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Ramírez-Núñez J
Universidad Autónoma Metropolitana Xochimilco. División de CBS. Maestría en Ecología Aplicada. Depto. El Hombre y su Ambiente. Laboratorio de Producción de Alimento Vivo y Biofloc. Calz. del Hueso No.1100, Col. Villa Quietud. Ciudad de México, Alcaldía de Coyoacán, Mexico

Castro-Mejía G
Universidad Autónoma Metropolitana Xochimilco. División de CBS. Maestría en Ecología Aplicada. Depto. El Hombre y su Ambiente. Laboratorio de Producción de Alimento Vivo y Biofloc. Calz. del Hueso No.1100, Col. Villa Quietud. Ciudad de México, Alcaldía de Coyoacán, Mexico

Castro-Mejía J
Universidad Autónoma Metropolitana Xochimilco. División de CBS. Maestría en Ecología Aplicada. Depto. El Hombre y su Ambiente. Laboratorio de Producción de Alimento Vivo y Biofloc. Calz. del Hueso No.1100, Col. Villa Quietud. Ciudad de México, Alcaldía de Coyoacán, Mexico

Ocampo-Cervantes JA Universidad Autónoma Metropolitana Xochimilco. División de CBS. Maestría en Ecología Aplicada. Depto. El Hombre y su Ambiente. Laboratorio de Producción de Alimento Vivo y Biofloc. Calz. del Hueso No.1100, Col. Villa Quietud. Ciudad de México, Alcaldía de Coyoacán, Mexico

Castro-Castellón AE
Autónoma Metropolitana Xochimilco. División de CBS. Maestría en Ecología Aplicada. Depto. El Hombre y su Ambiente. Laboratorio de Producción de Alimento Vivo y Biofloc. Calz. del Hueso No.1100, Col. Villa Quietud. Ciudad de México, Alcaldía de Coyoacán, Mexico

Corresponding Author:
Ramírez-Núñez J
Autónoma Metropolitana Xochimilco. División de CBS. Maestría en Ecología Aplicada. Depto. El Hombre y su Ambiente. Laboratorio de Producción de Alimento Vivo y Biofloc. Calz. del Hueso No.1100, Col. Villa Quietud. Ciudad de México, Alcaldía de Coyoacán, Mexico

Biofloc excess as raw material for flakes production to ornamental fish and their use as organic fertilizer (Liquid or dry) for plants

Ramírez-Núñez J, Castro-Mejía G, Castro-Mejía J, Ocampo-Cervantes JA and Castro-Castellón AE

Abstract
This research was focused to found and apply to Biofloc excess produced in fish culture. For this, two options were considered: a) Flakes production to feed *Ciprinus carpio* juveniles, and b) Liquid or dry Biofloc to use as fertilizer in *Capsicum annum* plants. To make Biofloc flakes, it was used 80% of Biofloc and 20% of charal flour (DE). Three diets were tested: 1) Only DE, 2) DE with carrot (as pigment source), and 3) Control diet (Wardley® flakes). For chili plants it was tested: liquid Biofloc, dry Biofloc, Triple 17 and only water as fertilizer. The experiments had a duration of 75 and 180 days respectively. With *C. carpio* the highest survival (80%) was found in Control diet, Biofloc diets only obtained between 10-26% of survival. With chili plants, dry Biofloc presented the best results with 11 fruits per plant, while the plants with only water presented only two fruits per plant. In both experiments, variance analysis (ANOVA) showed significant differences ($P<0.05$) between treatments. It is necessary to know the adequate concentration of Biofloc for the elaboration of flakes and use them as a food source for fish. Used as fertilizer, first, liquid Biofloc need to be dry and then applied to as fertilizer.

