BIOFLOC TECHNOLOGY –THE FUTURISTIC TECHNOLOGY FOR IMPROVING THE ECOLOGICAL & ECONOMIC SUSTAINABILITY OF SHRIMP FARMING AND PRAWN SEED PRODUCTION

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Biofloc Technology

Conversion of waste in to value:Biotechnological applications

Biofloc technology for the waste management in shrimp Aquaculture system

What is Biofloc technology?

- The basic principle of the activated suspension technique (AST) recently referred to as biofloc technology (BFT).

- . **BFT is the retention of waste and its conversion to biofloc as a natural food within the culture system**

Biofloc technology- Role of heterotrophic bacteria unassuming

- C:N ratio – 10:1 were optional for optimizing biofloc production
- 20-25 % of feed protein retained in fish
- Remaining – Ammonia , organic N2 in faeces, feed residue.
- Under optimum C:N ratio, inorganic nitrogen is immobilized into bacterial cell while organic substrates are metabolized.
- Conversion of ammonia – microbial protein – less dissolved oxygen is required when compared to oxygen requirement for nitrification
-
- * Preference for heterotrophic bacteria rather than nitrifying bacteria in Biofloc system
- **Growth rate and microbial biomass yield per unit substrate of heterotrophs are a factor 10 higher than that of nitrifying bacteria (Hargreaves,2006)**

Shrimp farming in crisis?

- Generation of wastes and pollutant in farms
- Lack of quality protein for the production of feed.
- Too much dependence on fishmeal and fish oil.
- Decline production,regular crop loss.
- Affected industry-financial loss
- Sustainability issues-ecological,economic

Environmental issue of shrimp aquaculture

Shrimp aquaculture in India-boomed 1990-95

Collapsed during 1995-96 - disease out break.

Nitrogen –Key role in aquaculture- duel function

- Nutrient
- Toxicant

Excessive accumulation of toxic inorganic nitrogen – Major threat to pond ecology.

Deterioration of surrounding environment.

Development of methods / solutions

- Water exchange
- Environment regulations
- Danger of pathogen introduction

- Huge expenditure-Pumping

Use of biofilters

- Enhancement of nitrification of ammonia to nitrite nitrate $\rightarrow$ – biofilters
- Use of nitrifying bacteria – expensive

Removal of ammonium from water through its assimilation into microbial protein by addition of carbonaceous materials

- Carbohydrate can potentially eliminate the problem of inorganic nitrogen accumulation.
- Advantage of the process - potential utilization of microbial protein as a source of feed protein for fish or shrimp.
- Ability of the animal to harvest such bacteria and to digest and utilize the microbial protein?
- Obvious constraint - Minimal size of the particles that can be imbibed by the shrimp
- Relatively large microbial cell clusters formed due to flocculation alone or in combination with clay or feed particles and the microbial protein favours to the growth of fish and shrimp. (Avinimelech 1982,1984)

Biofloc technology- (BFT)

Principle

This technology utilizes the co-culture of heterotrophic bacteria and algae grown in flocs under controlled conditions within the culture pond. Thus microbial biomass is grown on unconsumed feed, fish excreta, inorganic nitrogenous products resulting in a removal of these unwanted components from the water. The major driving force is the intensive growth of heterotrophic bacteria which consume organic carbon (Schryver, 2008). Avnimelech (1999) calculated a carbohydrate need of 20g to immobilise 1 g of N, based on a microbial C/N ratio of 4 and a 50 % C in dry carbohydrate.

What is biofloc ?

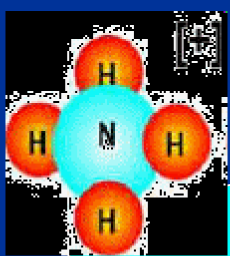
Flocs consist of a heterogenous mixture of microorganisms (floc formers and filamentous bacteria), particles, colloids. Organic polymers, cations and dead cells and can reach more than 1000 µm in size. Typical flocs are irregular by shape, have a broad distribution of particle sizes, are fine easily compressible, highly porous and are permeable to fluids.

