Survey on Nutrients from Agricultural Products in Lake Ecosystem

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INTRODUCTION

Modern agriculture often involves the application of nutrients onto fields in order to maximise production. However, farmers frequently apply more nutrients than are taken up by crop– or pastures. Regulations aimed at minimising nutrient exports from agriculture are typically far less stringent than those placed on sewage treatment plants and other point source polluters. It should be also noted that lakes within forested land are also under surface runoff influences. Runoff can wash out the mineral nitrogen and phosphorus from detritus and in consequence supply the water bodies leading to slow, natural eutrophication.

MATERIAL AND METHOD

Under elevated nutrient conditions, we observed the highest zooplankton biomass and gizzard shad biomass. This trend supports previous findings suggesting that increased gizzard shad survival and biomass with productivity is linked to increased food availability, in particular to small zooplankton species such as rotifers (Claramunt & Wahl, 2000; Bremigan et al., 2008) and copepods (Bremigan & Stein, 2001). Responses of lower trophic levels As we expected based on previous studies (Cuker, 1987; Cuker et al., 1990), addition of nutrients caused consistent increase in phytoplankton biomass during the experiment, while the sediment addition caused an overall decrease in phytoplankton biomass, except for the chlorophyll concentration observed in the first 2 weeks of the experiment (Fig. 3a). This short-term enhancement of phytoplankton biomass early in the experiment in the +S treatments probably was caused by phosphorus release from the initial sediment addition (see NVSS, nutrient and light below). The opposite seasonal trends in phytoplankton biomass between the +N and +N+S treatments suggest that greater phytoplankton sinking rates, probably due to flocculation during weekly sediment additions, caused an overall decrease in phytoplankton biomass in the +N+S treatment. Finally, we observed greater light penetration (lower k) in the +S treatment than in the +N and +N+S treatments during the last 5 weeks of the experiment (Fig. 5d). Therefore, lower phytoplankton biomass in the sediment treatment cannot be explained by a decrease in light penetration with sediment addition. Overall, phytoplankton biomass was considerably greater than periphyton biomass at the end of the experiment. However, the opposite responses of phytoplankton and periphyton biomass to the sediment addition (Fig. 4) suggest that the decline of periphyton on the walls of the tanks when nutrients were less limiting (+N+S treatment). Burkholder & Cuker (1991) also reported enhancement of periphyton growth with the addition of clay and phosphorus and suggested facilitation of phosphorus uptake from settling particles as a potential mechanism. Wolfe & Lind (2008) reported no negative effect of clay addition on nutrient uptake by periphyton at sediment concentration greater than those present in our enclosures (20, 80 and 200 mg L)1). In spite of the overall positive effect of increased chlorophyll biomass on zooplankton, the temporal trends observed in species composition suggest a combined effect of predation and food availability on zooplankton biomass dynamics. The decline of zooplankton biomass observed in all treatments during the first 3 weeks of the experiment (mainly rotifers and adult copepods; Fig. 3c,e) seems to be associated with larval fish predation. During this time, gizzard shad (<25.0 mm) were most likely obligate zooplanktivores with preference for the small zooplankton taxa (rotifers and cyclopoid copepods) that declined in our experiment (Dettmers & Stein, 1992 DeVries & Stein, 1992; Bremigan & Stein, 1994, Welker, Pierce & Wahl, 1994; Miranda & Gu, 1998). However, during the last 2 weeks, gizzard shad (>25 mm) probably had become omnivorous likely feeding on bottom organic matter and periphyton as well as zooplankton (Mundahl & Wissing, 1987; Yako et al., 1996; Schaus et al., 2002; Higgins et al. 2006), and differences in phytoplankton availability and invertebrate predation seem to regulate zooplankton biomass. For example, the recovery of rotifer biomass during the last 4 weeks may be the result of a reduced invertebrate predation due to reduced cyclopoid biomass (Brandl, 2005), while the increase in cladoceran biomass may be associated with the increase in periphyton since littoral species such as Chydorus sp., Alona sp., Scapholeberis sp. and Simocephalus sp., dominated the cladoceran assemblage.

NVSS, nutrient and light The mean NVSS concentrations in our elevated sediment treatments (+S = 6.2 ± 1.4 mg L)1; +N+S = 5.9 ± 0.4 mg L)1) fall within the range of NVSS concentrations in Ohio eutrophic reservoirs (1.58–38.96 mg L)1 in sites near stream inflows; 0.48–10.68 near dam outflows; Knoll et al., 2003), but we detected a rapid decline in turbidity during the experiment. However, gizzard shad were probably exposed to greater mean NVSS concentrations during the experiment than those reported here because our weekly NVSS measurements were collected 2 days after the most recent sediment addition. To obtain information about the maximum concentration of NVSS during the experiment, we measured light penetration and calculated k an hour after each sediment addition during 1 week of the experiment (23–29 June). We used these data to calculate the NVSS concentrations immediately after sediment addition using a relationship between NVSS and k (NVSS = 8.40 ǂ k) 17.82) during our experiment. Assuming a linear decline in NVSS concentration, the mean NVSS concentrations an hour after the sediment addition were considerably greater than those after 2 days of sediment addition (+S = 12.3 ± 4.6 mg L)1; +N+S = 9.1 ± 0.9 mg L)1). The higher TP values observed during the first 2 weeks of the experiment in the +S and +N+S treatments relative to the +N treatment seem to be 666 M. J. Gonza´lez et al. associated with release of P from the initial sediment addition. Pilati et al. (2009) determined a weekly P release of 1.2 g P week)1 from the 70 kg of sediments added to his ponds. Assuming the same release rate (per g sediment) as Pilati et al. (we used the same sediment slurry), our initial slurry (12.5 kg tank)1) released 42.9 lg P L)1, which represents 285% of the weekly P addition in the tanks (15 lg L)1) and 40.8% of the total P added during the entire experiment(105 lg L)1) in tanks receiving nutrient additions. The sediments added on a weekly basis during our experiment (1.19 kg tank)1) released 4.08 lg L)1, which represents only 3.9% of the total P added during the experiment to tanks receiving nutrient additions. Therefore, based on these calculations, the initial higher P concentration detected in our +S treatment was mainly caused by the initial addition of the sediment slurry. Reservoir management implications This study provides insights on the mechanisms underlying the success of gizzard shad in reservoirs in agricultural catchments. Furthermore, our findings support recommendations by previous studies (Vanniet al., 2005; Bremigan et al., 2008; Pilati et al., 2009) towards reservoir management practices considering the links between land use practices and food web dynamics. The findings of this study and Pilati et al. (2009) suggest that land use practices that reduce allochthonous nutrient and sediment inputs to productive reservoirs should negatively affect gizzard shad populations. Pilati et al. (2009) predicts that adult gizzard shad will grow more slowly and recruitment of YOY will also decrease under low nutrient and sediment inputs. According to our results, a primary potential mechanism underlying lower YOY recruitment would be decreased survival of larval gizzard shad due to lower food availability as nutrient and sediment inputs decrease.

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