Keywords: Biofloc excess, ornamental fish, organic fertilizer, plants

Introduction
Considering the exponential growth of human population and their need to satisfy the food source, alimentary production systems were developed for intensive production, without considering their impact on environment. In this case was found aquaculture system, which is an activity that allows us to produce a greater quantity of aquatic organisms of commercial interest in a smaller space, but which also presents several problems, principally, the fact that it generates waste, which is discharged to the environment, and consumes large volumes of water. From 1970 to 1987, aquaculture activity registered a fast-growing innovating new production semi and intensive production systems to culture fish species with high social impact, such as carp and tilapia [1]. But, with these technologies becomes and adjacent problems. The International Union for the Conservation of Nature in 2006 mentioned some inconveniences of traditional aquaculture: a) environmental impact of aquaculture installations, b) effluent discharge with potential pollution to local ecosystem, c) fish liberation of organisms with an ecosystem impact, d) the spread of pathogens to environments and pathogen contact in fish species, e) overexploitation of natural resources, and f) incorrect use of drugs and hormones [2].
In consequence with those problems, alternative production systems have been developed to decrease environmental impact from aquaculture and make optimal use of its productions, such as Biofloc system (BFT). A proposal that was developed in the 70s, which is based in microbial communities that help to minimize or avoid water changes [3]. Later in 1983 Azam F *et al.* [4] studied the role and dynamic that microorganisms have in this aquatic system, proving that bacteria can fix carbon as energy source and also can fix nitrogen to incorporate to protein synthesis, from dissolved organic matter, in an alternative trophic way that was denominated “microbial loop”. This implies a complex microorganism community that, among bacteria, includes fungi, diverse flagellates and ciliates. A consequence of these interactions is nutrient recycling and elimination of toxic metabolites. The application of these processes of natural aquatic environments in aquatic species production systems, started studies to find the

accumulation process of nitrogenous compounds, specially ammonium and nitrites, resulting in bioflocles (Biofloc), which were complex structures suspended in water, constituted by microorganism communities associated between them by a lax fibrous matrix made by compounds synthesized by the same microorganisms, that responds to a dynamic of trophic mesh that begins in heterotrophic capable to fix carbon from organic substances dissolved and particulate in water which can consumed by other microbes [5]. Biofloc is constituted by organic matter (60-70%), which includes a mix of microorganisms like fungi, algae, bacteria, protozoa (nano flagellates and ciliates), rotifers, copepods and nematodes, and inert organic compounds like colloids, organic polymers, cations and dead cells (30-40%) [6, 7].

The use of Biofloc system in aquaculture show grate advantages because decrease water changes and for the non-use of medicines, because it promotes the good health in the system and organisms (probiotics produced by heterotrophic bacteria). This has impacted in aquaculture activity, and researchers like Emerenciano MC *et al.* [8] considered BFT as the base of the new "blue revolution", because the nutrients can be continuously recycled and reused in culture media, while the minimum or no water exchange answers to actual limitations in the availability of this liquid in this activity.

Nevertheless, this system also can generate an environmental pollution if the excess of sedimented bioflocles (sludge) is poured to environment, because it contains a great quantity of excreta and non-consumed food [9], so it is important to make a correct disposal of this residue. Due to its composition, one of the alternatives for the utilization of this residue is like fish food. Therefore, in recent years, bioflocles have surged as an alternative for fish alimentation, for production of proteins, lipids, aminoacids and fatty acids for the aquaculture activity in the form of flour [10]. Since aquaculture effluents are rich in compounds of phosphorus and nitrogen, have been used for hydroponics, or just for the irrigation of vegetables [11]. On the other hand, bioflocles, besides having this advantage, also have other properties desirable in agriculture, such as increasing the organic content in soil and its conditioning, for example, contributing to better aeration and moisture retention [12. 13. 14].Therefore, the aim of this investigation is to find a use for Biofloc excess produced in fish farming, for which two options were considered: a) Elaboration of flakes to feed *Cyprinus carpio* juveniles, and b) as liquid or dry fertilizer in plants of Capsicum annuum.

Materials and Methods

The culture of Cyprinus carpio var. koi, as well as of Capsicum annuum, took place in the Live Food Production and Biofloc Laboratory in the Universidad Autónoma Metropolitana, Unidad Xochimilco.

Cyprians carpio culture

1. Experimental design

Three plastic containers (200 L) were used, with 150 L of water and an aeration system. Temperature was maintained between 23°±2°C. In each tub 30 *Cyprinus carpio* (var. koi) juveniles were placed. Experimental diets were: a) Wardley® flakes (Control diet), b) Biofloc flakes, c) Biofloc flakes + pigment. For diet b and c, it was added 20% of "charal" flour. Also, for diet "c" it was added carrot as pigment source. The quantity of supplied food was 5% of the total biomass per container. As carbon source, it was added coffee once per day (0.1% of the total biomass). Each fifteen days the organisms were extracted to obtain their weight and length to readjust the food and carbon quantities.

2. Obtention of Biofloc flakes

Each week it was extracted and filtrated 30 liters of water of each carp BFT system through a mesh screen of 34 µm. Collected Biofloc was spread in an aluminum tray and placed in an electric grill at 40 °C, taking care not to burn it. The flakes were detached with a spatula and micronized in a blender.

