Scientific Papers. Series D. Animal Science. Vol. LXVIII, No. 2, 2025
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

RESEARCH ON ACHIEVING HIGHER NATURAL FISH PRODUCTIVITY THROUGH RATIONAL ADMINISTRATION OF CHEMICAL AND ORGANIC FERTILIZERS IN PONDS

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Abstract

Organic fertilizers, through their ability to decompose and release carbon dioxide, ammonia, nitrogen, phosphorus and other nutrients, contribute to the proliferation of phytoplankton and therefore to the amplification of the trophic base in the pond. The need for phosphorus and nitrogen was ensured by fertilization with chemical fertilizers (ammonium nitrate and superphosphate). The paper presents the results of research on the rational use of fertilizers in first summer rearing ponds stocked with carp larvae Cyprinus carpio (Linnaeus, 1758). The experiments were carried out in the rearing ponds located in the South-West region of Dâmbovița County, at the Research and Development Station for Fisheries Nucet, in 3 experimental variants. The distribution of organic and chemical fertilizers in ponds with low nitrogen (below 2 mg N L^{-1}) and phosphorus (below 0.5 mg P L^{-1}) content, determined an abundant development of phytoplankton and a qualitative improvement of zooplankton and benthos, which constitute a food source for carp in the first year of growth.

Key words*: aquaculture, basin, cyprinid, natural productivity, nutrient.*

INTRODUCTION

The importance of macroelements (nitrogen, phosphorus etc.) and micronutrients (selenium, cobalt, manganese, iron) in the functioning of aquatic ecosystems arises from their chemical properties. They must be accessible to living organisms, through bioaccumulation and formation of a wide variety of organic compounds with both stable and labile chemical bonds, which allows them to be transformed under the action of various natural and anthropogenic factors and to migrate from one system to another. Therefore, nitrogen and phosphorus represent the biogenic elements of primary importance, their lack inhibiting the growth and development of plants, thus becoming one of the main factors of the biological productivity of aquatic ecosystems (Sterner & Elser, 2003). In intensive fish farming, one of the first-order problems, currently studied worldwide, refers to obtaining increasingly higher fish production by increasing the natural productivity of managed fish ponds (Dobrotă, 2009).

The dependence of the final production - fish, on the primary production, has been observed for a long time, which has led to the development of methods for increasing fish production, by acting with the help of fertilizers on the development of the first links of the trophic chains, respectively phyto and zooplankton (Costache et al., 2020).

The results so far have proven that this method can achieve high fish production, depending on the hydrological conditions of each region, the nature of the soil and water chemistry, the quality and population of each fish pond (Radu et al., 2024). The role of fertilizers in achieving high yields and superior quality indices is known and confirmed by numerous researches, with a close positive correlation between the amount of fertilizers used and the production obtained (Dolbeth et al., 2012). Fertilization is the simplest and best means of increasing fish production, being the most effective way to intensify production without the risk of quantitative depreciation. It also improves the hygiene of the basin through its direct and favourable action on the sediment level, where it stimulates bacterial activity and the storage of accessible forms takes place. In addition to all these properties, both organic and inorganic fertilizers represent the cheapest method of producing fish "meat". To determine the opportunity for fertilizing with phosphorus-based fertilizers, water analysis is not considered a good indicator, as doses are calculated based on the results of soil nutrient quantification analyses (Banerjee et al., 2009). There is a close interaction between nitrogen and phosphorus, the presence of phosphorus helps nitrogen-fixing bacteria to more easily accumulate nitrogen from the atmosphere, causes the processes of nitrification, facilitating the mineralization of organic substances (Das & Jana, 2003). Fertilization with ammonium nitrate or ammonium sulfate accelerates phytoplankton development, while also stimulating the sustainable production of zooplankton and benthos. Phosphorus fertilizers contribute to increasing natural productivity by over 50% and improving the quality of fish meat (Manea & Dobrotă, 2017). Nitrogen fertilizers should be applied 15 days after phosphate fertilizers. Superphosphate is administered in early spring when the water first warms up, to promote the development of natural food (Battes et al., 2003). The optimal temperature for fertilizer administration in ponds is 17-18ºC, a temperature that favors the development of groups with high trophic value. Nitrogen fertilizers increase production by over 50% (Dolbeth et al., 2012).

