EFFECT OF DIFFERENT LEVELS OF MINERAL PHOSPHORUS WITH AND WITHOUT NITROGEN ON THE DRY WEIGHT OF PLANKTONIC BIOMASS, INCREASE IN FISH PRODUCTION AND BIOMASS CONVERSION EFFICIENCIES

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An experiment to observe the effect of different levels of mineral phosphorus with and without nitrogen on the dry weight of planktonic biomass, increase in fish production and biomass conversion efficiencies was conducted at Fisheries Research Farms, University of Agriculture, Faisalabad in nine earthen ponds. The area under each pond was 30 x 16 x 2m. Fingerlings of *Hypophthalmichthys molitrix, Labeo rohita* and *Cyprinus carpio* were collected from the Govt. Fish Seed Hatchery, Faisalabad and stocked in the experimental ponds with a stocking density of 251 each pond. The experimental pond 0 served as the control without any additives, whereas the pond 1, 2, 3, and 4 received mineral fertilizer (triple superphosphate, 46% P_2O_5) at the rate of 0.06, 0.09, 0.12 and 0.15 percent of wet fish body weight per day, while pond 5, 6, 7 and 8 received phosphorus in the same ascending order along with nitrogen (urea, 46%) at the constant rate of 0.12% N, of wet fish body weight daily and the study continued for twelve months. Fortnightly observations on an increase in fish production, dry weight of planktonic biomass and biomass conversion efficiency ratios were made. The overall range of increase in fish biomass in 24 fortnights under T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_0, were in the tune of 1.64-27.42, 1.65-20.93, 1.92-44.59, 1.46-43.70, 1.48-69.63, 2.65-32.24, 0.89-32.09, 1.45-41.46 and 0.59-3.31 g m^{-3}; while the dry weight of planktonic biomass throughout the experimental period ranged from 43 to 176, 48 to 215, 42 to 220, 63 to 320, 49 to 327, 58 to 234, 48 to 210, 58 to 234 and 8 to 58 g m^{-3}, respectively. The biomass conversion efficiency ratios ranged from 0.01 to 0.25, 0.02 to 0.24, 0.02 to 0.55, 0.01 to 0.26, 0.02 to 0.44, 0.02 to 0.30, 0.02 to 0.18, 0.01 to 0.32 and 0.02 to 0.25 in T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_0, respectively. Treatment pond, T_5 which was fertilized with 0.06 percent phosphorus plus 0.12 percent nitrogen remained the best treatment in which maximum net fish production of 462.51 kg $pond^{-1}$ yr^{-1} was procured.

Keywords: Phosphorus, planktonic biomass, fish, conversion efficiencies

INTRODUCTION

The aim of pond fertilization is to provide adequate amounts of essential nutrients for the production of phytoplankton, which form the base of the grazing food chain of cultured fishes. In temperate waters, phytoplankton populations normally divide twice per day to once every 4 days (O' Brien, 1974). Phosphorus is considered to be the key nutrient limiting productivity in fresh water ecosystems, where as nitrogen is so in marine systems. The relationship between P_2O_5 doses and fish yield is almost linear under certain conditions (Hickling, 1962).

Mc Coy (1983) reported 10-fold increase in the phytoplankton standing crop after the addition of phosphorus fertilizer and another 10-fold increase in phytoplankton growth by adding nitrogen fertilizer. He further observed that if the nitrogen content of the lake water is increased but that of phosphorus is not, no increase in algal growth occurs. Warm water fishes have an optimum growing temperature in the range of 25-30°C (NRC, 1983).

Chakarbarti (1984) concluded that the application of poultry manure and inorganic fertilizer was found to be effective in increasing the production of plankton and bottom macro-fauna. Growth and survival in fish are optimum within a defined temperature range (Gadowski and Caddell, 1991). Barik *et al*. (2001) concluded that even the smallest concentration of phosphate in water has an influence over the production process in aqua-culture systems.

Tepe and Boyd (2001) tested a granular, water soluble sodium nitrate based fertilizer (8%N, 24%P_2O_5, 15% K_2O and trace elements; per application rate of 8 and 16 kg ha^{-1}) for potential use in freshwater sport fish pond. They found it effective in increasing net phytoplankton productivity and sun fish production at 16 kg ha^{-1} $application^{-1}$.