3. Preparation of Biofloc based diets

3.1 Biofloc+charal diet

To 50 g of Biofloc micronized flakes was added with 10 g of "charal" flour and one capsule of Omega 3 (Nature's life ®) which was previously dissolved on hot water. It was homogenized and wetted with water until obtaining a homogeneous mixture of fluid consistency with the aim of a blender.

3.2 Biofloc+charal+pigment diet

It was mixed 50 g of Biofloc flakes with 10 g of "charal" flour, one capsule of Omega 3 (Nature's life ®) and 60 g of carrot previously cooked. It was homogenized and wetted with water until obtaining a homogeneous mixture of fluid consistency with the aim of a blender.

Each mixture of food with Biofloc were placed in an aluminum tray (45 x 65 cm), previously greased with oil spray (PAM®), to prevent it from tray sticking. It was placed a thin layer of food and it was placed in an electric grill at 40°C to avoid burning the flakes, once dry it was detached with a spatula.

4. Carp biometry

The organisms were weighted every 15 days until 75 days, with the aim of a digital balance Nimbus (precision 0.01g). The parameters of standard length, width, high and length of caudal fin were taken with an electronic Vernier brand Taiwanes ® with 0.001 precision.

Capsicum annum culture

1. Experimental design

It was made a small greenhouse (1.80 m height) with rectangular shelves (1.20 x 40 cm), placed every 60 cm high. In the back, it was placed four LED lamps of 1.20 m length. Plants were cultured with a light-darkness photoperiod (12:12) and were covered with plastic to conserve temperature (20-22°C). Seedling of 5 cm was sown in culture vessels (10x65x15 cm) with commercial soil (Vigoro®), in which were seeded 10 plants (for triplicate). Four experimental tests were used: a) Biofloc flakes, b) liquid Biofloc, c) Triple 17 and d) water (as control treatment). Treatments were added every 15 days until the end of experiment (180 days).

2. Seedlings obtention

Chili seeds of Jalapeño variety were used, commonly used and easily acquired (Rancho Los Molinos ®), which were planted in pots at 2 cm deep as indicated by the supplier's specifications. To maintain moisture, daily watering's were applied in order to achieve a homogeneous seedling emergence.

3. Preparation and doses of fertilizer

In the surface of each pot per treatment, it were added the fertilizers every 15 days: a) 0.05 g of commercial granulated fertilizer Triple 17 (Excelso ®), b) 0.4 g of Biofloc flakes, c) 4 mL of liquid Biofloc (4 L filtrated though a mesh screen of 34 µm), d) 25 mL of water.

4. Plant biometry

The total plant length was measured every 15 days for 180 days, with the aim of an electronic Vernier brand Taiwanes ® with 0.001 precision.

Information processing

Both experiments data (carps and Jalapeño chili), weight, length, high, wide, and length caudal fin in carps; and length and number of fruits in Jalapeño chili, were introduced in a data base of Excel 2010 to determine its descriptive statistic and growth tendency curves.

The absolute growth rate (AGR) in both experiments were obtained with the formula:

$$AGR = \frac{\text{biometrical finnal value} - \text{biometrical innitial value}}{\text{culture days}}$$

The Instantaneous growth rate (IGR) in both experiments were obtained with the formula:

$$IGR = \frac{NL(\text{biometrical finnal value}) - NL(\text{biometrical in nitial value})}{\text{culture days}} \text{ x } 100$$

Where:
NL= Natural Logarithmic

The gain values (GV) in both experiments were obtained with the formula:

$$GV = \text{biometrical finnal value} - \text{biometrical innitial value}$$

Statistical analysis

One-way ANOVA test was made to determine significant differences (*P*<0.05) between treatments. When presenting differences, a comparison test of multiple means was made by Tukey technique.

Results

Cyprinus carpio var. koi

1. Survival

Highest survival was found in Control diet (Wardley) with 80% until 75 culture days. Only Biofloc flakes diet obtained 10%, and Biofloc+pigment with 26%.

2. Standard length

Mean values are presented in Table 1, while the growth tendency curves are presented in Figure 1.

The ANOVA test showed that organisms fed with Biofloc flakes and Wardley did not show significant differences (P=0.314) in this variable. Highest gain of length was obtained with Biofloc+Pigment and Wardley diets (3.741 and 3.737 mm respectively), fish fed with Biofloc flake obtained a gain of 2.252 mm. Organisms with Biofloc+Pigment and Wardley diets presented equal values of AGR (0.050 mm day^{-1}) and IGR (0.121% mm of daily increase). The AGR and IGR of the organisms with Biofloc diet was of 0.030 cm day^{-1} and 0.076% cm of daily increase respectively.

