS =T_1; 50% PPS + 50% Virgin soil (VS) = T_2; and 60% VS + 40% Cowdung + 50g TSP + 50g MoP = T_3. To compare with PPS treated treatments, treatment T_3 was considered as control because it is a standard and recommended fertilizing dose of BARI's tomato production. The PPS sediments were collected from different aged ponds ranging from 1to 5 years *Pangasius* culture. The old PPS was used in bag gardening for the determination of soil physico-chemical, plant morpho-physiological and production parameters. All PPS in bags were belonged to silt loam in texture. The total nitrogen level was higher in T_1 where 100% PPS was used. The T_1 had the plant height 77.98 cm, number of leaves per plant 184.33, leaf area 622.49 cm^2, which were significantly ($p<0.05$) higher than T_2 and T_3. In the case of phenological development, onset of early flowering and fruiting was noticed in T_1, which was almost 1.5 weeks earlier than T_2 and 2 weeks than T_3**.** The reproductive characters like flowers per plant (28.67), weight of fruit per plant (53.78g) and fruit yield per bag (1945.74g) and total biomass of plants after harvesting (119.47g) were also significantly ($p< 0.05$) higher in T_1 followed by T_2 and T_3 (control). The numbers of branches per plant (29.54), number of clusters per plant (35.84) and fruits per cluster (5.10) were higher in T_1 than T_2 and T_3. The vitamin C content of tomato (28.26 mg %) was also significantly ($p< 0.05$) higher in T_1 followed by T_2 (24.67 mg %) and T_3 (21.28 mg %). The treatment T_1 showed the best performance followed by T_2 and T_3 (control). The perceived aquaculture waste of PPS had the high potential to grow vegetables with better production without any manure and chemical fertilizers. Therefore, PPS could reduce use of chemical fertilizers, especially urea which is environment friendly and less costly for vegetable production in bag gardening system.

Keywords: *Pangasius* pond sediment, Morpho-physiological parameter, Vitamin C

Introduction

Bangladesh ranked sixth among the major aquaculture producing countries in the world (DoF, 2011). Aquaculture contributed 39% of the total fish production in 2008, indicating as the fastest growing food producing sector in Bangladesh (DoF, 2009). The catfish production was estimated to be 117,856 metric tons in 2008-2009; which was 4.36% of total inland fish production (DoF, 2010). *Pangasius* is a riverine catfish belonging to the members of the family Pangasidae. Thai *Pangasius* is one of the most suitable catfishes for rearing in ponds. The estimated total *Pangasius* production in Bangladesh was about 3,00,000 tones in the year 2008 (Edward *et. al.,* 2010 and Munir, 2009).

Pangasius is one of the best aquaculture species due to its ease of culture, high market demand and well suited to the weather condition and its propagation (Sarker, 2000). It is occupying the third most important freshwater fish within aquaculture sector for its rapid growth and market demand. *Pangasius* can be fed with kitchen waste, rice bran or pellet feeds at the rate of 2.5% of their average body weight. About 2kg of feed is required to produce 1kg of *Pangasius* fish (Haque, 2009). They utilize 30% of total nitrogen of supplied feed for their body building and 70% nitrogen is deposited on the pond bottom (Haque, 2009). This sediment holds a large amount of ammonia which is very harmful for pond water quality and surface environment. The farmers are unable to remove this sediment and subsequent uses due to lack of necessary knowledge, fellow land and available labor in dry season. Decomposed feed materials present in the deposited sediments converted into harmful gases and other substances. Thus *Pangasius* aquaculture has a vast potential for integrated aquaculture-horticulture using the sediments in the systems for improvement of pond environments and proper growth of fish.

Pangasius pond sediment (PPS) is a valuable waste as it contains high amount of nitrogen, organic carbon, available sulphur, phosphorus and optimum pH. The use of extra organic and/or inorganic fertilizers can be minimized by applying PPS in the crop field. Bag gardening known as vertical farms or gardens for which bags are filled with soil and plant growing in it. When plant in bags containing growing media are placed on roof termed as rooftop bag gardening (RBG). This bag gardening concept for a small and portable garden is good for the areas where the gardeners may have to continually relocate, as well as for areas where there is little or no healthy soil. Several initiatives aimed at providing and training in the use of these bag gardens have reported high levels of success in terms of improving nutrition, food security, and income.