MATERIALS AND METHODS

The experiment was conducted in nine earthen ponds, located at Fisheries research Farms, University of Agriculture, Faisalabad. The area of each pond was

30m x 16m x 2m (length x width x depth). Liming of the ponds was carried out with CaO at the rate of 9.6 Kg pond^{-1} (200 kg ha^{-1}). The ponds were filled with unchlorinated tube-well water upto the level of 1.5 m and this level was maintained throughout the experimental period.

Fingerlings of *Hypophthalmichthys molitrix, Labeo rohita* and *Cyprinus carpio* were collected from Govt. Fish Seed Hatchery, Satiana Road, Faisalabad and they were randomly assigned to each of the experimental ponds with the stocking density as suggested by Sheri *et al*. (1986). With 2.87 m^{3} fish^{-1}. The interspecies ratio was as follows:

Fish species	Number of individuals	Average weight (g)	Average fork length (mm)	Average total length (mm)
Hypophthalmichthys molitrix	163	38.60±0.95	142.46±3.27	162.49±3.39
Labeo rohita	50	37.49±0.88	118.39±3.09	140.27±3.04
Cyprinus carpio	38	30.75±0.82	105.66±2.33	123.13±2.47

Species ratio: *Hypophthalmichthys molitrix* : *Labeo rohita* : *Cyprinus carpio*
65 : 20 : 15

The combination of surface, column and bottom feeding fishes has been the basis of carp culture and so, the species ratios were according to the feeding habits and ecological niches of the fishes (Pillay, 1999).

The experimental pond 0 served as control without any additives, whereas the experimental pond 1, 2, 3, and 4 received mineral fertilizer (triple super phosphate, 46% P_2O_5) at the rate of 0.06, 0.09, 0.12 and 0.15% P of wet fish weight daily, while pond 5, 6, 7, and 8 received phosphorus in the same ascending order along with nitrogen (urea, 46% N) at the constant rate of 0.12% N of wet fish body weight daily. The study continued for twelve months.

The cultured fish stock was randomly sampled at each fortnight interval by using nylon drag net from each of the experimental pond. The morphometric characteristics of the fish viz., wet body weight in grams, fork length and total length in millimeters were measured and recorded to observe their growth performance under different treatments. After obtaining the data, the fish were released back into their respective ponds. The sample size for each fish species remained 11.

Water samples from each of the experimental ponds were collected for analysis fortnightly, at mid-fortnight interval for the whole study period. Temperature and pH of water were determined at the ponds site. Light penetration was determined with the help of Secchi's disc. The chemical factors including dissolved oxygen, carbon dioxide, carbonates, bicarbonates, total alkalinity, calcium, magnesium, total hardness and chlorides were determined by the methods described in A.P.H.A. (1992). Sodium, potassium, soluble orthophosphates and nitrates were determined by the methods of A.O.A.C. (1995). Total solids, total dissolved solids and dry weight of planktonic biomass were determined by standard methods.

RESULTS AND DISCUSSION

Fortnightly observations on an increase in fish production, dry weight of planktonic biomass and calculated biomass conversion efficiency ratios of nine treatments are given in Table 1. The overall range of increase in fish biomass in 24 fortnights under T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_0, were in the tune of 1.64-27.42, 1.65-20.93, 1.92-44.59, 1.46-43.70, 1.48-69.63, 2.65-32.24, 0.89-32.09, 1.45-41.46 and 0.59-3.31 g m^{-3}; while the dry weight of planktonic biomass throughout the experimental period ranged from 43 to 176, 48 to 215, 42 to 220, 63 to 320, 49 to 327, 58 to 234, 48 to 210, 58 to 234 and 8 to 58 g m^{-3}, respectively. The biomass conversion efficiency ratios ranged from 0.01 to 0.25, 0.02 to 0.24, 0.02 to 0.55, 0.01 to 0.26, 0.02 to 0.44, 0.02 to 0.30, 0.02 to 0.18, 0.01 to 0.32 and 0.02 to 0.25 in T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_0, respectively. The maximum values of conversion efficiency in T_1, T_2 and T_3 (0.25, 0.24 and 0.55, respectively) were achieved during the 2nd fortnight with the increase in fish production of 12.72, 12.60 and 23.27 g m^{-3}, respectively. The high values of conversion efficiency might be attributed to the increased fish activity with the concomitant increase in water temperature as well as the dry weight of planktonic biomass (51, 52 and 42 g m^{-3} in T_1, T_2 and T_3, respectively). These observations were in agreement with Hastings and Dickie, (1972); N.R.C., (1983); McCoy (1983) and Gadowski and Caddell (1991).