Table 1: Mean values (±S.D.) of fish standard length (mm) in the three experimental diets.

Sampling	Experimental diets		
	Biofloc flakes	Biofloc flakes+Pigment	Wardley
0	38.589	39.459	39.459
	±3.352	±4.704	±4.409
15	38.721	39.835	39.683
	±3.899	±4.052	±4.052
30	40.088	40.805	41.223
	±4.370	±5.167	±5.167
45	40.420	41.223	42.312
	±1.499	±3.507	±3.632
60	40.515	42.963	43.170
	±2.108	±2.793	±3.810
75	40.840^a	43.200	43.196^a
	±1.128	±1.994	±3.598

Note: Same letter per line, does not present significant differences (*P*<0.05).

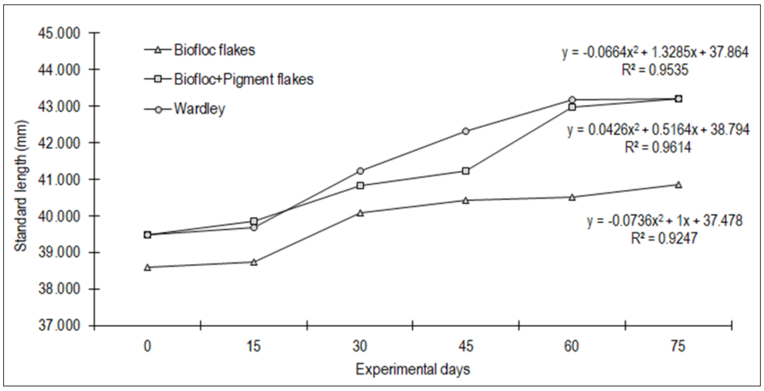

Fig 1: Growth tendency curves of standard length of organisms in the three experimental diets

3. Width

Mean values are presented in Table 2, while the growth tendency curves are presented in Figure 2.

The ANDEVA showed that organisms fed with flakes of Biofloc+Pigment and Wardley did not presented significative differences (P=0.786) in its width. Highest gain of width was obtained with Biofloc+Pigment diet with 1.382 mm. Biofloc diet obtained a gain with 0.994 mm and Wardley obtained 1.320. Biofloc+Pigment and Wardley diets presented equal values in AGR (0.018 mm day^{-1}), while with Biofloc diet was of 0.013 mm day^{1}. Highest percentage of IGR was for Biofloc+Pigment diet with 0.225% of daily increase, while for Biofloc and Wardley diets was of 0.184% and 0.215% of daily increase respectively.

Table 2: Mean values (±S.D.) of fish width (mm) in the three experimental diets

Sampling	Experimental diets		
	Biofloc flakes	Biofloc flakes+Pigment	Wardley
0	6.700	7.528	7.528
	±0.729	±0.765	±1.514
15	6.985	7.725	8.443
	±0.865	±0.945	±0.945
30	7.147	7.840	8.645
	±0.949	±0.914	±0.914
45	7.323	7.974	8.659
	±0.560	±0.712	±1.257
60	7.440	8.443	8.802
	±0.561	±0.738	±1.208
75	7.694	8.910^{a}	8.848^{a}
	±0.165	±1.612	±1.352

Note: Same letter per line, does not present significant differences (*P*<0.05).

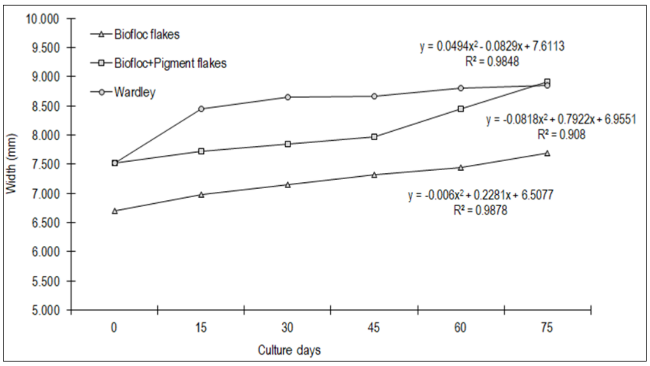

Fig 2: Growth tendency curves of width of organisms in the three experimental diets

4. High

Means values were shown in Table 3. Also, their growth tendency curve (Fig.3).

ANOVA test shown that fishes fed with all experimental diets showed significant differences between them (*P*<0.001). The highest gain values were obtained with Wardley diet with 3.235 mm, Biofloc flakes with 1.567 mm, and Biofloc+Pigment flakes with 2.538 mm. TCA values were 0.043 mm day^{-1} for Wardley diet, 0.021 mm day^{-1} for Biofloc flakes, and 0.034 mm day^{-1} for Biofloc+pigment. TCI values were 0.312% mm for Wardley diet, 0.251% mm for Biofloc+pigment, and Biofloc flakes with 0.174% mm of high increasing.