Different types of vegetables are used for daily consumptions but tomato (*Solanum lycopersicum)* increases the taste and color in different recipes and food value next to others vegetables. Five-ounce tomato growing in home or green house provides a third of our daily needs for vit-A, vit-C along with some iron, fiber and B vitamins. In terms of land resources, the alarming population growth, poverty, malnutrition, rapid industrialization and urbanization during the past few decades resulted in remarkable reduction of cultivated land. Therefore, these problems can be minimized partly and quickly by practicing integrated aquaculture- horticulture systems. The adoption of the integrated approach will help the community people economically and environmentally. Therefore, an attempt was taken to establish an integrated aquaculture-horticulture approach by utilizing the PPS effectively to produce tomato (horticultural vegetables) as RBG and to assess the efficiency of sediment nutrients on the growth and production performance of horticultural crop in bag gardening system.

Materials and Methods

The experiment was carried out on the rooftop of the Dean Office Building, Faculty of Fisheries and in the laboratory of the Department of Aquaculture, Faculty of Fisheries, Bangladesh Agricultural University (BAU), Mymensingh during the period from February, 2011 to April, 2012.

Preparation of soil samples

PPS samples were collected from *Pangasius* pond of a farm named Ma Fisheries in Dhanikhola village of Trishal Upazila under Mymensingh district. After filling the bags with dried PPS the bag soil nutrients were analyzed. During sample collection, four sub-samples of PPS were collected from a single pond and ground after dried at room temperature and then mixed together to make a single composite sample.

Physical and chemical analysis of PPS

The pond soil was analyzed before transplanting the tomato seedling in bag as well as after transplanting. Physical parameters such as soil particle size distribution and textural classes were determined by hydrometer method as outlined by (Bouyoucos, 1927). Among the chemical parameters pH was measured by a glass electrode pH meter according to Jackson, (1986). The organic matter was obtained by multiplying the content of organic carbon by Van Bemmelen factor of 1.73 (Page, 1982). Total nitrogen content was determined by Semi- Micro-Kjeldahl method. The ammonia was collected in boric acid solution and was titrated with 0.01N sulphuric acid (Black, 1965). Available phosphorus was analyzed by 0.5M $NaHCO_3$ extraction and ascorbic acid reduction method (Matt, 1970). Exchangeable potassium was analyzed by ammonium acetate extraction method. The calcium chloride extraction method was used for the determination of available sulphur.

Design and layout of the experiment

The Completely Randomized Design (CRD) was used to conduct the experiment comprising three treatments, each containing three replications. The treatments were T_1 = 100% PPS, T_2 = 50% PPS + 50% Vergin soil (VS), and T_3 = 60% VS + 40% Cowdung + 50g TSP + 50g MoP. Treatment T_3 was considered as control because the combination of soil, cowdung and other inorganic fertilizers has been recommended by Bangladesh Agricultural Research Institute's (BARI) tomato culture technology (BARI,

19 ... ted in one bag, which made a single replication. Before this, seeds of ... nursery bed on 06 February 2011. Twenty five days old tomato se ... bag gardening.

Da

Th ... were collected at 15 days intervals from planting to harvesting. The da ... henological and reproductive parameters.

Ve ... as measured by meter scale, number of branches and leaves per pla ... a and total biomass were recorded.

Ph ... st flowering, fruiting and maturity and days to end of fruit harvest we ...

Re ... of flower clusters per plant, flowers per cluster, flowers per plant, fruit clusters per plant, fruits per cluster, fruits per plant per week, fruits per plant were counted accordingly, fruit weight per plant and fruit yield were measured properly.

Biochemical parameters: Percent moisture and dry matter content were determined and estimation of vitamin C was done by dye methods.

Statistical analysis

One-way analysis of variance (ANOVA) was carried out to test the variation between the treatments. The mean differences were evaluated by DMRT (Duncan's Multiple Range Test) (Gomez and Gomez, 1984). Data were analyzed with the computer based statistical package SPSS.

