The use of sheep manure as nutrient with fish feed in pond fish polyculture in Transkei

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Abstract

Sheep manure was used as a nutrient in addition to formulated feed in a fish-cum-vegetable integrated production experiment conducted during the summer of 1985 to 1986. Results obtained showed that this kind of manure is not very suitable for use in fish-ponds but that the nutrient rich water produced favourable vegetable growth. Fish species used in the polyculture system included the European common carp *C. carpio* and the Chinese carps *H. molitrix*, *C. idella* and *A. nobilis*. A total fish yield of almost 5 t ha^{-1} was obtained over a period of 149 d.

Introduction

This paper constitutes the last in a series of fish polyculture experiments conducted in Transkei where the effects of animal wastes on fish production were evaluated (Prinsloo and Schoonbee, 1984a to c, 1986). This is the second report dealing with the integration of aquaculture and agriculture, the first being an investigation on a duck-fish-vegetable integrated system. (Prinsloo and Schoonbee, 1986b).

One of the major reasons why sheep manure was used as a nutrient in fish polyculture is the fact that sheep and goats are traditionally farmed with in Transkei where they are kept overnight in kraals and where the manure can be collected for use if fish-ponds become available. With the construction of fish-ponds and the planting of the embankments with kikuyu grass, adequate growth of a permanent source of grazing is available where high densities of sheep can be kept throughout the year. This was in fact practiced in the fish pond area at the Research Station where 50 to 60 sheep and 12 head of cattle were kept on a area of approximately 2,5 ha.

As was the case with the duck-fish-vegetable integrated system, water from the sheep-manured fish-ponds was also used to irrigate a vegetable garden.

Materials and methods

Preparation of fish-ponds

Three 200 m^2 earthen fish-ponds at the Umtata Dam Fish Research Centre were used for the investigation. Each pond is provided with a monk overflow system. Piped water used in the ponds was gravity fed from a weir on the Umhlahlane River approximately 50 km away from the Research Station. The mean depth of the ponds, when full, was 0,75 m.

Ammonium sulphate as well as superphosphate was applied fortnightly to the ponds in quantities of approximately 70 and 60 kg ha^{-1} respectively. Liming of the ponds at 150 kg ha^{-1} took place fortnightly by spreading the lime over the surface of the pond water. The concentrations of the fertilisers used are in accordance with standard practices used in fish-ponds elsewhere in the world (Hepher and Pruginin, 1981).

In anticipation of possible problems with low oxygen levels in the ponds due to the manuring programme, constant aeration was provided to each of the three ponds by means of perforated plactic pipes which were connected to a low pressure high volume Roots D 90 L air blower. Demand feeders for the application of formulated feed were installed in each pond. Irrigation water required for a vegetable garden was siphoned off from each pond using 50 mm diameter PVC piping equipped with filters and stop valves.

Pond water chemistry

Analysis of pond water (Table 1) was initially done fortnightly on water samples collected between 07h00 and 08h00. During the second half of the experiments, weekly analyses were conducted to evaluate oxygen levels in the ponds which may have been affected by possible algal blooms.

Water temperatures in the ponds were recorded on an installed Thies hydrothermograph supplied with a seven day recorder.

Dissolved oxygen values of the water in the ponds were taken with a Sylan O_2 Meter Model 4002 R whilst pH values were measured with a portable Metrohm Meter Model E604, recording to the nearest 0,01 reading. Electrical conductivity was measured with a Metrohm Conductivity Meter Model E587. Chemical parameters were determined according to APHA (1980) (Table 1).

Fish species used in polyculture

The fish species included in the present series of experiments were the following:

The Israeli Dor 70 variety of the common carp, *Cyprinus carpio* L., the Chinese silver carp *Hypophthalmichthys molitrix* (Val.), the Chinese grass carp *Ctenopharyngodon idella* (Val.) and the Chinese bighead carp *Aristichthys nobilis* (Richardson).

All the fish used in the investigation were spawned and reared at the Research Station (Prinsloo and Schoonbee, 1983; Schoonbee and Prinsloo, 1984). In contrast with earlier projects (Prinsloo and Schoonbee, 1984a, b, c) the juveniles were first overwintered before being used the following summer when they were all large enough to grow to marketable sizes during the same summer growing season.