Table 3: Mean values (±S.D.) of fishes' high (mm) at three experimental diets.

Tim	Experimental diets		
	Biofloc flakes	Biofloc+Pigment flakes	Wardley
0	11.270	12.272	12.272
	±1.160	±1.677	±1.911
15	12.153	13.486	13.486
	±1.447	±2.142	±2.142
30	12.204	13.516	13.978
	±1.332	±1.706	±1.706
45	12.717	13.565	14.535
	±0.820	±1.348	±1.557
60	12.833	13.715	14.977
	±0.621	±1.412	±1.953
75	12.837	14.810	15.507
	±0.216	±2.418	±1.952

Note: Same letter per line, does not present significant differences (*P*<0.05).

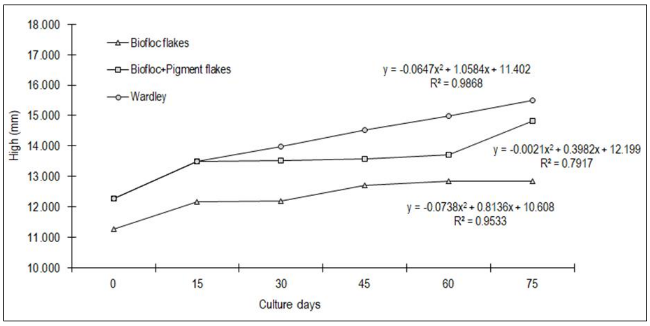

Fig 3: Growth tendency curves of fishes' high in the three experimental diets.

5. Weight

The mean values of juvenile fishes' weight were shown in Table 4. Also, their grow tendency curve (Fig. 4).

ANOVA test show that fishes fed with Biofloc flakes, and Biofloc+Pigment flakes did not show significant differences between them (P=0.768). Better weight gain was for Wardley diet with 0.707 g, with a TCA of 0.003 g day^{-1}, and TCI of 0.378% g day^{-1}. For Biofloc+ Pigment flakes diet, it obtained a gain of 0.398 g, TCA value of 0.005 g day^{-1}, and TCI value of 0.260% g day^{-1}. The lowest gain was for Biofloc flakes diet with 0.221 g, a TCA values of 0.009 g day^{-1}, and TCI value of 0.161% g day^{-1}.

Table 4: Mean values (±S.D.) of fishes' weight (g) with three experimental diets.

Tim.	Experimental diets		
	Biofloc flakes	Biofloc+Pigment flakes	Wardley
0	1.719	1.850	2.155
	±0.523	±0.506	±0.573
15	1.734	1.859	2.175
	±0.557	±0.564	±0.569
30	1.750	1.957	2.405
	±0.429	±0.510	±0.708
45	1.801	2.037	2.736
	±0.406	±0.478	±0.699
60	1.909	2.101	2.812
	±0.407	±0.628	±0.734
75	1.940^{a}	2.248^{a}	2.862
	±0.445	±0.452	±0.785

Note: Same letters in a row did not shown significant differences (*P*<0.05).

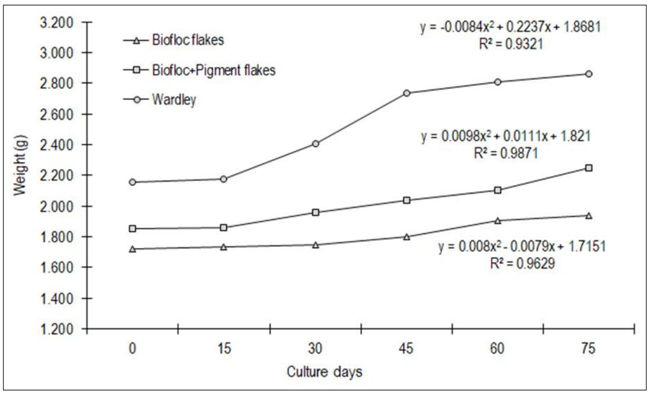

Fig 4: Grow tendency curve of fishes' weight with three experimental diets.

6. Caudal fin length

Mean values were shown in Table 5. Also, the grow tendency curve (Fig. 5).