Carbon Nitrogen ratio optimization as the backbone of BFT

- Controlling organic nitrogen by manipulating carbon/Nitrogen ratio potential control method for aquaculture system
- Practical and inexpensive means for reducing the accumulation of inorganic nitrogen.
- Nitrogen control is induced by bacteria with carbohydrate- Subsequent intake of nitrogen from water by the synthesis of microbial protein.

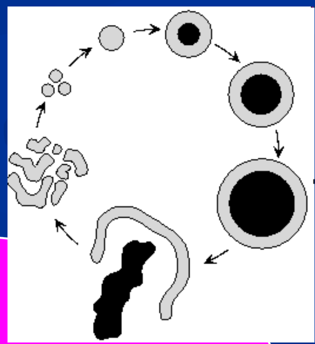
What is happening in this system?

Addition of Tapioca



Reduction of ammonia

Microbial conversion coefficient ie C/N ratio in the microbial bio mass + carbon content of the added material



Production of microbial protein

Prawn feed

Conversion of waste in to value

Biofloc-32-38% protein
Commercial production of Biofloc-dry form
Biofloc as a substitute for Fish meal in aquaculture feed

Industrial level units started functioning

Biofloc manipulation through C/N ratio optimization.

- **The Theory:** ***Avnimelech (1999)***

  Inorganic nitrogen in aquaculture system can be controlled by the addition of carbohydrate

  It is a practical and inexpensive means of reducing the accumulation of inorganic nitrogen in the pond

  Inorganic nitrogen control is induced by feeding bacteria with added carbohydrate, and through the subsequent uptake of nitrogen from the water, by the synthesis of microbial protein

The mechanism

The control of inorganic nitrogen accumulation is based on

1. Carbon metabolism
2. Nitrogen immobilizing microbial process

Bacteria and other microorganisms use carbohydrate (sugar, starch and cellulose) as food to produce protein and new cells (microbial cells)

Microbial conversion efficiency

which is the percentage of ***assimilated carbon with respect to metabolized feed carbon*** is accompanied by the immobilization of inorganic nitrogen - the basic microbial process taking place in the pond

- **The relationship among:**

  1.Addition of carbohydrate
  2.Reduction of ammonium / inorganic nitrogen
  3.Production of microbial protein

depends on

Microbial conversion efficiency
The carbon content of the added material

Previous study *Avnimelech et al (1992)*

Addition of carbonaceous substrate was found useful in reducing the inorganic nitrogen in commercial Tilapia ponds

The produced microbial proteins were consumed by the fish (Shrimp and fish filter out particles larger than 20 um)

This was also useful in reducing the feed cost by replacing the valuable protein partially

- Based on the above study the quantity of carbohydrate added was calculated following eq (1) and assuming that the added carbohydrate contains minimum 50 % carbon, the carbohydrate addition needed (Δ CH) to reduce total ammonia nitrogen concentration by 1 g nitrogen/ m^3 is 20 g /m^3

$$\Delta CH = \Delta N / 0.05 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

It can be assumed that ammonium flux into water, ΔNH_4^+ directly by excretion or indirectly by microbial degradation of feed residues, is roughly 50 % of the feed nitrogen

ΔN = Quantity of feed x % N in feed x % N excretion ……………………………(2)

The amount of carbohydrate addition needed to assimilate the ammonium flux into microbial protein is calculated using eqs. (1) and (2) :

ΔCH=Quantity of feed x % N in feed x % N excretion/0.05

Variables in the above equation

- Quantity of feed
- % Nitrogen in feed (Calculated from crude protein content of the feed)

Shrimp culture experiments based on biofloc technology

Application of Biofloc Technology in extensive shrimp farming

(No aeration)

Experimental design

Experimental tanks were distributed following RBD and triplicates were maintained for each treatment