Similarly the maximum values of conversion efficiency in T_4, T_5 and T_6 (0.26, 0.44 and 0.30, respectively) were achieved during the 20th fortnight for T_4 and 1st fortnight for T_5 and T_6 with the increase in dry weight of

Table 1. Fortnightly observations on average increase in dry weight of planktonic biomass (g m^{-3}) of nine treatments

Fortnight	Treatments									
	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	Mean
1	19	70	66	56	81	49	64	58	102	62.78
2	24	51	52	42	64	87	58	48	62	54.22
3	15	54	80	51	87	92	102	86	73	71.11
4	26	43	58	66	84	117	86	74	68	69.11
5	31	87	48	96	63	105	73	105	58	74.00
6	28	73	76	74	84	104	64	85	76	73.78
7	20	68	83	72	93	53	58	76	95	68.67
8	36	55	84	90	112	117	110	48	106	84.22
9	18	102	76	110	124	88	95	56	105	86.00
10	42	137	112	96	160	131	116	68	116	108.67
11	8	156	170	134	175	140	105	102	80	118.89
12	34	176	162	158	186	146	140	140	180	146.89
13	26	151	194	187	197	164	180	144	60	144.78
14	36	165	188	202	226	201	210	156	168	172.44
15	42	138	215	220	320	205	160	182	210	188.00
16	58	136	174	216	244	257	226	210	224	193.89
17	33	174	160	192	284	305	210	158	234	194.44
18	48	121	126	168	208	327	216	148	165	169.67
19	32	110	135	154	218	260	234	206	190	171.00
20	34	75	146	126	168	264	224	166	145	149.78
21	28	105	169	140	172	226	190	165	158	150.33
22	28	89	152	170	118	194	210	142	142	138.33
23	26	141	127	187	136	204	158	140	131	138.89
24	30	107	112	168	148	184	140	146	130	129.44
Mean	30.08	107.67	123.54	132.29	156.33	167.50	142.88	121.21	128.25	

T_0 = control
T_1 = Inorganic fertilizers added @ 0.06% P of wet fish body weight daily
T_2 = Inorganic fertilizers added @ 0.09% P of wet fish body weight daily
T_3 = Inorganic fertilizers added @ 0.12% P of wet fish body weight daily
T_4 = Inorganic fertilizers added @ 0.15% P of wet fish body weight daily
T_5 = Inorganic fertilizers added @ 0.06% P + 0.12% N of wet fish body weight daily
T_6 = Inorganic fertilizers added @ 0.09% P + 0.12 N of wet fish body weight daily
T_7 = Inorganic fertilizers added @ 0.12% P + 0.12 N of wet fish body weight daily
T_8 = Inorganic fertilizers added @ 0.15% P + 0.12 N of wet fish body weight daily

Table 1a. Fortnightly observations on average increase in fish production (g m^{-3}) of nine treatments