MATERIALS AND METHODS

For the experiments, the growth ponds no. 1 (EC 1 CAP) and no. 2 (EC 2 CAP) from the Experimental base no. 1 Nucet, with an area of 2.5 ha, and the growth pond no. 3 (EC1 Cazaci) from the Experimental base Cazaci-Marata, with an area of 2.8 ha, were chosen, which were stocked with 3-5 days old carp larvae, obtained at the Artificial Reproduction Station No. 4 Nucet. The experiments were conducted over two study years, in 2023 and 2024. The two Experimental Bases belonging to S.C.D.P Nucet are located in the major bed of the Ilfov stream, downstream of the Ilfoveni reservoir dam. Regarding the soil, the ponds studied, EC1 CAP and EC2 CAP, after a long period of exploitation, have pond bottoms with lower mineralization, while the recently unclogged/redeveloped EC1 Cazaci pond has better mineralized soil. Consequently, the experiments focused on directing the distribution of fertilizers based on chemical and biological analyses performed in the pond and therefore their effect on chemistry, biology and fish production. Since winter, the ponds have been treated with calcareous amendments distributed by spreading on the dry bottom, depending on the calcium needs of each pond.

In order to increase natural productivity, three experimental variants were tested, based on organic and chemical fertilizers. Manure was used as organic fertilizer, distributed in 2000-4000 kg ha^{-1} on the dry bottom of the pond, before flooding. The chemical fertilizers used were ammonium nitrate with 34% N and superphosphate with 17% P_2O_5. It is generally considered that a pond has high natural productivity when the ratio between nitrogen (N) and phosphorus (P) is greater than 4. Very good production results are obtained by ensuring a ratio between N and P of 6/1-8/1 (Dobrotă, 2009). The ratio between the fertilizers used and the active element they contain was as follows:

- 1 kg N per 3 kg NO_3NH_4;
- 1 kg P per 15 kg superfosfat.

By establishing the 3 experimental variants, a variation in the content of biogenic elements was sought, administered in different combinations of chemical and organic fertilizers, taking into account the needs of the respective ponds, as follows:

- in the EC 1 CAP pond, 2000 kg ha^{-1} of manure, 250 kg ha^{-1} of ammonium nitrate and 300 kg ha^{-1} of superphosphate were administered, of which 150 kg were distributed in water and 150 kg mixed with manure;
- in the EC 2 CAP pond, 3000 kg ha^{-1} of manure, 300 kg ha^{-1} of ammonium nitrate and only 150 kg ha^{-1} of superphosphate were administered in the water;
- in the EC 1 Cazaci pond, 4000 kg ha^{-1} of manure, 300 kg ha^{-1} of ammonium nitrate and 350 kg ha^{-1} of superphosphate were administered, of which 150 kg were distributed in water and 200 kg were mixed with manure.

Chemical fertilizers were distributed in 10 doses of aqueous solutions, spread from the boat on the water surface: the first 3 doses distributed daily; the next three doses distributed every 3-7 days; the last four doses distributed every 7-14 days. In the two experimental years (2023-2024), the fertilization action with chemical fertilizers of the 3 ponds was carried out between April 14 and June 28. In addition to the chemical fertilizers distributed in the water, an additional distribution of superphosphate was also planned, constituting 5-15% of the weight of the organic fertilizer, in order to intensively stimulate the appearance and development of plankton.

During the experimental period, hydrochemical and hydrobiological parameters were monitored from the three ponds and the water supply source.