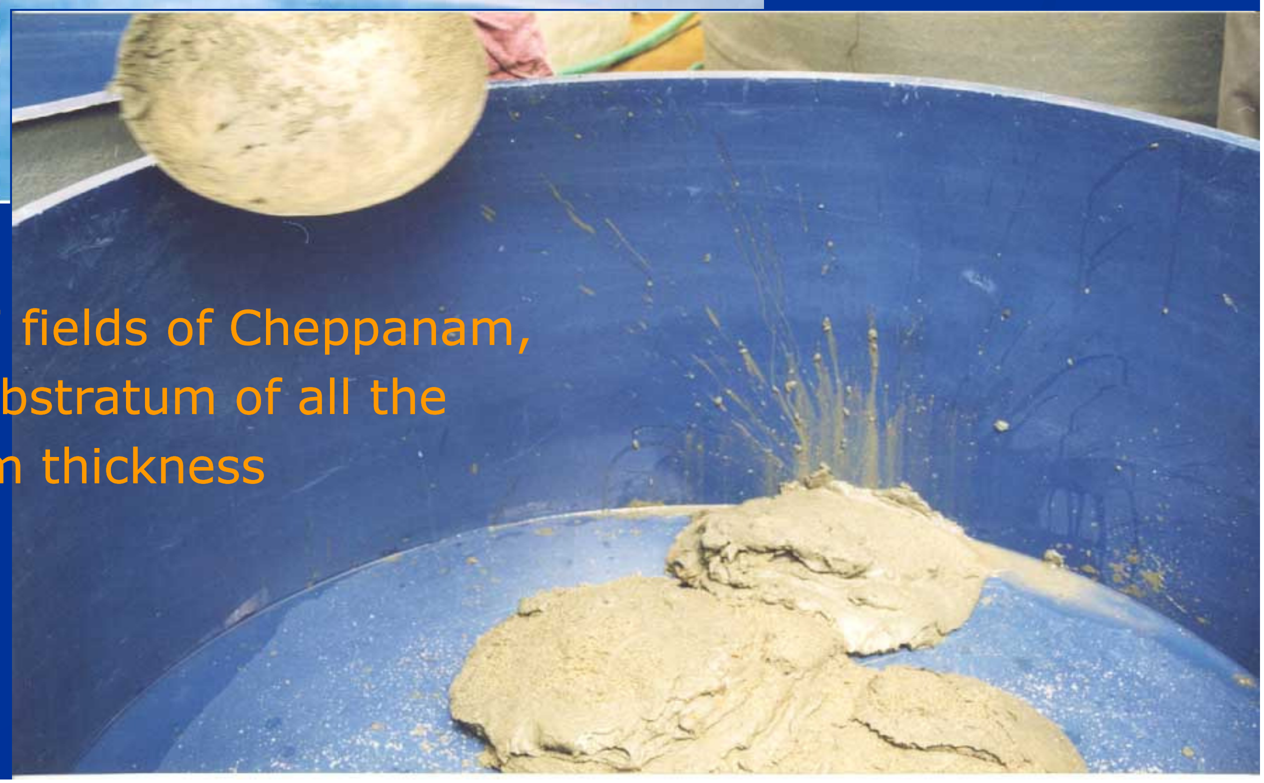
Treatment 1**: Shrimps fed with 40% diet (P40)**

Treatment 2**: Shrimps fed with 40% diet + application of carbohydrate source (tapioca flour) to the water column (P40 + CH)**
(20 g of CH were added per g of $N\text{-}NH_4^+$ released)

Treatment 3 **: Shrimps fed with 25% diet (P25)**

Treatment 4 **: Shrimps fed with 25% diet + application of carbohydrate source (tapioca flour) to the water column (P25 + CH)**
(20 g of CH were added per g of $N\text{-}NH_4^+$ released)

12 FRP tanks having 1200-liter capacity (each with a Bottom area: 1.86m²)



Mud collected from Pokkali fields of Cheppanam, Cochin was used as the substratum of all the experimental tanks at 6 cm thickness

Tanks were filled with seawater with 25 ppt salinity at 50 to 55 cm depth

Post larvae of *Penaeus monodon* were stocked at 6 m^{-2}
(a total of 12 shrimps per tank)

Two experimental diets :
Crude protein content of 40 and 25%
lipid content of 7%

The shrimps were fed two times daily (Morning and evening) at 15% of initial weight and adjusted gradually to 6% at the end of the culture

