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Effect of fertilization with *Tithonia diversifolia* (HEMSL.) on zooplanctonic productivity and zootechnical performance of fingerlings of *Oreochromis niloticus* (Linneaus, 1758)

Nana Towa Algrient[1*], Efole Ewoukem Thomas[2], Kpoumie Nsangou Amidou[3], Tiogue Claudine[4], Tonfack Achille Peguy[5], Kenfack Donhachi Aimérance[6], Pouomogne Victor[7], Tchoumboue[8]

[1, 3, 4, 5, 6, 8] Department of Animal production, University of Dschang, Cameroon
[2] Department of Forestry, University of Dschang, Cameroon
[7] Institute of Agricultural Research for Development, Foumban, Cameroon

Abstract
The effect of fertilization with *Tithonia diversifolia* on the productivity of zooplankton and the growth performance of fingerlings of *Oreochromis niloticus* were investigated between May and October 2014 at the IRAD of Foumban in order to contribute to the improvement of the production of the fishes.
A total of 513 fingerlings with an average weight of 8.89 ± 0.91 g, were randomly distributed into six ponds of 85 m^2 previously equipped with compost crib occupying 5% of the surface area. Each randomly selected pond was administered weekly doses (3,75kg; 5kg and 6, 25 kg/are) of *T. diversifolia* previously chopped. At the end of the study, the highest biomass of zooplankton were obtained with the highest dose (6,25kg/are). But the growth performances of *O. niloticus* and its productivity were significantly higher with the dose of 5kg/are.
The dose of 5kg/are of *Tithonia* proved most convincing to improve the production of *Oreochromis niloticus*.

Keywords: *Oreochromis niloticus, Tithonia diversifolia,* zooplankton, zoo technical performances

Introduction
In the semi-intensive fish farming system, ponds fertilization to improve fish productivity is a common practice. Fertilization of ponds allows the production of zooplankton which appears as a reliable alternative for the feeding of larvae and fingerlings. Zooplankton is often used as a supplement dietary in semi-intensive systems at the time of pre-growing or growing fish (Bonou, 1990) [6]. In livelihoods, using live prey or zooplankton is already widespread in many Asian (Fokusho *et al.*, 1976; Kureha *et al.*, 1977) [14], Europeans (Barnabe, 1991; Awaïss & Kestemont, 1992) [3] and Americans countries (Herbert, 1995) [12]. But there is little development in African countries. In spite of the studies carried out in the laboratory, knowledge on the production of zooplankton by simple ponds fertilization through local available inputs remains unsatisfactory. However, several extension services and programs promote compost crib for fertilization (Kestemont *et al.*, 1995; Bogne *et al.*, 2013) [5].
Thus various weeds were used for the fertilization of fish ponds, *Pennisetum purpureum* and *Musa sapientum* (Nsangou *et al.*, 2014) [18], *Tithonia diversifolia* and *Chromolaena odorata* (Pouomogne *et al.*, 2005) [23]. Among these weeds, *Tithonia diversifolia* was assume most effective in improving the yield of the fish production. However, in the peasant environment, high mortalities (about 80%) of *Oreochromis niloticus* (Nile tilapia) have been reported by fish farmers after using *Tithonia diversifolia* without a precise dose in their compost crib (Pouomogne, 2002) [21]. On the other hand, 86% survival rate for the same species in the Central region of Cameroon was reported with the same weed used at 5kg / are (Pouomogne *et al.*, 2005) [23]. The improvement of the zootechnical performance of *Oreochromis niloticus*, particularly at the pre-growth stage, crucial phase for the success of its breeding through the control of optimal doses of *Tithonia diversifolia* is essential.
The aim of this work is to contribute to the improvement of the production of *Oreochromis niloticus* through the improvement of zooplankton productivity. Specifically to evaluate the effect of doses of *Tithonia diversifolia* on the Physico-chemical characteristics of water, zooplankton density and biomass and some zootechnical performances of *Oreochromis* fingerlings.