The monitored hydrochemical parameters were: pH was determined colorimetrically, according to STAS 6235-75; calcium ion concentration was determined by the titrimetric method with complexon III, according to STAS 3662/62; magnesium ion concentration was determined by the volumetric method, according to STAS 6674-77; the amount of phosphates was determined by the spectrometric method, according to STAS 10064/75; nitrite anion concentration was determined by the spectrometric method, according to STAS 8900/2-71 and dissolved oxygen was determined using the HQ40d portable multiparameter.

Monitoring of hydrobiological parameters involved quantitative and qualitative analysis of plankton (phytoplankton and zooplankton). Quantitative analysis involved determining planktonic biomass (cc/m^3) and density (number of specimens/m^3). Qualitative analysis involved identifying all species in the processed sample and compiling a list of species by systematic groups.

The following biotechnological indicators were determined for the harvested biological material:

$$FCR = \frac{\text{Feed given (kg)}}{\text{Fish weight gain (kg)}} \quad (1)$$

$$Sv\ (\%) = \frac{\text{Number of specimens harvested}}{\text{Number of specimens stocked*100}} \quad (2)$$

$$\text{Fertilizer coefficient} = \frac{\text{kg fertilizer}}{\text{kg fish growth}} \quad (3)$$

During the growing season, in the experimental years 2023 and 2024, combined feed was administered, and the components of the feed recipe were: soybean meal (15%), sunflower meal (18%), wheat (19%), barley (23%), corn (16%), meat/fish meal (2%), feed yeast (3%), calcium (3%), premix (1%). The crude protein for this feed was 22 %. (Dobrotă et al., 2012).

In 2023, the feeding of fish material began on May 30 and ended on October 14, totalling 119 days. The total quantities of feed administered were: in variant V1 (EC1 CAP) = 11390 kg; in variant V2 (EC2CAP) = 15011 kg and in variant V3 (EC1 Cazaci) = 14212 kg.

In 2024, the feeding of fish material began on May 26 and ended on October 15, totalling 122 days. The total quantities of feed administered were: in variant V1 (EC1 CAP) = 11138 kg; in variant V2 (EC2CAP) = 16639 kg and in variant V3 (EC1 Cazaci) = 13476 kg.

On Sundays, the fish material was not fed.

The recorded data on growth parameters during the two years of study for carp were statistically analyzed using Microsoft Office Pro Plus. The results were presented in tables and graphs.

RESULTS AND DISCUSSIONS

From the hydrochemical analyses (Table 1 and Figures 1, 2 and 3) performed, it was found that differences appear between the three ponds studied, in terms of the dynamics of biogenic elements, as well as between the pond and the supply water of the two experimental bases. In the water from the Ilfov stream, which feeds both experimental bases (Nucet and Marata-Cazaci), the values of biogenic elements were: phosphates usually absent, and nitrates ranged between 0-4.60 N mg L^{-1}.

In the experimental ponds, through the fertilization and amendment works carried out, the situation has improved. Regarding phosphates, it is remarkable that the EC1 CAP and EC1 Cazaci ponds, where a superphosphate supplement was distributed mixed with manure, managed to maintain a minimum threshold of phosphorus in the water throughout the experiment.

At the same time, in the water of the EC2 CAP pond, where only 150 kg ha^{-1} of superphosphate was administered, phosphorus could not be detected. The amounts of nitrogen fertilizers distributed in the three ponds were similar, between 250-300 kg ha^{-1}.

Table 1. Average values of hydrochemical parameters recorded in the two years of study (2023-2024) in the experimental ponds