The quantity of carbohydrate added in the experiment was calculated following

Reference: Avnimelech,Y., 1999. Aquaculture 176, 227-235

40% dietary protein pellet feed contain 6.2% N and assumed 50% of feed nitrogen into water directly by excretion or indirectly by microbial degradation of feed we get:

Quantity of N excreted =100 g feed x 6.2/100 x 50/100

= **3.1 g N**

20 g Carbohydrate have to add for 1 g of N-NH_4^+

Quantity of CH for 100 g 40% feed = 3.1 x 20

= **62 g**

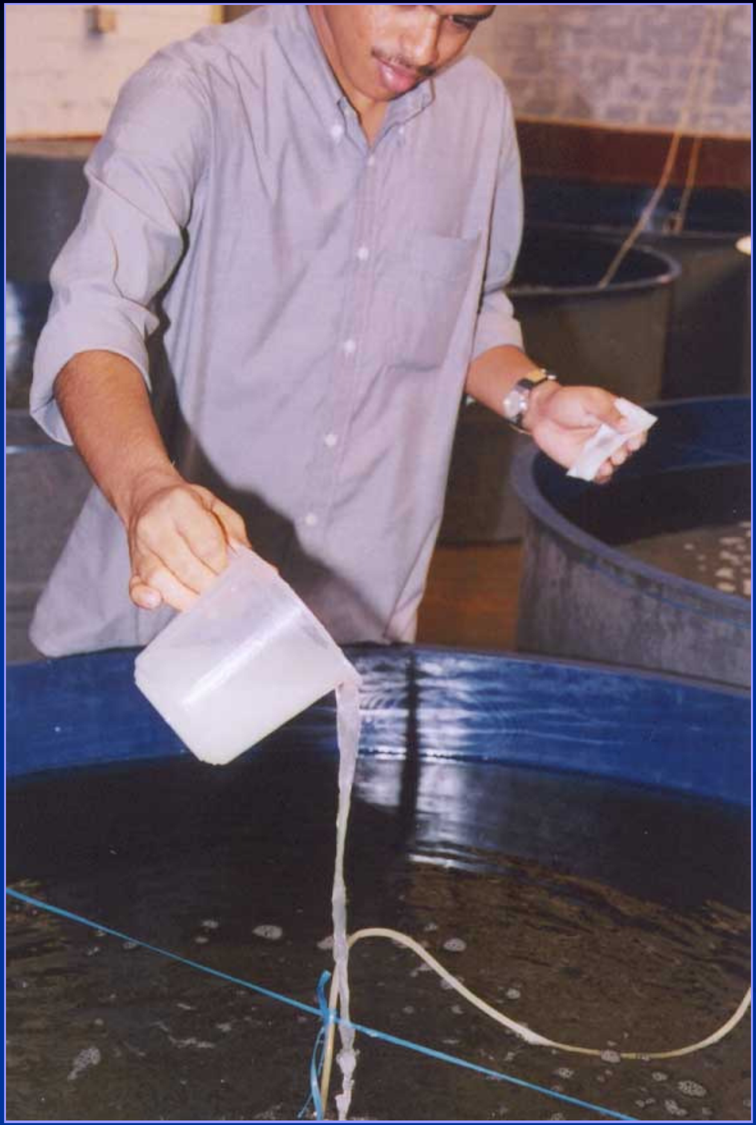
25% dietary protein pellet feed contain 3.88 % N

Quantity of N excreted =100 feed x 3.88/100 x 50/100

= **1.94 g N**

Quantity of CH for 100 g 25% feed = 1.94 x 20

= **38.8 g**



Carbohydrate was added to the water column once daily @ 20 g of CH per g of N-NH_4 released. Assuming 50% of the dietary protein was wasted