Material and methods
Period and area of study
The study took place from May 14 to October 26, 2014 at IRAD of Foumban, More precisely at the fish station of Koupa-Matapit (LN: 5º 21 'to 5º 58' and LE: 10º 17 'to 11º 02'). The average altitude is 1145 m. The climate is Sudano-Guinean and includes one rainy season (March - October) and one dry season (November - February). The annual average temperature and rainfall are 22º C and 1800mm respectively.

Animal material and the conduct of the test
Five hundred and thirteen (513) fingerlings of *Oreochromis niloticus* reproduced at the Koupa Matapit fish station with an average weight of 8.89 ± 0.91 g, total length 8.5 ± 0.8 cm, were used.

Compost crib was built on the sunniest side in 6 ponds with an area of 5% of the total area surface of the pond. The water supply was made from a holding lake, "Andrey" Lake, using an earth supply channel. The leaves of *Tithonia diversifolia* in the run-up phase were cut, then chopped into pieces of about 10 cm, and weighed with a mechanical scale (BUFALO brand) with a precision of 0,5kg. Each of the three doses of *Tithonia diversifolia* (D1 = 3.75kg / are, D2 = 5kg / are, and D3 = 6.25kg / are) was distributed in duplicate in 6 ponds of 85m^2 randomly and weekly.

One week after the first fertilization with *Tithonia diversifolia*, the fingerlings of *Oreochromis niloticus* (previously weighed and measured) were stocked at 1 individual / m² in all ponds. The compost was returned every week to facilitate the solubility of minerals. The physico-chemical parameters of water such as dissolved oxygen, pH, conductivity and temperature were measured directly "*in situ*" weekly, while the nutrient salts (NH_4^+, NO_2^-, NO_3^-, and $PO43^-$) were analyzed at the Laboratory of Ichthyology and Applied Hydrobiology (LABIHA) of the University of Dschang. The samples were stored in 250 ml double-capped polyethylene bottles at 4ºC.

The collection of zooplankton was carried out weekly between 6.30 - 8 am with plankton net (40µm of diameter). Identification were made using a binocular magnifying glass microscope (type MOTIC,) using keys (Pourriot *et al.*, 1982) [24], followed by their counting. The density of zooplankton was determined by formula give by Agadjihouedé *et al.* (2010);

$$D = \frac{n}{v1} \times \frac{v2}{v3} \quad (1)$$

With D = density, n = number of individuals counted, V1 = volume (ml) of the collected filtrate, v2 = volume (ml) of the concentrated filtrate, v3 = volume (ml) of filtered water.

The zooplankton biomass expressed as dry weight (PS) (µg PS / l) was estimated from the density and individual weight of the species of zooplankton obtained from the literature as follow:

$$B = D \times P \quad (2)$$

With; B = biomass, D = density (individual / liter) and P = weight (µg PS). The individual weight provided by the literature is 0.19 µg PS for *Brachionus calyciflorus* (Legendre *et al.*, 1987) [15]; 3.5 / 2.7 / 0.2 µg PS respectively for adult females, juveniles and neonates of *Moina micrura* (Sipaúba-Tavares & Bachion, 2002) [26]; 0.08 / 1.36 µg PS for the naupliiand adults of Thermocyclops sp. (Legendre *et al.*, 1987) [15].

A biometric check was carried out monthly on 10% of the fish population of each pond taken by a beach seine. At the end of the test (3 months) each pond was completely dry of its water and all the fish were harvested, Measured (total length and standard length) using an ichthyometer and weighed individually with electronic scale (Mettler Toledo) to determine zootechnical performance.

Statistical analysis

The data were submitted to the one-way analysis of variance (ANOVA 1), when the treatment effects were significant, The Duncan test was used to separate the means at 5% threshold. All analyzes were performed using the SPSS software version 20. 0. The Pearson correlation test was used to establish relationships between different parameters.