Results and Discussion

Table 1. The physico-chemical characteristics of bag soil of the experiment

Soil characteristics	Treatments		
	T_1	T_2	T_3
pH	6.86±0.04	6.86±0.03	7.14±0.02
Organic-C (%)	3.15±0.04	1.56±0.05	4.15±0.07
Total-N (%)	0.30±0.00	0.14±0.00	0.36±0.01
Available-P (ppm)	115.63±0.68	102.33±1.03	156.66±1.03
Exchangeable-K (ppm)	106.83±4.31	65.48±3.16	402.53±6.31
Available-S (ppm)	86.06±0.66	51.29±0.43	31.17±0.66
Sand (%)	25.71±0.58	27.71±0.58	36.37±0.58
Silt (%)	66.00±0.00	62.00±0.00	46.00±0.00
Clay (%)	8.29±0.58	10.29±0.58	17.63±0.58
Texture	Silt loamy	Silt loamy	Loamy

The soils used in this experiment belonged to the silt loam textural class (Table 1). Soils like silt loam and clay loam have higher agricultural values being less susceptible to become loose and open (Weir, 1989).

Chemical characteristics of PPS

All soils belonged to slightly acidic to almost neutral in nature. The pH (6.86) of bag soil in T_1 was found in a suitable range of vegetable production which was almost similar to the findings of Monir (2009) who reported the pH concentration varied from 6.82 to 6.90 in different treatments of the *Pangasius* farming (Table 1). The percent organic carbon content was varied from 4.15 to 1.56 where the 100% PPS showed suitable range of OC for vegetable production (Table 1). Hepher (1965) reported that the sediment of carp ponds after 5 year of production had an OC content of 1.99%. This result indicated that the PPS organic carbon was cost effective than the chemical fertilizers used at T_3. The total nitrogen value (0.30) was stimulating to vegetable production in 100% PPS containing bag. There was no significant variation between T_1 and T_3 bag soil's total nitrogen concentration but had significant difference with T_2 bag soil. The findings of the present study were higher than that of Karim (2009), who obtained the range of total

nitrogen from 0.04 to 0.096%. The amount of P was ranged from 156.66 to 102.33 ppm where T_1 contained 115.63 ppm. There was no significant variation occurred in T_1 and T_3 but T_2 had significant variation from others. Bhuiyan (1988) conducted an experiment on different soil series of Bangladesh and found the P content was varied from 2.2 to 140 ppm with a mean value of 21.2 ppm. The P requirement in 100% PPS containing bags was suitable for vegetable production. The K content was varied from 402.53 to 65.48ppm among three different bag soils where T_1 content 106.83 ppm. According to Bhuiyan (1988) experiment on different soil series of Bangladesh, the K content was ranged from 39.10 to 132.94 ppm with an average value of 70.38 ppm. The K in 100% PPS was found at a suitable range for vegetable production. The S content was varied from 86.06 to 31.17ppm among different bag soils. The maximum S content (86.06ppm) was noticed in T_1 and the minimum (31.17 ppm) in T_3. The S content was ranged from 15.29 to 128.05 ppm with a mean of 16.8 ppm which was found in Bhuiyan (1988) experiment on different soil series of Bangladesh.

Vegetative development

Plant height and branch number: The plant height was measured from 0 to 90 days after transplanting (DAT) and it almost steadily increased with the age of the plant and attained its maximum at 90 DAT. The tallest plant height (77.98 cm) was observed in 100% PPS (T_1), whereas, the smallest (52.79cm) was observed in T_3 (control). The branch number of tomato plant was gradually increased with the growth of the plant at different DAT. The highest branch number (29.54) was recorded in $T_1$and the lowest (23.33) was in T_3. There was a positive relation between plant height and branch number.

Number of leaves and leaf area: The number of leaves was counted from 30 to 75 DAT. The maximum number of leaves (156.71) was recorded in T_1 and the minimum (96.33) in T_3 (Fig. 1). Leaf production gradually increased until 60 DAT and then decreased. The number of leaves per plant increased gradually with the advancement of growth stages and decreased thereafter due to leaf abscission and crop aging (Pandey *et. al*., 1978). Leaf area was increased gradually with the advancement of time until 45 DAT and then declined. The maximum leaf area (548.00 square cm) was noticed in T_1 and the minimum (383.00 square cm) in T_3 (Fig. 2). The development of leaf area during optimum vegetative growth was the result of generation of new leaves and expansion of the existing ones. The subsequent reduction in leaf area up to maturity after attaining the maximum was due to very poor development of new leaves, leaf rolling and the age effect resulting from senescence of older leaves (Pandey *et. al*., 1978).