ANOVA test shown that fishes fed with Biofloc flakes and Biofloc+Pigment flakes did not show significant differences (P=0.664). Highest gain of caudal fin length was with Biofloc+Pigment flakes with 4.745 mm, followed Wardley diet with 4.422 mm, and Biofloc flakes (lowest value) with 2.318 mm. TCA values were 0.063, 0.059, 0.031 mm day^{-1} respectively. TCI values were 0.431%, 0.328%, 0.188% mm day^{-1}

Table 5: Mean values (±S.D.) of caudal fin length of fishes with three experimental diets.

Sampling	Experimental diets		
	Biofloc flakes	Biofloc+Pigment flakes	Wardley
0	15.277	12.430	15.851
	±2.583	±3.681	±3.967
15	16.340	15.851	16.890
	±2.828	±4.811	±4.811
30	16.790	15.973	17.175
	±2.348	±3.520	±3.520
45	16.910	16.660	19.913
	±2.788	±3.126	±5.519
60	17.103	17.052	19.972
	±2.671	±4.505	±4.723
75	17.595^a	17.175^a	20.273
	±2.716	±1.315	±6.179

Note: Same letter per line, does not present significant differences (*P*<0.05).

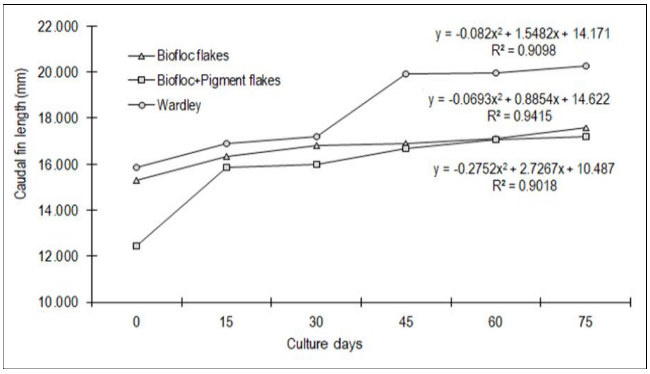

Fig 5: Grow tendency curve of caudal fin length of fishes with three experimental diets.

Capsicum annuum

1. Total length

Mean values of total length were shown in Table 6. Also, grow tendency curve in Fig. 6.

Plants with highest length were those fertilizer with dry Biofloc flakes with a mean value of 34.610 ±1.459 cm. Lowest value was found in plants with only water as fertilizer with 27.480 ±1.513 cm. The ANOVA test show significant differences (*P*<0.05), but when Tukey test was made, the differences was found between plants length fertilized with liquid Biofloc and only water (P=0.938). The highest gain of length was found with dry Biofloc flakes with 27.900 cm, followed by chemical fertilizer (Triple 17) with 25.780 cm. Plants fertilized with liquid Biofloc and only water obtained gain values of 21.730 cm and 20.00 cm respectively. TCA values were 0.155, 0.143, 0.121, y 0.111 cm day^{-1} and TCI values were 0.911%, 0.815%, 0.811%, 0.723%. of daily increasing (Dry Biofloc flakes, Chemical fertilizer Triple 17, Liquid Biofloc, and Only Water respectively).

Table 6: Mean values (±S.D.) of total length from plant of C. annuum with four experimental fertilizers.

Sampling	Experimental fertilizers			
	Dry Biofloc flakes	Liquid Biofloc	Chemical fertilizer (Triple 17)	Only water
0	6.710	6.580	7.720	7.480
	±0.441	±0.270	±0.169	±0.316
15	8.830	7.980	9.660	8.110
	±0.371	±0.326	±0.250	±0.446
30	11.750	9.050	9.960	9.010
	±0.502	±0.363	±0.250	±0.504
45	14.360	9.970	11.790	10.070
	±1.223	±0.350	±0.742	±0.718
60	16.500	11.990	13.880	11.830
	±0.677	±0.498	±0.352	±0.655
75	19.810	13.690	16.290	13.490
	±0.810	±0.563	±0.420	±0.746
90	22.560	15.460	18.220	14.970
	±0.958	±0.652	±0.501	±0.843
105	26.190	17.950	20.770	16.910
	±1.114	±0.723	±0.546	±0.907
120	29.310	20.650	23.970	19.270
	±1.244	±0.842	±0.634	±1.068
135	31.380	23.340	26.850	21.600
	±1.336	±0.978	±0.670	±1.192
150	32.940	25.440	29.560	23.550
	±1.397	±1.043	±0.788	±1.310

165	33.940	27.220	31.910	25.440
	±1.430	±1.116	±0.832	±1.405
180	34.610	28.310[a]	33.500	27.480[a]
	±1.459	±1.133	±0.852	±1.513

Note: Same letters in a row did not shown significant differences (P<0.05).