The mean stocking density per pond was 12 500 fish ha^{-1}. Stocking of the individual fish species which varied from 750 (grass carp) to 7 000 (common carp) fish ha^{-1} is listed in Table 2.

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TABLE 1
RESULTS OF REGULAR PHYSICAL AND CHEMICAL ANALYSES OF FISH-CUM-SHEEP POND WATER DURING THE PERIOD OCTOBER 1985 TO MARCH 1986

Analyses	N	x̄	Min	Max	Sx	CV
Ponds receiving sheep manure plus feed						
Dissolved oxygen mg ℓ^{-1}	27	4,6	2,4	8,2	1,64	35,60
pH	25		6,25	7,29	0,31	
Conductivity μS cm^{-1}	27	99,0	85,0	122,0	9,78	9,89
Alkalinity as $CaCO_3$, mg ℓ^{-1}	19	16,58	10,00	31,00	6,41	38,66
Total hardness as $CaCO_3$, mg ℓ^{-1}	24	23,25	10,00	40,00	7,37	31,70
Nitrate (NO_3), mg ℓ^{-1}	14	0,332	0,039	1,399	0,332	100,00
Ammonia (NH_4), mg ℓ^{-1}	24	0,558	0,157	0,959	0,241	43,18
Orthophosphate (PO_4), mg ℓ^{-1}	24	0,144	0,045	0,326	0,084	58,3

TABLE 2
MEAN VALUES OF THE INDIVIDUAL CONTRIBUTION OF THE VARIOUS FISH SPECIES TO THE TOTAL PRODUCTION IN THE THREE PONDS RECEIVING SHEEP MANURE AND FORMULATED FEED DURING THE PERIOD OCTOBER 1985 TO MARCH 1986 (149 DAYS)

	Stocking density and initial biomass ha^{-1}			Final total fish biomass					
Fish species	Mean stocking density ha^{-1}	Mean initial biomass (kg ha^{-1})	%	Final fish density ha^{-1}	Mean final biomass (kg ha^{-1})	%	Mean final individual mass of fish in g	Fish yield in kg ha^{-1}	%
Common carp	7 000	730,6	69,8	6 583	3 859,3	64,3	586,3	3 128,7	63,1
Bighead carp	1 000	69,0	6,6	917	342,1	5,7	373,1	373,1	5,5
Grass carp	750	142,1	13,6	750	767,0	12,8	1 022,7	624,9	12,6
Silver carp	3 750	104,3	10,0	3 033	1 035,2	17,2	341,3	930,9	18,8
TOTAL	12 500	1 046,0	100,0	11 283	6 003,6	100,0		5 057,6	100,0

Application of manure and formulated feed

Fresh sheep manure was obtained from a nearby kraal from sheep which grazed during the day amongst the fish-ponds at the Research Station. Since no information was available on the actual sheep manuring dosage levels required to stimulate optimal fish growth at the densities mentioned (Table 2), the initial quantities applied during the first 32 day period amounted to 30,8 kg $ha^{-1}.d^{-1}$ (as dry mass). These quantities corresponded with application levels used for cattle manure (Prinsloo and Schoonbee 1984b) and they were gradually increased for subsequent periods to approximately 50, 85, 120 and 140 kg $ha^{-1}.d^{-1}$ respectively.

The feeding programme in the present series of experiments was based exclusively on the calculated biomass of the benthic feeding common carp alone, which was adjusted for each consecutive period indicated in Table 3. It was assumed that the other fish species would mainly utilise the natural production in the fish ponds. Formulated 18% protein Epol poultry laying pellets was used as food. The daily dosage food quantity amounted to 4% of the calculated total biomass of the common carp in the ponds. Food was applied by means of demand feeders constructed over the ponds. Applications of food took place each morning at 09h00. The experiment lasted for 149 d.

In order to monitor fish growth, subsamples equivalent to 30 to 40% of each species were collected and fish weighed individually, accurate to the nearest gram on an electronic balance. Weighing took place monthly. This enabled the calculation of estimates of the standing crop of the fish in the ponds for each consecutive period (Table 3).