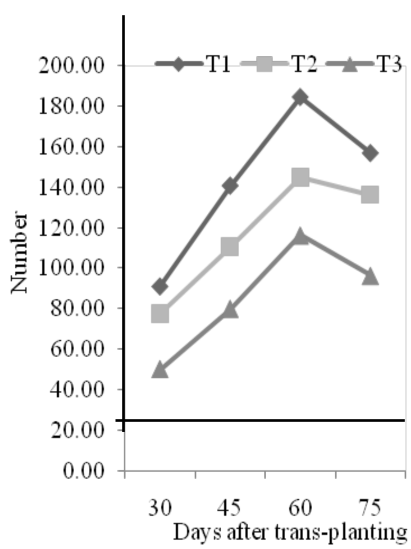

Fig. 1. Number of leaves per treatment in different treatments

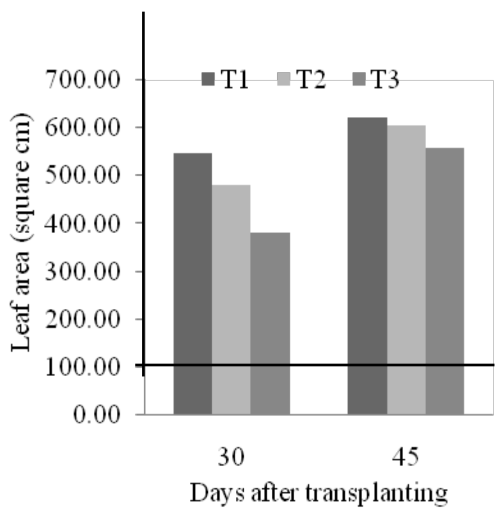

Fig. 2. Measurment of leaf area (square cm) in different treatments.

Phenological development: The early flowering (after 15.67 DAT) was noticed in T_1 and late flowering (after 34.67 DAT) was recorded in T_3 (control). Early fruiting (after 21.67 DAT) was found in T_1 and late flowering (after 39.67 DAT) was recorded in T_3 (Fig. 3). Early maturity is one of the important aspects for harvesting of fruit. Total fruit bearing period was also prolonged under 100% PPS condition. For that reason, total number of harvests was more in T_1 than the other treatment.

Reproductive development

Number of flowers: The number of flowers was measured from 20 to 65 DAT at 15 days of interval. Flower number was significantly influenced the production of crops. It increased gradually with the advancement of time except 65 DAT because, at this stage, all the flowers were converted to fruits. A statistically significant number of flowers were produced by T_1 from 20 to 50 DAT while T_2 and T_3 gave minimum at the same DAT except 50 DAT (Fig. 4).

Number of clusters: The cluster number was measured from 20 to 65 DAT at 15 days interval. It was significantly influenced the production of crops. It increased gradually with the advancement of time for all the treatments. Statistically, T_1 recorded better cluster from 20 to 35 DAT and 50 to 65 DAT followed by T_2 (Fig. 5).

Number of fruits per cluster: It was measured two times at 15 days of interval and increased gradually with the advancement of time for all the treatments at 30 and 45 DAT (Fig. 6). Statistically no significant variation was observed among T_1, T_2 and T_3 at two different DAT.

Number of fruits per replication: The numbers of fruits were recorded weekly from 30 to 65 DAT and measured as weight/treatment/week. The maximum number (53.78) of fruits was recorded in T_1 and minimum (22.33) in T_3. Statistically no significant production was recorded at 30 and 37 DAT in $T_1$and T_2 but it was increased gradually from 44 to 65 DAT (Fig. 7).

Total production of tomato: Statistically significant ($p<0.05$) production was recorded in T_1 (1945.74g) followed by T_2 (1399.74g), whereas, the minimum was recorded in T_3 (888.90g) (Fig. 8). The total production rate determines the quantity of crops.