Fortnight	Treatments									
	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	Mean
1	3.31	8.67	15.23	29.50	12.50	21.64	19.48	5.17	13.32	14.31
2	2.99	12.72	12.60	23.27	12.39	20.80	16.31	4.56	13.02	13.18
3	0.82	4.46	12.54	18.22	9.09	11.41	5.30	4.69	8.01	8.28
4	1.06	7.19	11.93	7.40	8.48	12.83	4.62	3.86	7.52	7.21
5	0.59	3.92	6.94	4.78	5.15	2.86	6.58	4.51	4.78	4.46
6	0.77	4.15	4.65	4.18	4.80	3.50	5.75	3.09	4.08	3.89
7	0.84	1.18	2.78	3.11	1.46	2.82	2.91	1.40	2.39	2.10
8	0.76	1.67	2.47	3.17	1.50	2.53	2.65	1.22	1.45	1.94
9	1.01	1.64	1.65	2.00	2.30	1.48	2.74	0.89	4.57	2.03
10	1.61	1.93	2.41	1.92	2.05	7.16	2.93	1.42	4.41	2.87
11	2.04	4.29	3.85	6.24	3.23	16.29	3.03	2.25	2.72	4.88
12	2.16	5.17	4.40	5.10	2.82	15.57	2.72	2.59	2.55	4.79
13	2.58	11.40	8.19	26.93	5.53	14.68	4.33	16.99	6.91	10.84
14	2.67	14.30	7.27	20.49	5.10	16.73	8.12	15.26	6.14	10.68
15	2.28	17.80	20.93	43.65	15.25	46.32	27.26	27.36	14.67	23.95
16	2.28	27.42	20.21	39.09	15.31	43.96	22.95	32.09	13.32	24.07
17	2.22	21.88	17.45	17.77	15.65	32.30	25.53	26.61	8.48	18.65
18	2.23	24.68	19.43	35.89	15.63	40.52	24.26	26.14	12.54	22.37
19	1.51	17.68	14.16	25.30	28.50	43.99	21.73	14.06	21.90	20.98
20	1.46	16.20	13.06	21.75	43.70	57.66	5.93	12.91	24.27	21.88
21	0.71	10.85	9.16	44.59	36.36	56.75	6.33	12.63	29.95	23.04
22	0.92	10.62	10.21	39.52	24.63	69.63	20.72	12.19	18.17	22.96
23	2.44	3.78	16.28	44.17	34.02	52.51	18.54	20.72	41.46	25.99
24	1.99	9.72	17.07	39.29	25.07	51.03	32.24	20.36	40.29	26.34
Mean	1.72	10.14	10.62	21.14	13.77	26.87	12.21	11.37	12.79	

Table 1b. Fortnightly observation on the conversion efficiencies of nine treatments

Fortnight	Treatments									
	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	Mean
1	0.174	0.124	0.231	0.527	0.154	0.442	0.304	0.089	0.131	0.242
2	0.125	0.249	0.242	0.554	0.194	0.239	0.281	0.095	0.210	0.243
3	0.055	0.076	0.157	0.357	0.104	0.124	0.052	0.055	0.110	0.121
4	0.041	0.167	0.206	0.112	0.101	0.110	0.054	0.052	0.111	0.106
5	0.019	0.045	0.145	0.050	0.082	0.027	0.090	0.043	0.082	0.065
6	0.028	0.057	0.061	0.056	0.057	0.034	0.090	0.036	0.054	0.053
7	0.042	0.017	0.033	0.043	0.016	0.053	0.050	0.018	0.025	0.033
8	0.021	0.030	0.029	0.035	0.013	0.022	0.024	0.025	0.014	0.024
9	0.056	0.016	0.022	0.018	0.019	0.017	0.029	0.016	0.044	0.026
10	0.038	0.014	0.022	0.020	0.013	0.055	0.025	0.021	0.038	0.027
11	0.255	0.028	0.023	0.047	0.018	0.116	0.029	0.022	0.034	0.063
12	0.064	0.029	0.027	0.032	0.015	0.107	0.019	0.019	0.014	0.036
13	0.099	0.076	0.042	0.144	0.028	0.090	0.024	0.118	0.115	0.082
14	0.074	0.087	0.039	0.101	0.023	0.083	0.039	0.098	0.037	0.064
15	0.054	0.129	0.097	0.198	0.048	0.226	0.170	0.150	0.070	0.127
16	0.039	0.202	0.116	0.181	0.063	0.171	0.102	0.153	0.059	0.121
17	0.067	0.126	0.109	0.093	0.055	0.106	0.122	0.168	0.036	0.098
18	0.046	0.204	0.154	0.214	0.075	0.124	0.112	0.177	0.076	0.131
19	0.047	0.161	0.105	0.164	0.131	0.169	0.093	0.068	0.115	0.117
20	0.043	0.216	0.089	0.173	0.260	0.218	0.026	0.078	0.167	0.141
21	0.025	0.103	0.054	0.319	0.211	0.251	0.033	0.077	0.190	0.140
22	0.033	0.119	0.067	0.232	0.209	0.359	0.099	0.086	0.128	0.148
23	0.094	0.027	0.128	0.236	0.250	0.257	0.117	0.148	0.316	0.175
24	0.066	0.091	0.152	0.234	0.169	0.277	0.230	0.139	0.308	0.185
Mean	0.067	0.100	0.098	0.173	0.096	0.153	0.092	0.081	0.103	