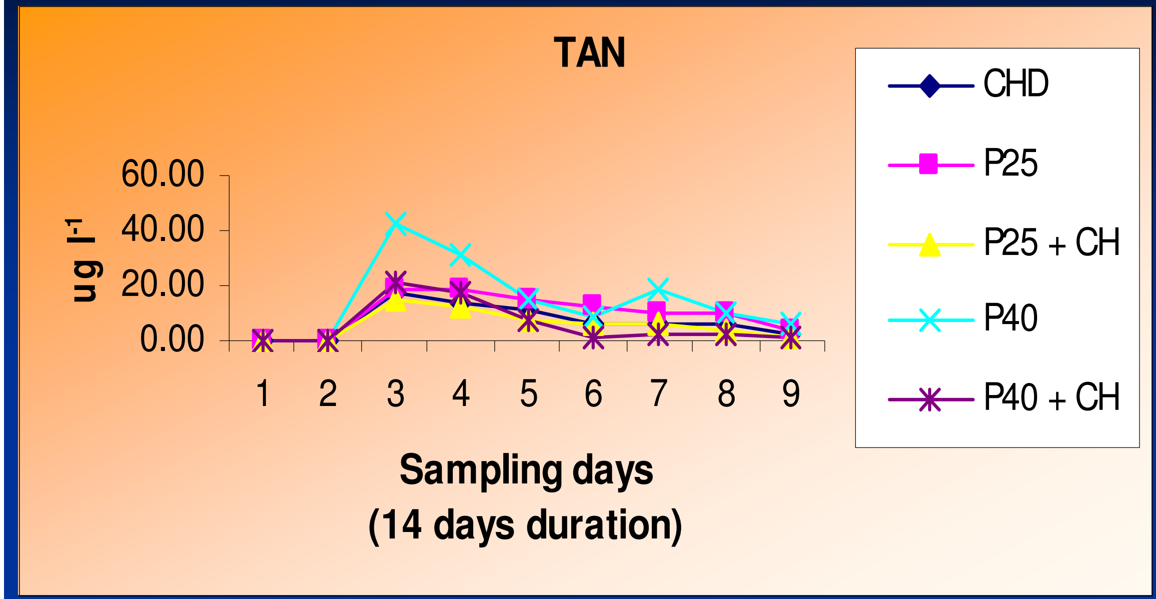
Effect of carbohydrate addition and dietary protein level on the water and sediment quality in outdoor