Total biomass at different DAT

Total biomass production: The biomass was recorded two times. At initial stage (seedling stage), total biomass production for all the treatments were almost same but after final harvest it was significantly maximum (119.47g) at T_1 followed byT_2 (93.41g) (Fig. 9). As the value of other morphological parameters of tomato plant was higher in T_1, therefore, total biomass production was also higher.

Biochemical Measurement

Percent moisture and dry matter content of tomato: The moisture content was ranged from 91.50 to 91.82% in all the treatments. The maximum amount of moisture content (91.82%) was measured in $T_{2,}$ whereas, the minimum in T_1 (91.50%).The dry matter content of tomato was calculated from percent moisture contents. The highest dry matter was found in T_1 (8.50%) followed by T_3 (8.25%).

Vitamin C content in tomato fruits: Vitamin C content was varied from 19.28 to 26.26 mg per 100g of tomato in all treatments. Treatment T_1 contained the highest amount (26.26mg) of Vitamin C followed by T_2 (22.67mg) whereas T_3 had the minimum (19.28mg) (Fig. 10). Statistically significant difference was measured in T_1 in compare to other treatments. The above finding was much greater than that of Kalloo (1985) who concluded that tomato contain Vitamin C at the level of 15-20 mg/100g.

Vitamin C content in tomato fruit: The fresh and pesticide free vegetables are not easily accessible for the urban people as well as rural non-producers. This is because vegetable marketing has a long value chain from rural production area to urban retail market. This long distance transportation of vegetable like tomato potentially reduced the Vitamin C content which is one of the important nutrients for human health.

Vitamin C is a great antioxidant and helps protect the body against pollutants. According to WHO, the daily Recommended Dietary Allowance (RDA) of Vitamin C is 45 milligrams per day per person. Therefore, to get required amount of Vitamin C, people need to consume fruits and vegetables as fresh as possible which is possible by bag gardening. After harvesting, Vitamin C of vegetables is being oxidized from its original reduced form with the passing of time. As a result, Vitamin C content of vegetables is decreased upon transportation and storage. Therefore, growing vegetables (e. g, tomato), spices (e. g, chili) and citrus fruits (lemon and orange etc.) in bag gardening specially in urban areas can get more amount of Vitamin C to inhabitants. In addition, they can get fresh vegetables for their daily need which is good quality, and safe (free from pesticides and chemicals) for human health. The nature of bag gardening in terms of tomato production on the rooftop and its higher level of Vitamin content explains the potential of integrated aquaculture-horticulture using unutilized *Pangasius* pond sediments.