Collection station	Year	Month	pH	Ca^{2+} (mg L^{-1})	Mg^{2+} (mg L^{-1})	P (mg L^{-1})	NO_2 (mg L^{-1})	O_2 (mg L^{-1})
Watter source (Ilfov Stream)	2023	May	7.1	30	18.24	0.04	2.88	8.13
		June	7.6	72	18.52	0	4.75	8.42
		July	7.3	62	17.52	0	3.04	9.64
		August	7.4	39.5	10.04	0	0.76	11.49
		September	7.3	48.1	16.52	0	0	11.43
	2024	May	7.15	26	16.28	0.08	3.52	10.33
		June	7.2	48	10.16	0	4.45	10.82
		July	7.5	54.8	10.52	0	4.48	10.32
		August	7.4	44.5	11.84	0	1.16	10.47
		September	7.6	44.0	15.08	0	0	10.51
	Monthly average of the years 2023-2024	May	7.1	28	17.26	0.06	3.20	9.23
		June	7.4	60	14.34	0	4.60	9.62
		July	7.4	58.4	14.02	0	3.76	9.98
		August	7.4	42.0	10.94	0	0.96	10.84
		September	7.4	46.0	15.80	0	0	10.97
EC1 CAP	2023	May	7.1	36.0	7.96	0.23	0.09	11.23
		June	7.4	49.2	17.93	0.16	0.38	10.8
		July	7.4	44.5	15.64	0.36	0.74	11.18
		August	8.1	50.2	17.02	0.38	0.7	12.4
		September	7.4	38.0	10.23	0.01	0.52	12.46
	2024	May	7.3	40.0	10.02	0.21	0.15	9.71
		June	7.2	45.2	15.63	0.18	0.44	9.76
		July	7.8	48.3	16.08	0.48	0.3	11.86
		August	7.9	46.6	9.24	0.42	0.84	12.20
		September	7.6	34.0	9.21	0.03	0.6	12.56
	Monthly average of the years 2023-2024	May	7.2	38.0	8.99	0.22	0.12	10.47
		June	7.3	47.2	16.78	0.17	0.41	10.28
		July	7.6	46.4	15.86	0.42	0.52	11.52
		August	8.0	48.4	13.13	0.40	0.77	12.20
		September	7.5	36.0	9.72	0.02	0.56	12.51
EC2 CAP	2023	May	6.9	39.74	10.05	0	0.15	9.28
		June	7.2	48.6	12.76	0	0.40	9.5
		July	7.2	47.4	12.58	0	0.50	9.04
		August	7.0	40.8	10.3	0	0.59	11.47
		September	7.2	40.4	10.96	0	0.38	11.72
	2024	May	7.1	37.56	7.03	0	0.31	8.68
		June	7.0	44.2	11.56	0	0.54	10.12
		July	7.2	43.4	11.5	0	0.54	9.88
		August	7.2	44.8	11.58	0	0.77	13.09
		September	7.4	36.4	8.48	0	0.46	13.84
	Monthly average of the years 2023-2024	May	7.0	38.56	8.54	0	0.23	8.98
		June	7.1	46.4	12.16	0	0.47	9.81
		July	7.2	45.4	12.04	0	0.52	9.46
		August	7.1	42.8	10.94	0	0.68	12.28
		September	7.3	38.4	9.72	0	0.42	12.78
EC1 Cazaci	2023	May	7.1	60.4	14.12	0.08	11.06	7.46
		June	7.2	39.4	9.32	0.07	1.8	8.04
		July	7.0	49.96	10.12	0.03	3.74	8.8
		August	7.4	51.0	13.66	0.11	0.68	12.4
		September	7.2	39.4	13.06	0	0.09	10.78
	2024	May	6.9	58.0	13.1	0.04	9.46	8.98
		June	7.0	39.0	7.7	0.05	2.2	9.26
		July	7.2	47.72	9.12	0.05	3.38	9.28
		August	7.0	53.0	14.06	0.13	0.84	13.56
		September	7.2	42.2	13.68	0	0.13	12.26
	Monthly average of the years 2023-2024	May	7.0	59.2	13.61	0.06	10.26	8.22
		June	7.1	39.2	8.51	0.06	2.0	8.65
		July	7.1	48.84	9.62	0.04	3.56	9.04
		August	7.2	52.0	13.86	0.12	0.76	12.98
		September	7.2	40.8	13.37	0	0.11	11.52
Values according to Ordinance MMGA 161/2006	-	Minimum	6.9	30.0	6.0	0.005	0	6.0
		Optimum	7.0-7.8	90-120	10-40	0.05-1.5	0.03	7-12
		Maximum	8.0-8.5	160.0	50.0	3.0	0.06	14