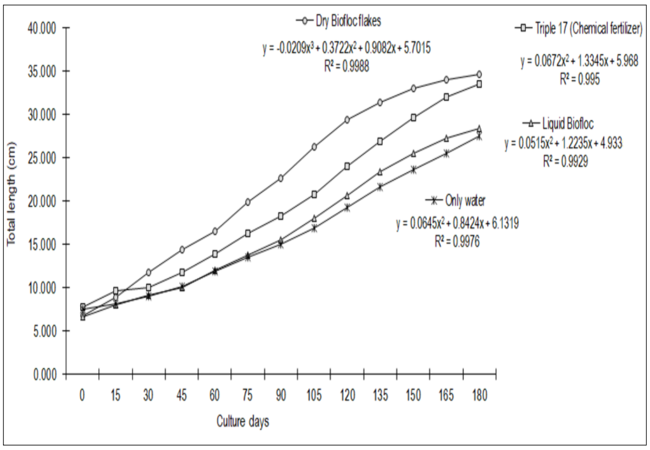

Fig 6: Grow tendency curves of total length of plants of *C. annuum* with four experimental fertilizers.

2. Number of fruits (chili)

Table 7 shown de mean values of number of fruits per plant produced.

Plants which show highest number of lowers per plant were those fertilized with Dry Biofloc flakes. From each flower was obtained a fruit (Chili). The lowest number of flowers was in plants fertilized with only water. Fruits (Chilis) with highest length were those fertilized with Liquid Biofloc and Only water. Highest wide values were obtained in plants fertilized with Dry Biofloc flakes and Liquid Biofloc. Highest weight values were obtained in plants fertilized with Dry Biofloc flakes, and lowest values in plants with Triple 17 and only water. The ANOVA test shown in all cases significant differences (P>0.05), between fertilizers, but with Tukey test (multiple mean comparison), only did not shown differences (P=0.938) with respect total length Liquid Biofloc and only water; with respect fruit (chili) wide, plants fertilizer with Triple 17 and only water (P=0.356), Liquid Biofloc and Dry Biofloc flakes with P=0.998. With respect fruit (chili) weight, plants fertilized with only water and Triple 17 did not show significant differences (P=0.123).

Table 7: Mean value of number of fruits (chili) of C. annuum produced by each plant with different experimental fertilizers.

Variable	Experimental fertilizers			
	Dry Biofloc flakes	**Liquid Biofloc**	**Triple 17(Chemical fertilizer)**	**Only water**
Number of flowers per plant	11	9	4	2
Fruits per plant	11	9	4	2
Total length of fruits (chili)	5.10	5.80[a]	4.50	5.50[a]
	±0.25	±0.53	±0.45	±0.54
Wide of fruit (chili)	7.40[a]	7.10[a]	5.50[b]	5.00[b]
	±1.17	±1.18	±1.19	±1.17
Weight of fruit (chili)	8.60	8.20	5.40[a]	5.20[a]
	±1.13	±1.17	±1.18	±1.19

Note: Same letters in a row did not show significant differences *(P*<0.05).

Discussion

Biofloc system is an important producer of organic matter, and the correct management of that sediment excess is important to not make it an environmental pollutant causing eutrophication of soil and water nearest those aquaculture farms that use this Biofloc system to produce shrimps or fishes. That's why is important to employ this excess of organic matter as component of inert diets (pellets) or use it as fertilizer.

It should be noted that there are no researches where dry Biofloc or moist is used as food for ornamental fish. Nevertheless, there are researches that used Biofloc moist or dry for shrimp and tilapia culture. Some authors [15] used in their experiment for twelve days dry Biofloc at different concentrations (25%, 50%, 75% and 100%) as substitute of culture diet of shrimp postlarvae. These authors found that treatment with 50% of dry Biofloc improved the survival of 95.4 ± 0.6%, and a growth rate of 17.5 ± 0.01%. The results with lowest survival was with 100% Biofloc treatment with 37.7 ± 0.4%, and growth rate of 10.3 ± 0.05%. Which contrasts with the diets made in this experiment, which was elaborated with 83.3% for Biofloc diet and 41.66% for Biofloc+pigment diet, these diets had low survival, 26% for Biofloc+pigment and 10% for Biofloc diet, while. In contrast with Control group (Wardley) with 80% survival. Also, other authors [16] obtained an increase of survival in *Litopenaeus vannamei* culture in Biofloc, having a survival of 90% during the first three months of experimental period.