Vegetable production

Two plots of equal size measuring 500 m^2 each, were used in the vegetable production experiment. Vegetables included beetroot, lettuce, potatoes, spinach and tomatoes. Subportions allocated to each vegetable type per plot are indicated in Table 4. Crop production results were converted to t ha^{-1}. The first vegetables were planted during the beginning of summer in October 1985. Experiments were terminated towards the end of March 1986 after a period of 5 months. Because of a severe hailstorm, tomatoes had to be replanted during the first week in December (midsummer). One complete crop of vegetables could be harvested over this period. Flood irrigation from the ponds receiving sheep manure, was done weekly when necessary. Due to exceptionally high rainfall during this period, irrigation was done infrequently.

In addition to nutrients in the irrigation water, inorganic and organic fertilizers were applied to the vegetable plots according to standard procedures prescribed for vegetable production by Jackson (1974), Joubert (1974), Joubert and Coertze (1980), Nott (1980) and Van Niekerk (1984).

When required, insecticides and fungicides were sprayed on crops such as potatoes, tomatoes and spinach with a knapsack sprayer. During cropping of each vegetable type, all edible material produced was accurately weighed to the nearest gram on an electronic balance. Vegetables were sold to the local community at a reduced rate.

TABLE 3
RESULTS OBTAINED ON THE COMBINED MEAN GROWTH AND PRODUCTION OF THE EUROPEAN COMMON CARP AND THE CHINESE BIGHEAD, GRASS AND SILVER CARPS USED IN POLYCULTURE IN PONDS RECEIVING SHEEP MANURE AND FORMULATED FEED DURING THE SUMMER PERIOD OCTOBER 1985 TO MARCH 1986 (149 DAYS)

					Empirical values based on final numbers and biomass for each species					
Period	Days	Date	Mean and range pond temp. for period (°C)	Stocking (s) and final (f) densities (fish ha^{-1})	Standing crop (kg ha^{-1})	Yield requirements (kg ha^{-1})	Production (kg $ha^{-1}.d^{-1}$)	Manure applied (as dry mass) for each period (kg ha^{-1})	Pelleted feed applied for each period (kg ha^{-1})	FCR (Feed conversion ratio)*
0	0	15/10/85		12 500 (s)	1 046,0					
1	32	15/10-14/11	17,3							
			14,6-20,0	11 550	1 813,3	767,3	24,0	988,1	1 131,1	1,5
2	57	15/11-9/12	22,5							
			21,6-23,4		3 068,7	1 255,4	50,2	1 271,3	1 484.2	1,2
3	85	10/12-6/1	22,6							
			21,1-23,6	11 400	3 884,7	816,0	29,1	2 457,0	2 452,5	3,0
4	120	7/1-11/2	21,2							
			20,6-21,6		5 444,4	1 559,7	44,6	4 200,0	3 500,0	2,2
5	149	12/2-12/3	20,3							
			17,8-22,5	11 283 (f)	6 003,6	559,2	19,3	4 054,1	4 205,0	7,5
					Total:	4 957,6	$\bar{x}$ = 33,5	Total:	12 772,8	$\bar{x}$ = 2,6**

*Calculations based on feed quantities used
**Mean FCR over entire period

TABLE 4
VEGETABLE PRODUCTION OBTAINED USING SHEEP MANURE AND FRESHWATER FOR FIVE DIFFERENT VEGETABLES. RESULTS EXPRESSED IN PRODUCTION PER HECTARE

			Sheep manure water		Freshwater	
Vegetables	Relative sizes of plots per crop (m^2)	(%)	Production in kg $plot^{-1}$	Production in t ha^{-1}	Production in kg $plot^{-1}$	Production in t ha^{-1}
Beetroot	2 220	22,2	7 570,2	34,1	7 281,6	32,8
Lettuce	1 110	11,1	7 259,4	65,4	5 860,8	52,8
Potatoes	2 780	27,8	12 982,6	46,7	11 648,2	41,9
Spinach	1 670	16,7	7 548,4	45,2	6 880,4	41,2
Tomatoes	2 220	22,2	19 580,4	88,2	14 319,0	64,5
TOTAL	10 000	100,0	54 941,0		45 990,0	

Results

Water chemistry of fish ponds

Despite the considerable loads of manure applied to the ponds, values for ammonia, nitrate and soluble reactive phosphorus were seldom exceptionally high (Table 1). The values recorded for dissolved oxygen, with a minimum of 2,4 mg ℓ^{-1} never declined to levels low enough to endanger fish life. Values for pH were on the average not very high, indicating in part also the general lack of algal blooms which usually occurred in fish ponds which receive chicken manure (Prinsloo and Schoonbee 1984a, b, c). A factor which may have contributed towards the relatively low levels of organic nutrients in the water in the sheep manured ponds, is the regular replacement of irrigation, evaporation and seepage water from the ponds with clean piped water from a mountain stream.