Table 2. Performance of 9 treatments for average dry weight of planktonic biomass, increase in fish production and biomass conversion efficiencies of treatments

A. ANOVA

S.O.V.	d.f.	Mean squares		
		Biomass ($g\ m^{-3}$)	Fish production (increase) ($g\ m^{-3}$)	Conversion efficiencies
Fortnight	23	19229.326**	731.196**	0.03613**
Treatment	8	37414.667**	1206.879**	0.02753**
Error	184	1039.848	66.457	0.00419

NS = Non significant (P>0.05); ** = Highly significant (P<0.01)

Comparison of means for different treatments

Treatments	**Means values**		
	Biomass ($g\ m^{-3}$)	**Increase in fish production** ($g\ m^{-3}$)	Conversion efficiencies
T0	30.08 ± 2.20 f	1.72 ± 0.59 d	0.067 ± 0.011 b
T1	107.67 ± 8.47 e	10.14 ± 1.18 c	0.100 ± 0.015 b
T2	123. 50 ± 10.1 cde	10.62 ± 1.65 c	0.098 ± 0.014 b
T3	132.30 ± 11.4 cd	21.14 ± 1.92 b	0.173 ± 0.030 a
T4	156.30 ± 14.3 ab	13.77 ± 1.46 c	0.096 ± 0.017 b
T5	167.50 ± 15.9 a	26.87 ± 1.48 a	0.153 ± 0.023 a
T6	142.90 ± 12.6 bc	12.21 ± 2.65 c	0.092 ± 0.017 b
T7	121.20 ± 10.2 de	11.37 ± 0.89 c	0.081 ± 0.011 b
T8	128.30 ± 11.0 cd	12.79 ± 1.45 c	0.104 ± 0.017 b

Means sharing similar letters in a column are statistically non-significant (P>0.05).

Comparison of means for different fortnights

Fortnight	**Means values**		
	Biomass ($g\ m^{-3}$)	**Increase in fish production** ($g\ m^{-3}$)	**Conversion efficiencies**
1	**62.78 ± 7.55 f**	**14.31 ± 3.31 b-e**	**0.242 ± 0.051 a**
2	**54.22 ± 5.73 f**	**13.18 ± 2.99 c-f**	**0.243 ± 0.044 a**
3	**71.11 ± 8.97 f**	**8.28 ± 0.82 efg**	**0.121 ± 0.032 b-f**
4	**69.11 ± 8.74 f**	**7.21 ± 1.06 efg**	**0.106 ± 0.018 c-g**
5	**74.00 ± 8.72 f**	**4.46 ± 0.59 fg**	**0.065 ± 0.013 e-i**
6	**73.78 ± 6.82 f**	**3.89 ± 0.77 g**	**0.053 ± 0.006 f-i**
7	**68.67 ± 7.71 f**	**2.10 ± 0.84 g**	**0.033 ±0.005 hi**
8	**84.20 ± 10.2 ef**	**1.94 ± 0.76 g**	**0.024 ± 0.002 i**
9	**86.00 ± 10.8 ef**	**2.03 ± 0.89 g**	**0.026 ± 0.005 i**
10	**108.70 ± 12.0 de**	**2.87 ± 1.42 g**	**0.027 ± 0.005 hi**
11	**118.90 ± 17.5 cd**	**4.88 ± 2.04 fg**	**0.064 ± 0.026 e-i**
12	**146.90 ± 15.2 bc**	**4.79 ± 2.16 fg**	**0.036 ± 0.010 ghi**
13	**144.80 ± 20.4 bc**	**10.84 ± 2.58 d-g**	**0.082 ± 0.014 d-i**
14	**172.40 ± 18.7 ab**	**10.68 ± 2.67 d-g**	**0.064 ± 0.010 e-i**
15	**188.00 ± 24.9 a**	**23.95 ± 2.28 a**	**0.127 ± 0.021 b-e**
16	**193.90 ± 20.9 a**	**24.07 ± 2.28 a**	**0.121 ± 0.020 b-f**
17	**194.40 ± 26.6 a**	**18.65 ± 2.22 a-d**	**0.098 ± 0.014 d-h**
18	**169.70 ± 25.8 ab**	**22.37 ± 2.23 ab**	**0.131 ± 0.020 b-e**
19	**171.00 ± 23.7 ab**	**20.98 ± 1.51 abc**	**0.117 ± 0.015 b-f**
20	**149.80 ± 23.2 bc**	**21.88 ± 1.46 ab**	**0.141 ± 0.028 bcd**
21	**150.30 ± 18.8 bc**	**23.04 ± 0.71 ab**	**0.140 ± 0.035 bcd**
22	**138.30 ± 18.4 bcd**	**22.96 ± 0.92 ab**	**0.148 ± 0.034 bcd**
23	**138.90 ± 16.6 bcd**	**25.99 ± 2.44 a**	**0.175 ± 0.031 bc**
24	**129.40 ± 14.9 cd**	**26.34 ± 1.99 a**	**0.185 ± 0.028 ab**