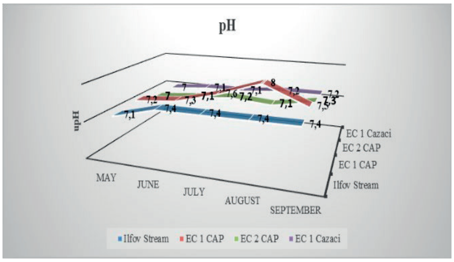

Figure 1. pH values recorded (average of the two years of study 2023-2024) in the experimental ponds

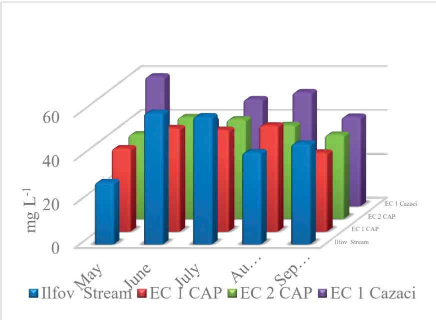

Figure 2. Calcium content values (mg L^{-1}) recorded (average of the two years of study 2023-2024) in the experimental ponds

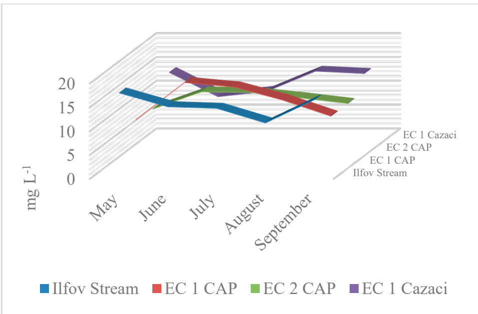

Figure 3. Magnesium content values (mg L^{-1}) recorded (average of the two years of study 2023-2024) in the experimental ponds

Although there was a gap of approximately two weeks in the period of starting the fertilizer administration action, the determined nitrate values in the water of the experimental ponds were similar.

Studies by Boyd (1998) show that the controlled application of chemical fertilizers, especially those based on nitrogen and phosphorus, improves the trophic quality of the water, without compromising the ecological balance of the pond. Also, Araujo et al. (2022) emphasizes the importance of a correlation between fertilizer doses and physicochemical parameters of the water (pH, dissolved oxygen) to prevent excessive eutrophication.

Only the EC1 Cazaci pond, in the first part of the interval in 2023, showed an excess of nitrogen, because flooding was delayed and therefore the development of planktonic organisms consuming chemical salts was slow, which is why the nitrogen reserve was preserved in large quantities. Another effect of the fertilizers was the restoration of the Ca/Mg ratio to as normal values as possible, 3/1-4/1, achieved by triggering chemical reactions that favoured better solubilisation of calcium salts.

The other hydrochemical parameters were maintained within the optimal limits of a category II aquaculture water: pH in the weak alkaline range; dissolved oxygen, with a few insignificant exceptions, usually at saturation, and oxidizability (8.20-30.52 mg L^{-1}) in the range of optimal values.

As a result of the intense calcium consumption in the EC1 Cazaci pond, an increase in calcium requirements was noted from spring (981 kg ha^{-1}) to autumn (1432 kg ha^{-1}).

In the USA, providing 8 mg phosphorus, 4 mg nitrogen, 2 mg potassium and 16 mg calcium per liter of water resulted in production 3-4 times higher than in unfertilized ponds. In Japan, 8 mg phosphorus, 10 mg nitrogen and 4 mg potassium per liter of water were used to stimulate phytoplankton development, generating a significant increase in biomass (Todoran & Bud, 2013).

From a trophic point of view, experiments with complex fertilizers have highlighted several issues to consider.