Results

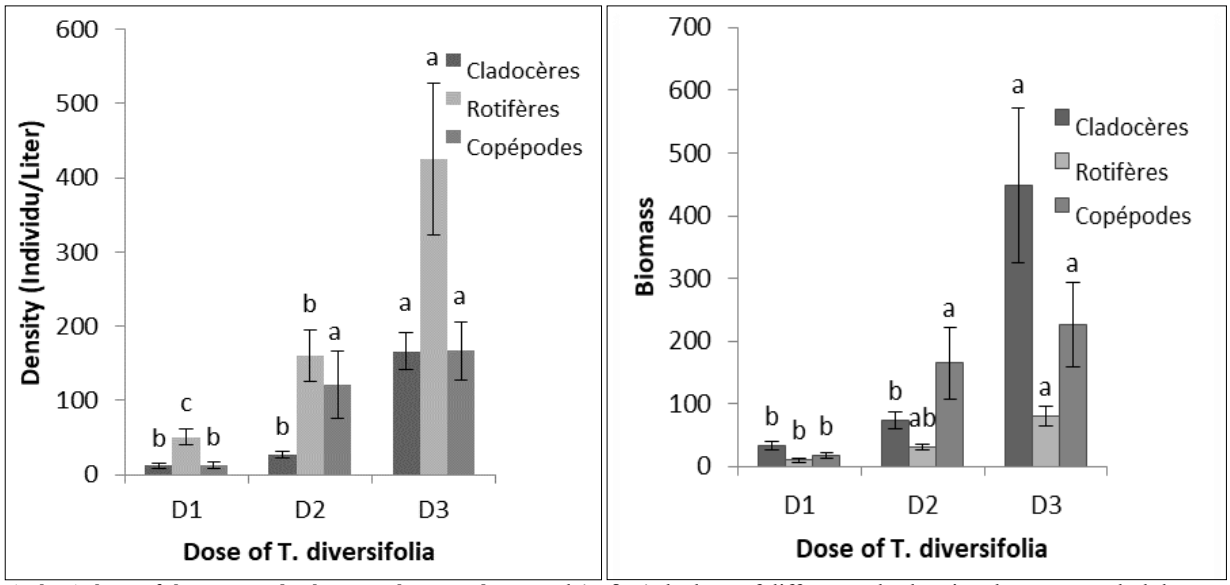
The physico-chemical characteristics according to the doses of *Tithonia diversifolia* summarized in Table 1, shows that except the pH and ammoniacal nitrogen in doses D2 and D3 no significant differences were observed.

Table 1: Average physico-chemical characteristics of water by doses of *Tithonia diversifolia*

Physico-chemical Parameter	Doses of *Tithonia diversifolia* (kg/are)		
	D1	D2	D3
Température (ºc)	25,75 ± 0,89^a	25,50 ± 0,52^a	26,01 ± 0,75^a
Dissolved Oxygen (mg /l)	6,60 ± 1,32^a	6,56 ± 1,42^a	6,28 ± 1,44^a
pH (UC)	7,81 ± 0,52^{ab}	7,94 ± 0,51^a	7,46 ± 0,27^b
Conductivity (µs/cm)	16,00 ± 6,99^a	16,00 ± 5,16^a	19,00 ± 5,68^a
Transparency (cm)	60,40 ± 0,03^a	60,70 ± 0,06 ^{a}	60,35 ±0, 01^a
NH_4^+ (mg/l)	0,32 ± 0,05^b	0,30 ± 0,06^b	0,43 ± 0,05^a
NO_2^- (mg/l)	1,23 ± 0,28^a	1,15 ±0,34^a	1,08 ± 0,33^a
NO_3^-(mg/l)	0,27 ± 0,08^a	0,26 ± 0,04^a	0,32 ± 0,05^a
PO_4^{3-}(mg/l)	0,01 ± 0,00^a	0,02 ± 0,01^a	0,02 ± 0,01^a
N total (mg/l)	1,82 ± 0,93^a	1,71 ± 0,44^a	1,83 ±0,43^a

(a, b); The values of the lines bearing the same letters are not significantly different (P> 0.05).
D1 = 3.75 kg, D2 = 5 kg, D3 = 6.25 kg / are of *Tithonia diversifolia*

The density and biomass of zooplankton base of the dose of *Tithonia diversifolia* illustrated in fig 1, shows that, regardless of the zooplankton group considered, the density and the biomass were significantly high (p <0.05) with the D3 dose. Thus, the rotifer density was significantly high (p <0.05) independently of the dose. On the other hand, the copepod biomass was higher with the D3 dose.