Means sharing similar letters in a column are statistically non-significant (P>0.05).

planktonic biomass of 168, 49 and 64 g m^{-3}, which increased the fish biomass by 43.70, 21.64 and 19.48 g m^{-3}, respectively. Maximum fish production was observed in the pond T_5, which was fertilized at the rate of 0.06 percent phosphorus along with 0.12 percent mineral nitrogen, which were in line with Chakarbarti (1984); Tepe and Boyd (2001) and Barik *et al*. (2001). The same trend of maximum values of conversion efficiencies was observed in T_7 and T_8 (0.18 and 0.32) during the 18th and 23rd fortnights, where the dry weight of planktonic biomass increased to 148 and 131 g m^{-3} that increased the fish biomass to the tune of 26.14 and 41.46 g m^{-3}, respectively. So far as the reference pond i.e. T_0 was concerned, the value of maximum conversion efficiency remained as 0.25, which increased the dry weight of planktonic biomass by 8 g m^{-3} and ultimately the fish biomass by 2.04 g m^{-3} (Table 1).

Analysis of variance (Table 2) shows highly significant differences among the treatments as well as fortnights in respect of planktonic biomass, increase in fish production and biomass conversion efficiency ratios of ponds. Duncan's Multiple Range test revealed maximum fish production under T_5, followed by T_3, which were statistically different. These were followed by T_4, T_8, T_6, T_7, T_2 and T_1, which were statistically at par with each other but were in the given descending order. The minimum fish production was recorded under T_0, which received no additives. The biomass production was maximum (167.50g m^{-3}) in T_5, which was closely followed by T_4 and T_6 with the values of 156.30 and 142.90 g m^{-3}. Then came T_3 and T_8, which were statistically similar, followed by T_2, T_7, T_1 and T_0 with the values of 132.30, 128.30, 123.50, 121.20, 107.67 and 30.08 g m^{-3}, respectively (Table 2). These findings were in line with McCoy (1983), who achieved 10 fold increases in phytoplankton population after the addition of phosphorus fertilizer and another 10 fold by adding nitrogen fertilizer.

The increase in fish production, planktonic biomass and biomass conversion efficiencies of nine ponds were also compared at fortnight levels. The maximum values in planktonic biomass production remained between 12th to 24th fortnights, while the maximum values for fish production remained between 15th to 24th fortnights. However, the best period for converting biomass into fish weight was from 15th to 16th and 18th to 24th fortnights (Table 2).

During the period, the mean average water temperature values remained 24.21-33.18 ºC, the nitrates values remained 0.87-1.69 mgL^{-1} and the orthophosphates values remained 0.047-0.117 mgL^{-1}. These results fully substantiate the findings of Yousoff and McNabb (1989) and Tice *et al* (1996), who worked on effects of nitrogen and phosphorus on fish production in tropical fish ponds and concluded that additions of nitrogen and phosphorus stimulated production at all trophic levels.

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