Fish production results

Information on the results obtained on fish growth and production, the quantities of manure and feed used as well as yields and feed conversion, is contained in Tables 2 and 3.

Survival of all the fish species in the three ponds used in the present investigation, was generally good. With the exception of the silver carp (81,0% survival), the mortalities amongst the other species were less than ten per cent (Table 2). The total yield obtained (Figure 1) over a period of 149 d was close to 5 t ha^{-1} which does not compare well with fish-ponds receiving fresh duck manure for the same summer season (Prinsloo and Schoonbee, 1986b). Although the common carp contributed most towards the eventual fish yield obtained, it was the silver carp which increased its relative importance by almost 9%. The bighead and grass carps showed a slight decline in their eventual relative contribution (Table 2). Maximum production exceeded 50,2 kg $ha^{-1}.d^{-1}$ with a mean over the entire period of 33,5 kg $ha^{-1}.d^{-1}$ (Table 3; Figure 1).

Values for feed conversion based on the feed applied to common carp only, were generally good except for one period between 12 December 1985 and 6 January 1986 when it increased to 3,0 and also during the last 29 d period (February to March 1986) when the feed conversion ratio deteriorated to 7,5. Because of this, the mean FCR for the entire period increased to 2,6. (Table 3).

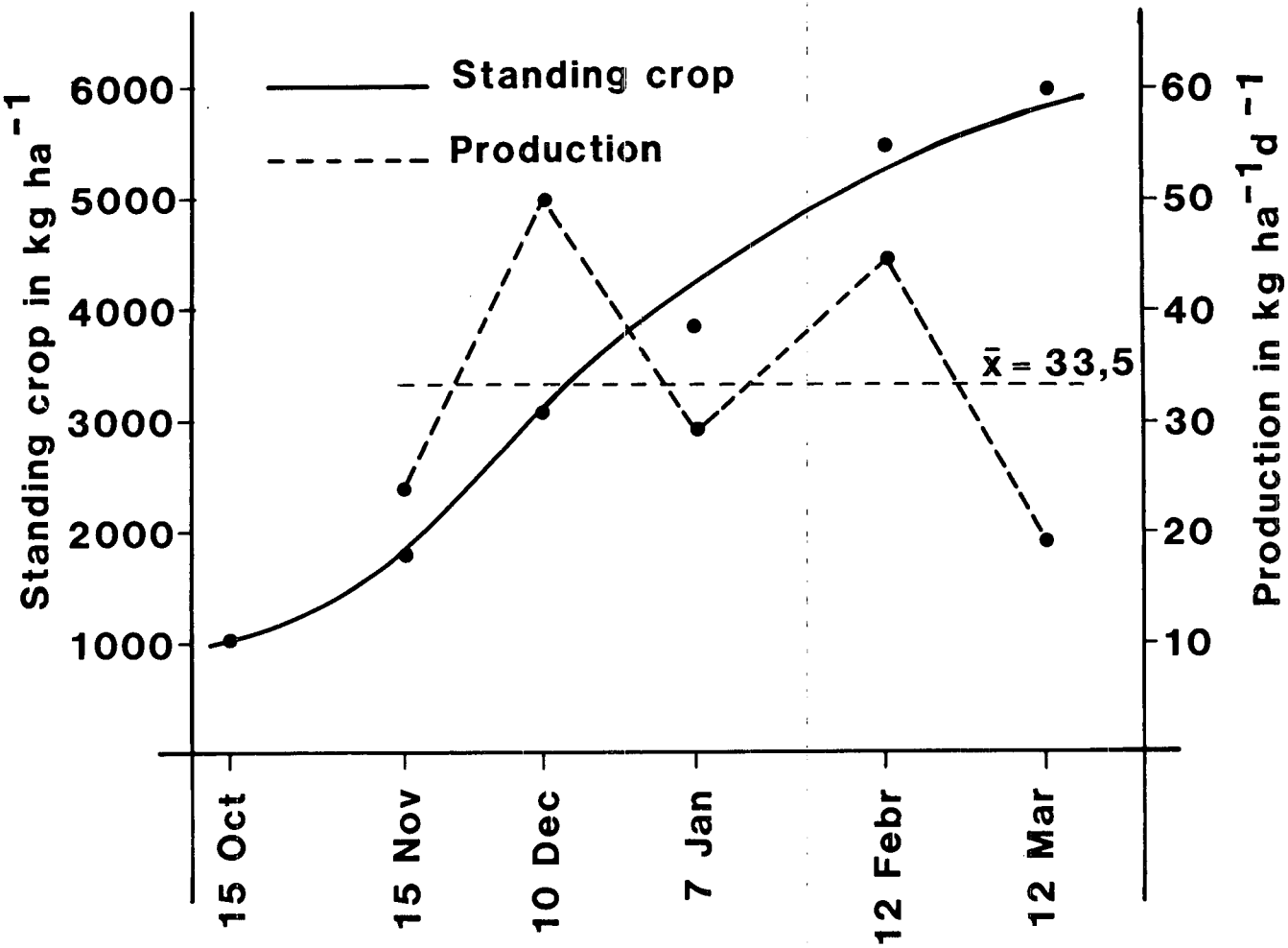

Figure 1
Fish standing crop (kg ha^{-1}) and production (kg ha^{-1}.d^{-1}) in ponds receiving sheep manure and formulated feed.

Vegetable production

A comparison was made of the effects of irrigation water on vegetable production using on the one hand sheep manured water and on the other freshwater (Table 4). This comparison showed an overall higher production where the manured water was used, with lettuce and tomatoes benefitting most (Table 4). In the case of tomatoes a yield of 88,2 t ha^{-1} was obtained compared to 64,5 t ha^{-1} where freshwater was used.

Discussion