In this experiment it was observed low acceptance of food, this can be due to Biofloc palatability. This agrees with other authors [17], because they mentioned that taste can be affected when there are high microbial products that make food less palatable and digestible. Another author [18] also worked with dry Biofloc as substitute of fish flour for the culture of shrimp, with percentages of 10%, 15%, 21% and 30%. They find no significant differences with survival between all treatments, nevertheless, a faster growth was obtained compared to control group. With respect this research with *C. carpio*, organisms do not accept the Biofloc flakes, but these findings are not significant to eliminate the use of Biofloc flakes in these fishes. Some authors [19] which cultured *C. carpio* during six months in a Biofloc system with different carbon sources, having favorable results in weight gain of the organisms, when Moringa was used as carbon source. These authors obtained a weight gain of 907 g. These results were different with our findings, because the weight gain were only 0.398 g and 0.221 g with Biofloc+Pigment and Biofloc diet respectively. Not only carps have given positive results, *Puntius conchonius* cultured in Biofloc system [20] obtained higher final weight of 2.45 g, length of 5.27 cm and high of

1.35 cm cultured in Biofloc system. Low palatability of Biofloc flakes cannot be attributed to their protein content, because authors like Becerril *et al*. [21] determined a mean value of 30.28 ± 5.33% of protein in Biofloc flakes with different carbon sources and using coffee source as Control group. However, it is necessary to make other replacement Biofloc flour concentration researches to find the optimal concentration to use it in ornamental fishes.

Another alternative proposed in this investigation was to use excess of Biofloc as dry and wet fertilizer in the culture of *Capsicum annum* L. Biofloc can be applied as fertilizer, because of the nature of the system, fish feces and non-consumed food are converted in nitrite and other beneficial nutrients which can be absorbed by fruits and vegetables, so it can be used as natural fertilizer [22]. Nevertheless, there are few works where Biofloc excess is used as fertilizer.

There are studies with chili peppers growing in aquaponics systems. These systems use the nutrients in water produced by fish culture to plants fertilizer. Some authors [23] compared *C. annum* cultured in ground and in aquaponic system. Plants sowing in ground obtained plants with 70 cm length unlike those sowing in aquaponic which only reach 11 cm length. In this experiment, higher length values were obtained in plants sowing in ground fertilized with Biofloc flakes with 34.610 ±1.459 cm unlike those fertilized with only water (27.480 ±1.513 cm). Other authors [24] compared the culture of chili with organic fertilizer (plants with 7.25 cm length) against those fertilized with chemical fertilizer (6.37 cm length). The width length of chili was 3 cm with chemical fertilizer and with organic fertilizer was 2.38 cm. Similarly, higher values were obtained in this experiment using dry and liquid Biofloc with 5.10 and 5.8 cm respectively. Regarding to chili width, the highest values were presented in dry and liquid Biofloc with 7.40 and 7.10 cm respectively.

World Fertilizer use Manual [25] specifies that principally nutrients for plants growth were nitrogen, phosphorus, and potassium. Some authors [26] mentioned that principally problem of chemical fertilizer use (NPK), tend to leach and volatized their nitrogen compounds. Another authors [21] reported in Biofloc with coffee as carbon source a concentration of potassium (K) of 7.33 ± 1.53 mEq L^{-1}. Other authors [27] mentioned that phosphorus excretion in a tilapia culture can be of 84%. Therefore, it can be assured that Biofloc as fertilizer has the main compounds for plant growth.

In this experiment, the plants that had Biofloc obtained a higher quantity of fruits with respect chemical and only water treatments. Some authors [28] mentioned that organic cultures move mineralized compounds that are requires for plants and fruits, therefore there is a higher quantity of fruits. On the other hand, plant growth and higher production of fruits can be explained due to presence of degrading bacteria that solubilize compounds and this can be absorbed by the plant. Some authors [29] identified bacteria genus in Biofloc system, such as *Sphingomonas*, *Pseudomonas*, *Nitrospira sp.*, *Nitrobacter sp*. and *Bacillus sp.* From which *Nitrospira sp.* and *Nitrobacter sp*. are nitrogen solubilizers. Other authors [30] mentioned that *Pseudomonas* sp. and *Bacillus* sp. have different properties as phosphate solubilizers, allowing a better use for plants.

Conclusions

Due to the obtained results in this investigation, it is necessary to continue the investigations to determine the percentage of dry Biofloc incorporated to diets for acceptance for ornamental fish. Regarding to Biofloc as fertilizer, it showed positive results as an alternative of fertilizer and for a use of Biofloc excess, it is proposed to continue researching in sowing in plot cultivation or with another variety of plant.

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