Quantitatively, planktonic biomass, stimulated by fertilizer input, although residual, reached high values. The best situation was presented by the EC1 Cazaci pond, where the administration of the supplement of 350 kg ha^{-1} superphosphate, associated with 4000 kg ha^{-1} manure, was noted. In addition to the fact that planktonic biomass indicated increased values, they were maintained throughout the entire period, permanently ensuring sufficient natural food for the fish population (Table 2 and Figure 4).

Table 2. Average values of hydrobiological parameters recorded in the two years of study (2023-2024) in the experimental ponds

Collection station	Year	Month	Planktonic biomass cc/m³	Thousands of exemplars/m³		Dominant group	
				Phytoplankton	Zooplankton	Phytoplankton	Zooplankton
Watter source (Ilfov Stream)	2023	May	32	2750	27	Bacillariophyceae	Copepoda
		June	33	29400	37	Bacillariophyceae	Copepoda
		July	28	8590	61	Bacillariophyceae	Copepoda
		August	23	1350	100	Bacillariophyceae	Rotifera
		September	12	355	79	Bacillariophyceae	Rotifera
	2024	May	28	2850	23	Bacillariophyceae	Copepoda
		June	32	29320	43	Bacillariophyceae	Copepoda
		July	29	8530	55	Bacillariophyceae	Rotifera
		August	22	1310	110	Bacillariophyceae	Copepoda
		September	13	325	81	Bacillariophyceae	Rotifera
	Monthly average of the years 2023-2024	May	30	2800	25	-	-
		June	32.5	29360	40		
		July	28.5	8560	58		
		August	22.5	1330	105		
		September	12.5	340	80		
EC1 CAP	2023	May	122	1935	2015	Chlorophyceae	Copepoda
		June	9	11395	5421	Chlorophyceae	Rotifera
		July	28	12568	3862	Chlorophyceae	Rotifera
		August	74	19862	1952	Cyanophyae	Copepoda
		September	135.0	3145650	7192	Cyanophyae	Rotifera
	2024	May	123	1945	2025	Chlorophyceae	Copepoda
		June	11	11355	5433	Chlorophyceae	Rotifera
		July	24	12604	3850	Chlorophyceae	Copepoda
		August	76	19838	1948	Cyanophyae	Rotifera
		September	135.0	3145950	7208	Cyanophyae	Rotifera
	Monthly average of the years 2023-2024	May	122.5	1940	2020	-	-
		June	10	11375	5427		
		July	26	12586	3856		
		August	75	19850	1950		
		September	135.0	3145800	7200		
EC2 CAP	2023	May	8.1	9867	680	Chlorophyceae	Rotifera
		June	11.5	11530	785	Chlorophyceae	Copepoda
		July	32.8	10856	4254	Chlorophyceae	Rotifera
		August	53	11170	6100	Cyanophyae	Rotifera
		September	148	26069	5540	Chlorophyceae	Rotifera
	2024	May	8.7	9873	688	Chlorophyceae	Copepoda
		June	13.5	11570	775	Chlorophyceae	Rotifera
		July	32	10848	4270	Cyanophyae	Rotifera
		August	47	11230	5900	Chlorophyceae	Copepoda
		September	145	26081	5660	Chlorophyceae	Rotifera
	Monthly average of the years 2023-2024	May	8.4	9870	684	-	-
		June	12.5	11550	780		
		July	32.4	10852	4262		
		August	50	11200	6000		
		September	146.5	26075	5600		
EC1 Cazaci	2023	May	7.2	4130	52	BacillariophyceaeC	Rotifera
		June	47.0	40150	660	hlorophyceae	Copepoda
		July	62.3	6820	554	Cyanophyae	Rotifera
		August	89	7825	51650	BacillariophyceaeC	Rotifera
		September	141.5	127100	2430	hlorophyceae	Rotifera
	2024	May	7.8	4120	48	BacillariophyceaeC	Copepoda
		June	53.0	39850	620	hlorophyceae	Rotifera
		July	68.5	6860	566	BacillariophyceaeC	Rotifera
		August	85	7775	51550	hlorophyceae	Copepoda
		September	133.5	127180	2410	Chlorophyceae	Rotifera
	Monthly average of the years 2023-2024	May	7.5	4125	50	-	-
		June	50.0	40000	640		
		July	65.4	6840	560		
		August	87	7800	51600		
		September	137.5	127140	2420		