(a, b, c); bars of the same color bearing the same letter and (α, β, γ) the bars of different color bearing the same symbol do not differ significantly (P > 0.05). D1 = 3.75kg / are, D2 = 5kg / are, D3 = 6.25kg / are of *Tithonia diversifolia*

Fig 1: Density and biomass of zooplankton according to doses of *Tithonia diversifolia*

Correlation between physico-chemical characteristics of water and zooplankton shown in Table 2, reveals that the biomass of the zooplankton of the D1 dose and the density and biomass of the zooplankton of the D2 dose were significantly and negatively correlated (p <0.01) to the conductivity of the water. Thus the zooplankton density of the D2 dose was significantly and negatively correlated (p <0.05) to the nitrate concentration of the water.

Table 2: Correlations between zooplankton and physicochemical characteristics of water.

Doses	Characteristics of zooplankton	physicochemical Characteristic							
		NH_4^+	NO_2^-	NO_3^-	PO_4^{3-}	T°c	O_2	pH	Conductivity
D1	Biomass	0,41	0,27	-0,47	0,71*	-0,19	0,44	0,28	-0,80**
	Density	0,09	-0,11	-0,32	0,51	0,27	0,58	0,36	-0,37
D2	Density	0,38	-0,14	-0,73*	0,51	-0,60	0,40	-0,10	-0,76**
	Biomass	0,13	-0,14	-0,55	0,39	-0,42	0,44	-0,25	-0,78**
D3	Density	-0,19	-0,07	0,18	-0,31	-0,09	-0,01	0,46	-0,09
	Biomass	-0,34	0,15	0,22	-0,25	0,01	0,05	0,43	0,05

** The correlation is significant (P <0.01); * The correlation is significant (P <0.05).

NH_4^+, NO_2^-, NO_3^-, PO_4^{3-}, O_2 (in mg/l) Conductivity (µS)

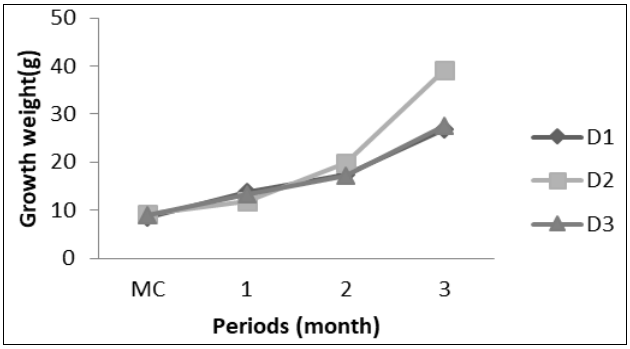
Zootechnical performances of *O. niloticus* according to dose of *Tithonia diversifolia* summarized in Table 3, reveals that, with the exception of the survival rate and the condition factor k, all Zootechnical performances of the fingerlings were significantly high (P <0.05) with the D2 dose.

Table 3: Zootechnical performances of O. *niloticus* according to dose of *Tithonia diversifolia*

Animal performance.	Doses of *Tithonia diversifolia*		
	D1	D2	D3
Survival(%)	73,00 ± 8,48[a]	75,50 ± 12,02[a]	69,00 ± 19,79[a]
final weight (g)	26,85 ± 8,39[b]	39,22± 8,39[a]	27,49 ± 6,99[b]
final total length (g)	11,10 ± 1,16[b]	12,78 ± 0,93[a]	11,19 ± 0,99[b]
final standard length (g)	9,08 ± 0,87[b]	10,33 ± 0,75[a]	9,16 ± 0,83[b]
weight growth (g)	18,26 ± 7,86[b]	30,03 ± 8,46[a]	18,61 ± 7,09[b]
Daily growth (g)	0,20 ± 0,09[b]	0,33 ± 0,09[a]	0,20 ± 0,08[b]
Rate of specific growth (%/j)	0,86 ± 0,23[b]	1,19 ± 0,27[a]	0,87 ± 0,26[b]
condition factor K	1,92 ± 0,15[a]	1,86 ± 0,08[a]	1,94 ± 0,16[a]

(a, b); the values of the lines bearing the same letters are not significantly different (P> 0.05

It appears from the monthly evolution of the weight gain of *O. niloticus* base to dose of *Tithonia diversifolia* illustrated in fig 2, that the rate of change in weight gain was comparable between dose D1 and D3 (P <0.05). However, at the end of the trial, the significantly increased weight gain (P <0.05) was obtained with the dose D2.