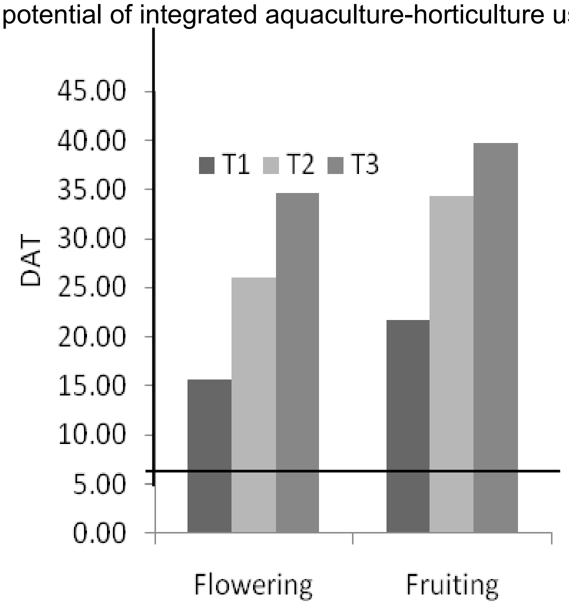

Fig. 3. Onset of flowering and fruiting in tomato plant

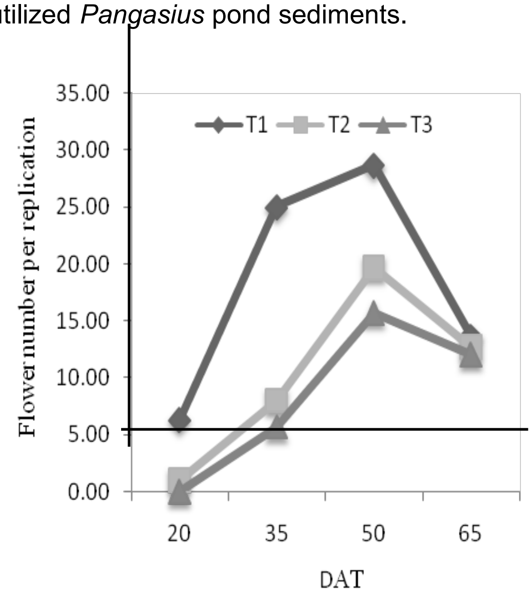

Fig. 4. Flowering pattern in tomato plant in different treatments

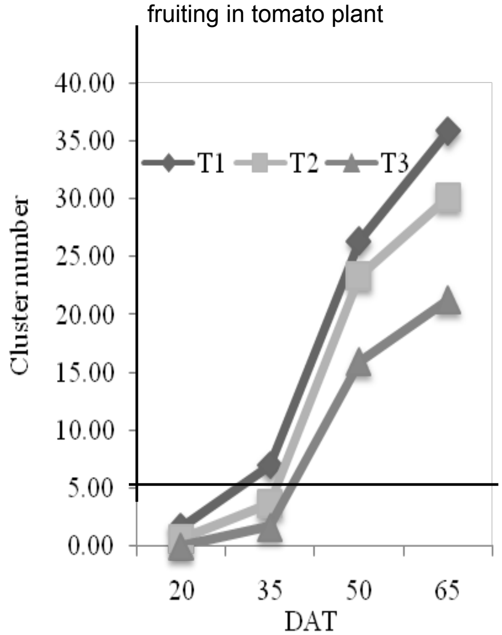

Fig. 5. Number of cluster in different treatments

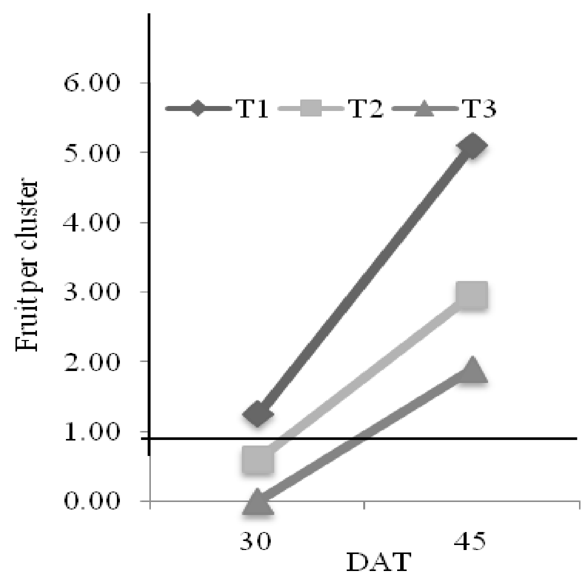

Fig. 6. Number of fruits per cluster in different treatments

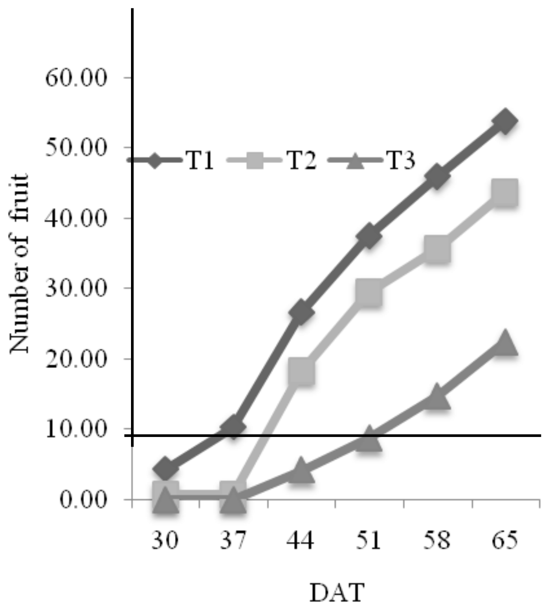

Fig. 7. Number of fruits of tomato plant in different treatments

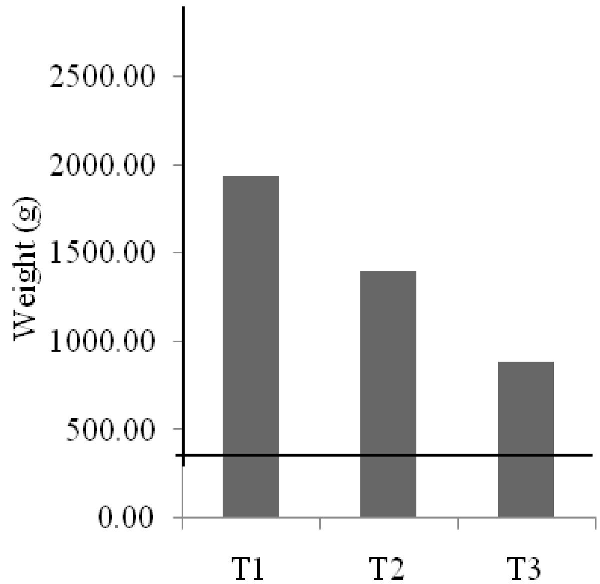

Fig. 8. Total production of tomato in different treatments

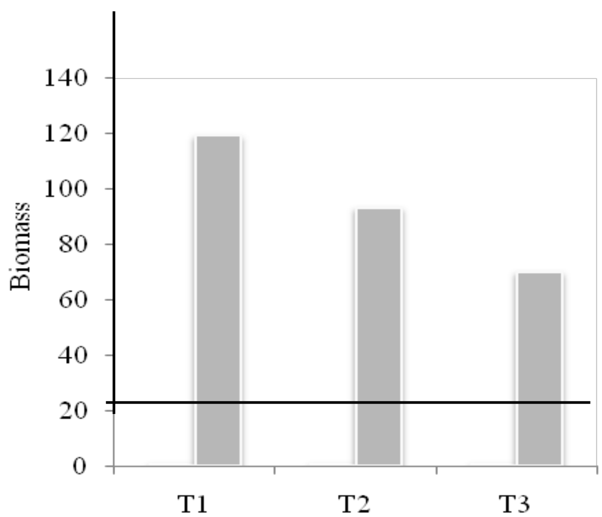

Fig. 9. Measurement of total biomass (g) in different treatments

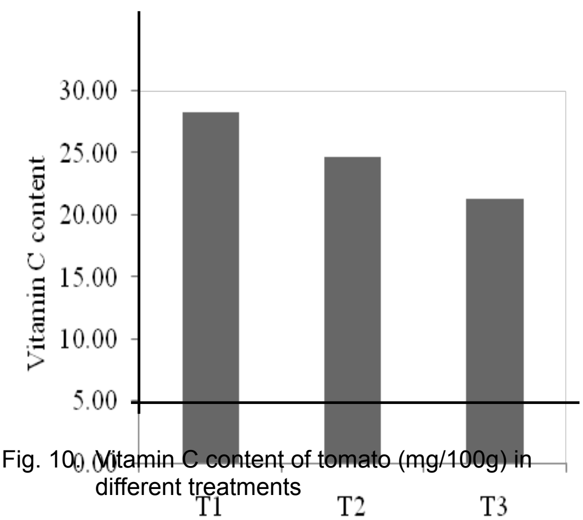

Fig. 10. Vitamin C content of tomato (mg/100g) in different treatments

Conclusion

The NPK were high in *Pangasius* pond sediment. The total nitrogen content of the sediment was 0.30% which was almost similar to the compost manure (0.4-0.5%). The organic carbon content was also very high in PPS sediment. By considering all the characters, it is concluded that treatment T_1 *i. e.,* plants grown at 100% *Pangasius* pond sediment showed the best performance followed by T_2 and T_3. Besides, PPS performed the high potential on vegetables (tomato) production in bag gardening. It was interesting that negligible PPS had the potential to grow vegetables with better production without any manure and chemical fertilizers. Therefore, PPS can reduce the use of chemical fertilizers especially urea and this practice could be environment friendly and cost-effective.

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