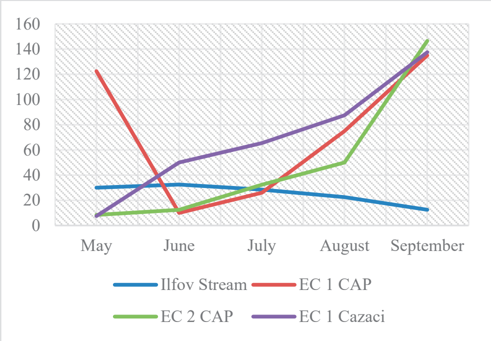

Figure 4. Variation of planktonic biomass (cc/mc) recorded (average in the two years of study 2023-2024) in experimental ponds

In the other two ponds (EC1 CAP and EC2 CAP), the peaks of development alternated with periods of decline of trophic organisms, either due to lower amounts of organic fertilizers or the lack of superphosphate additionally distributed in the manure, which gave an intensity to the appearance and development of trophic organisms. Qualitatively, the effect of fertilizers was felt in the change in plankton composition, taking the water from the supply source as a reference factor. In the watter source throughout the experiment, diatoms predominated in the phytoplankton, while in the zooplankton, depending on the season, copepods, protozoa or rotifers temporarily dominated.

In the experimental ponds, the produced transformations manifested themselves uniformly. In phytoplankton, the composition changed in favor of chlorophyceae throughout the summer, and towards autumn there was a predominance of cyanophyceae, which sometimes produced blooms, as was the case in pond EC1 CAP. In zooplankton, rotifers developed very intensively, constituting the predominant group (70-100% of the number of zoobionts) in all three experimental ponds, throughout the entire study period. It is obvious that the administration of complex fertilizers stimulated the development of planktonic elements with high nutritional value, necessary and indicated in the food of carp fry.

Rational fertilizer management in ponds is an essential factor in increasing fish productivity. Fertilization with organic fertilizers, such as fermented manure, stimulates the development of phytoplankton and zooplankton, constituting a natural source of food for fish (Dhawan & Toor, 1989).

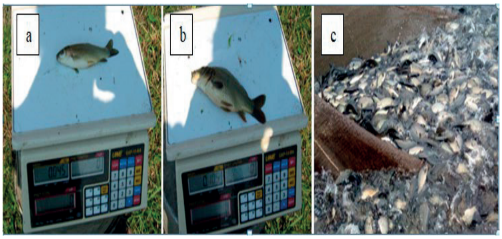

Figure 5. Biological material in harvest fishing: a) carp from EC2 CAP; b) carp from EC1CAP; c) carp from EC1Cazaci (original)

An intense development of benthic fauna was also reported, stimulated by the effect of complex fertilizers, with the predominance of chironomid larvae in all experimental ponds. Due to the population of carp larvae, this trophic base remained underutilized. As much as possible, stocking was sought to be a constant factor in the three experimental ponds (Figure 5), in order to ensure the most homogeneous conditions from this point of view. As a result, the experimental ponds were stocked with 390.000-406.000 ex. C_0 ha^{-1} obtained through artificial reproduction on different dates (May 5-26).

In parallel with the administration of organic and chemical fertilizers, feed composed of different varieties was distributed as supplementary food throughout the growing period (Dobrotă et al., 2012).

The lowest production achieved per unit area (1980 kg ha^{-1} in 2024) was in the EC1 CAP pond and this was due to a very low survival of the fry (4.6%) because there were unfavourable thermal variations during stocking (being the first pond stocked in May), as well as due to a blue-green algae bloom, produced in August-September. The high growth rate of the fry in this pond (104 g/ex.) did not compensate for the very low survival (Table 3). In the other experimental ponds, high productions were achieved, reaching 2610 kg ha^{-1} in the EC2 CAP pond in 2024 and over 3000 kg ha^{-1} in the EC1 Cazaci pond in both study years (2023-2024), with average fry weights of 34- 56 g/ex and with a much higher survival rate (13.9-18.7%) compared to the EC1 CAP pond.