MC = stocking

Fig 2: Monthly evolution of the mean weight gain of *O.niloticus* fingerlings according to dose of *Tithonia diversifolia*.

The monthly evolution of the condition coefficient K according to dose of *Tithonia diversifolia* illustrated in fig (3) shows that, the condition coefficient K evolved in the opposite direction with the doses D1 and D2.

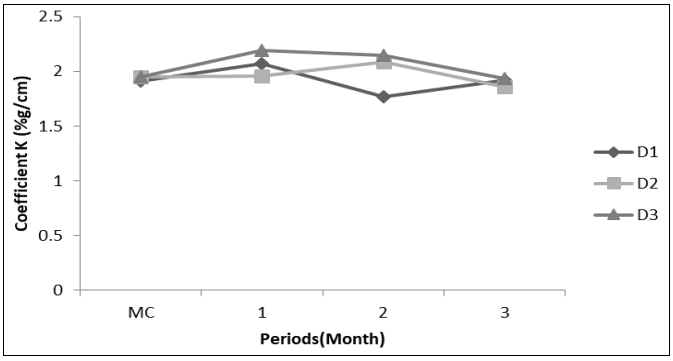


Fig 3: Monthly evolution of the condition coefficient K as according to dose of *Tithonia diversifolia*

The weight-length relationship in the fingerlings of *Oreochromis niloticus* according to dose of *Tithonia diversifolia* summarized in Table 4 shows that, the coefficient of determination was very high (R2 = 0.9) regardless of the dose considered, the allometry coefficient was substantially equal to 3 considered as the reference value in dose D2.

Table 4: weight- length relationship in *Oreochromis niloticus* depending on the dose of *Tithonia*

Doses of *T. diversifolia*	Weight- length relationship					Type de croissance
	N	Equations	R^2	a	b	
D1	10	$Pf = 0{,}034Lt^{2,761}$	0,935	0,034	2,761	Minorante
D2	9	$Pf = 0{,}026Lt^{2,857}$	0,958	0,026	2,857	Minorante
D3	31	$Pf = 0{,}054Lt^{2,566}$	0,904	0,054	2,566	Minorante

D1, D2, D3 = doses *Tithonia diversifolia*, N = number of fish, R2 = coefficient of determination, a = regression coefficient, b = coefficient of allometry.

Correlations between growth performance of *Oreochromis* fingerlings and zooplankton characteristics presented in table 5 show that weight gain, total length, standard length, the specific growth rate, and average daily gain in a dose D2 *T. diversifolia* were significantly ($P < 0.01$) related to positive manner to the biomass and the zooplankton density.

Table 5: Correlations between growth performance of *Oreochromis* fingerlings and zooplankton characteristics.

Growth performance.	Characteristics of zooplankton					
	D1		D2		D3	
	Density	Biomass	Density	Biomass	Density	Biomass
Gp (g)	0,227	0,225	0,776**	0,915**	-0,342	-0,481
Lt (cm)	0,138	0,154	0,754*	0,902**	-0,361	-0,498
Ls (cm)	-0,029	0,016	0,732*	0,886**	-0,354	-0,492
ADG (g)	-0,009	0,033	0,789**	0,916**	-0,134	-0,287
CT (%)	-0,407	-0,314	0,781**	0,917**	0,363	0,227
K	0,366	0,277	-0,509	-0,499	0,244	0,391

** The correlation is significant (P < 0 01.); * Correlation is significant (P < 0. 05). Gp = weight gain, Lt = total length Ls = standard length, condition factor K = k, ADG = average daily gain, CT = specific growth rate.

A net and annual yields of *Oreochromis niloticus* base to dose of *Tithonia diversifolia* presented in Table 6, shows that the net and annual yield were significantly higher with the dose D2 (5kg / are).