The integration of agriculture with aquaculture has received increasing attention in recent years with emphasis on the incorporation of animal manures as a nutrient in fish ponds. (Delmendo, 1980; Schroeder, 1980; Nash and Brown, 1980). The integration of duck, geese and chicken with fish polyculture systems is amongst the most popular in Far Eastern and European countries. (Sin 1980; Woynarovich, 1980a; Wetcharagarun, 1980) followed by pig-cum-fish and cattle-cum-fish production systems (Chen and Li, 1980; Cruz and Shehadeh, 1980; Tan and Khoo, 1980; Schroeder, 1978; Wohlfarth, 1978; Wohlfarth and Schroeder, 1979; Woynarovich, 1980b). Scant information is however available on the integration of sheep farming with aquaculture with the present data providing the first results on the use of sheep manure as a nutrient in a fish pond polyculture system in South Africa.

Fish production results obtained with sheep manure do not compare well with those of fresh duck manure (Prinsloo and Schoonbee, 1986b); However, fish species such as the silver carp benefitted from the use of this kind of manure in fish ponds (Table 2), probably because of the utilisation of bacteria which accumulated on the suspended manure particles in the water.

If the results obtained on the use of various kinds of manure in fish polyculture production in Transkei are considered (Prinsloo and Schoonbee, 1984a, b, c; 1986; 1987) the comparative effectiveness of the manures on the development of organisms in the food web is as follows: duck manure > pig manure > chicken manure > cattle manure > sheep manure. It must be pointed out however, that sawdust used to collect chicken manure, negatively affects the overall efficacy of this manure type when applied to fish-ponds. In this case raw manure without the inclusion of foreign material should be used to promote biological activity in ponds. Based on our experience with sheep manure, it is advised that this manure should preferably not be used in fish-ponds but rather be incorporated in compost for direct use on cultivated land. Where fish-cum-vegetable irrigation ponds are used in rural development programmes, the utilisation by sheep farmers of the grazing area amongst the ponds should receive priority as the carrying capacity has proved in the present investigations to be high compared to ordinary grazing land, sustaining 30 to 50 sheep ha^{-1} without additional fertilisation of the grazing area.

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