Table 3. Stocking densities, achieved production, average weight and survival in experimental ponds in the two years of study

Year	Variant	Pond	Surface (ha)	Stocking date	Stocking C_0 (ex.ha^{-1})	Production (kg ha^{-1})	Wmed (g/ex.)	Sv (%)
2023	V1	EC1 CAP	2.5	5-10.05.	390000	2090	95	5.6
	V2	EC2 CAP	2.5	16-20.05.	408000	2555	38	16.5
	V3	EC1Cazaci	2.8	21-26.05.	395000	3095	54	14.5
2024	V1	EC1 CAP	2.5	17-21.05.	410000	1980	104	4.6
	V2	EC2 CAP	2.5	12-15.05.	410000	2610	34	18.7
	V3	EC1Cazaci	2.8	12-15.05.	400000	3105	56	13.9
Average	V1	EC1 CAP	2.5	-	400000	2035	99.5	5.1
	V2	EC2 CAP	2.5	-	409000	2583	36	17.6
	V3	EC1Cazaci	2.8	-	397500	3100	55	14.2

Table 4. Comparative values of production yields, amount of feed and conversion and fattening coefficients in experimental ponds in the two years of study (2023-2024)

Year	Variant	Pond	Surface (ha)	Amount of feed administered (kg ha^{-1})	Conversion Coefficient (FCR)	Fertilizer coefficient (kg fertilizer/kg fish growth)		
						K_O	K_N	K_P
2023	V1	EC1 CAP	2.5	4556	2.18	0.96	0.12	0.10
	V2	EC2 CAP	2.5	6004	2.35	1.17	0.12	0.12
	V3	EC1Cazaci	2.8	5076	1.64	1.29	0.10	0.11
2024	V1	EC1 CAP	2.5	4455	2.25	1.01	0.13	0.10
	V2	EC2 CAP	2.5	6656	2.55	1.15	0.11	0.11
	V3	EC1Cazaci	2.8	4813	1.55	1.29	0.10	0.11
Average	V1	EC1 CAP	2.5	4506	2.22	0.98	0.12	0.10
	V2	EC2 CAP	2.5	6330	2.45	1.16	0.12	0.12
	V3	EC1Cazaci	2.8	4944	1.60	1.29	0.10	0.11

The specific feed consumption values (Table 4) are relatively low and close in the EC1 CAP and EC2 CAP ponds (2.18-2.55) and very good (1.55-1.64) in the EC1 Cazaci pond where the greatest production increase was achieved (3095 kg ha^{-1} in 2023, respectively 3105 kg ha^{-1} in 2024).

CONCLUSIONS

The high yields obtained were achieved without using excessive amounts of fertilizers, with the achieved fertilization coefficients being 0.96-1.29 for organic fertilizer, 0.10-0.13 for ammonium nitrate and 0.10-0.12 for superphosphate.

It has been found that nitrogen is a limiting factor for primary biological productivity, especially in limiting the proliferation of green algae on which the zooplankton develops, which constitutes the basic food of carp in the first weeks of life.

The nitrogen level in the water decreases much faster than that of phosphorus during the vegetative period, this is due to algae.

Distributing organic and chemical fertilisers in ponds with low nitrogen (below 2 mg L^{-1}) and phosphorus (below 0.5 mg L^{-1}) content causes abundant phytoplankton development and improves the quality of the zooplankton and benthos, which provide feed for carp.

Rational fertilization, combined with careful monitoring of environmental parameters, can lead to superior natural productivity in fish ponds. Judicious application of manure and supplementation with low-dose chemical fertilizers optimize yields without compromising water quality or fish health.

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