Table 6: Net and annual yields of *Oreochromis niloticus* fry depending doses of *T. diversifolia*

Yields	Doses of *Tithonia diversifolia*		
	D1	D2	D3
nets ($g/m^2/j$)	$0{,}33 \pm 0{,}04^b$	$0{,}80 \pm 0{,}10^a$	$0{,}24 \pm 00^b$
annuels (t/ha/an)	$0{,}88 \pm 0{,}93^b$	$2{,}92 \pm 00^a$	$1{,}20 \pm 0{,}05^b$

(a,b); the values of the lines with the same letters are not significantly different (P > 0.05). D1, D2 and D3 = doses of T. diversifolia

Discussion

Values of physico-chemical characteristics of the water were within the recommended range for the development of zooplankton (Wang & Eckmann, 1994) [28] and that of *Oreochromis niloticus* (24-28 ° C) (Malcolm *et al.*, 2000; Kottelat & Freyhof, 2007) [16, 13].

The relatively neutral pH values measured were comparable to the recommended limits as a references value for better survival of zooplankton as well as better growth of *Oreochromis niloticus* (De villers *et al*., 2005; Malcolm *et al.*, 2000) [9, 16].

The conductivity values recorded with all doses have been low compared to the ranges 150 to 450 µS / cm for fish farming (Mamadou, 1998) [17]. These values could be explain by natural water characteristics of the region and the nature of the subtrate.

The relatively low dissolved nutrient compounds are linked to the nutritive composition of *Tithonia diversifolia*. The values of N- NH4 + N- NH 3 (0.30 ± 0.06 mg / l) were below 4mg / l which is lethal to *Oreochromis niloticus* (Pouomogne, 1994) [20]. However, these values were above 0.1 mg / l threshold considered for better growth of *Oreochromis niloticus*. Transparencies Secchi disk was high (> 0.6m) compared to the optimum (0.30 to 0.50m) for good fertilized ponds. This can be explain by the low phosphate content (0.2%) of *Tithonia diversifolia*, considered as limiting factor for plankton production (Chandrashekar & Gajanana, 2003) [8].

The globally low densities of zooplankton observed in the 3rd week would be due to the low mineral content of *T. diversifolia* (Pouomogne, 2007) [22]. However the highest density of zooplankton obtained with dose D3 can be explain by its high organic matter load.

The fingerlings survival rate was higher compared to that reported in rice-fish farming system (Avit *et al*., 2012) and the 65 ± 1.86% obtained in the pond fertilized by *Musa sapientum* (Nsangou *et al.*, 2014) [18]. However, it was below the rate reported with the application of *Tithonia diversifolia* (Pouomogne *et al.*, 2005) [23]. The low survival rate can be explained by deficiency of feed.

Fingerlings weight gain recorded was higher than 14,22g obtained by *Oreochromis niloticus* fingerlings fed with wheat bran. However lower than 46,1g obtained by Sayou (2008) [25] using chicken manure in the western highland. This could due to the low density of zooplankton (Planquette et Petel, 1976) [19].

The minorant allometric observed shows that the weight of fingerlings believes slower than the cube of length (Wang & Eckmann, 1994) [28]. This would be linked to the low nutrient in ponds.

The values of factor K condition were greater than 1 (K > 1) and positively correlated with biomass and density of zooplankton. Thus K > 1 means that they are healthy according to Fulton (1992) [11]. Yields of fingerlings of *Oreochromis niloticus* were significantly different between doses. Generally the yield recorded in this trial was over 1t / ha / year (Brummett *et al.*, 2004) [7].

4. Conclusion

At the end of the study, except ammonium and pH of the water no significant difference was observed between doses of *Tithonia*.

Density and biomass of zooplankton were significantly higher in dose 6kg/are / week *Tithonia diversifolia*.

Except condition K factor, all animal performances were positively affected by the density and biomass of zooplankton in the dose 5kg / are / week *Tithonia diversifolia*. The yields of fingerlings of *Oreochromis niloticus* were significantly higher in the dose 5kg / are / week *Tithonia diversifolia*.

The dose 5kg/are *Tithonia diversifolia* could be used to improve the production of *Oreochromis niloticus*. However it would be desirable to extend this analyze on all stages of development of *Oreochromis niloticus*.

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