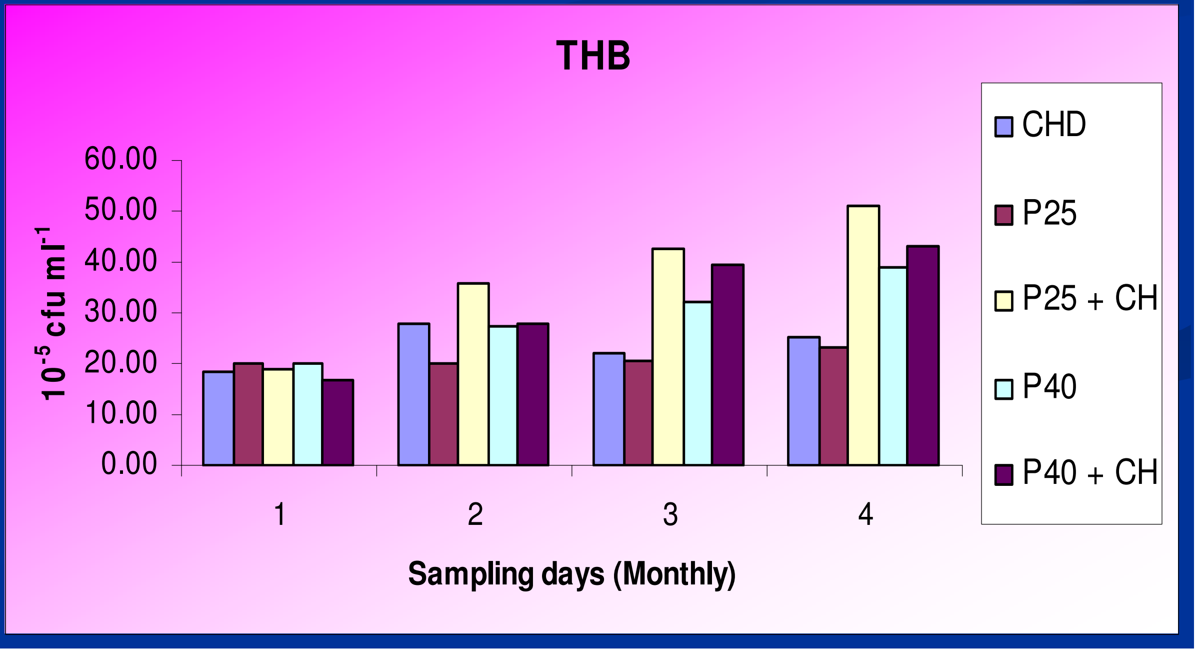
	Treatments (mean ± SD)				
	CHD	P25	P25 + CH	P40	P40 + CH
Water quality variable					
BOD ($mg\ l^{-1}$)	3.93 ± 1.98^{ac}	3.31 ± 1.86^{ab}	2.96 ± 1.85^{b}	3.70 ± 2.05^{bc}	4.30 ± 2.05^{c}
Alkalinity ($mg\ CaC0_3\ l^{-1}$)	80.31 ± 29.54^{a}	79.37 ± 34.88^{b}	84.64 ± 33.09^{ab}	68.21 ± 28.14^{c}	84.32 ± 30.93^{ab}
TAN ($ug\ l^{-1}$)	7.04 ± 5.99^{ab}	9.79 ± 6.91^{a}	5.91 ± 4.98^{b}	14.69 ± 15.84^{c}	8.61 ± 10.60^{ab}
Nitrite-N ($ug\ l^{-1}$)	1.40 ± 2.07^{b}	2.03 ± 2.96^{a}	0.81 ± 1.12^{c}	3.38 ± 5.01^{d}	1.99 ± 3.15^{a}
Nitrate-N ($ug\ l^{-1}$)	3.38 ± 1.67^{a}	3.14 ± 1.23^{a}	3.13 ± 1.42^{a}	3.61 ± 1.99^{a}	3.29 ± 1.75^{a}
THB (10^{-5}cfu ml^{-1})	23.5 ± 6.74^{cd}	20.8 ± 6.95^{d}	37.0 ± 14.26^{ab}	29.7 ± 9.62^{bc}	31.9 ± 11.62^{ab}
Chlorophyll -a ($ug\ l^{-1}$)	28.97 ± 37.74^{a}	30.33 ± 31.24^{a}	45.03 ± 56.86^{a}	37.35 ± 26.08^{a}	60.85 ± 33.24^{a}
Sediment quality variable					
Soil pH	8.33 ± 0.34^{a}	8.25 ± 0.21^{a}	8.29 ± 0.18^{a}	8.24 ± 0.22^{a}	8.26 ± 0.16^{a}
TAN ($ug\ l^{-1}$)	20.70 ± 8.10^{a}	20.16 ± 8.20^{a}	17.84 ± 6.67^{d}	25.94 ± 9.97^{c}	22.0 ± 8.87^{b}
Nitrite-N ($ug\ l^{-1}$)	0.02 ± 0.02^{a}	0.03 ± 0.02^{a}	0.03 ± 0.02^{a}	0.03 ± 0.03^{a}	0.03 ± 0.02^{a}
Nitrate-N ($ug\ l^{-1}$)	0.14 ± 0.15^{a}	0.11 ± 0.09^{a}	0.12 ± 0.10^{a}	0.1 ± 0.08^{a}	0.12 ± 1.00^{a}
Organic carbon ($ug\ l^{-1}$)	11.12 ± 4.03^{a}	10.39 ± 3.92^{a}	12.13 ± 3.84^{a}	11.01 ± 3.61^{a}	11.52 ± 3.68^{a}
THB (10^{-7}cfu ml^{-1})	50.61 ± 41.59^{b}	45.22 ± 29.01^{b}	74.56 ± 50.71^{a}	41.54 ± 23.36^{b}	73.80 ± 44.53^{a}

Results from ANOVA Two factor without replication

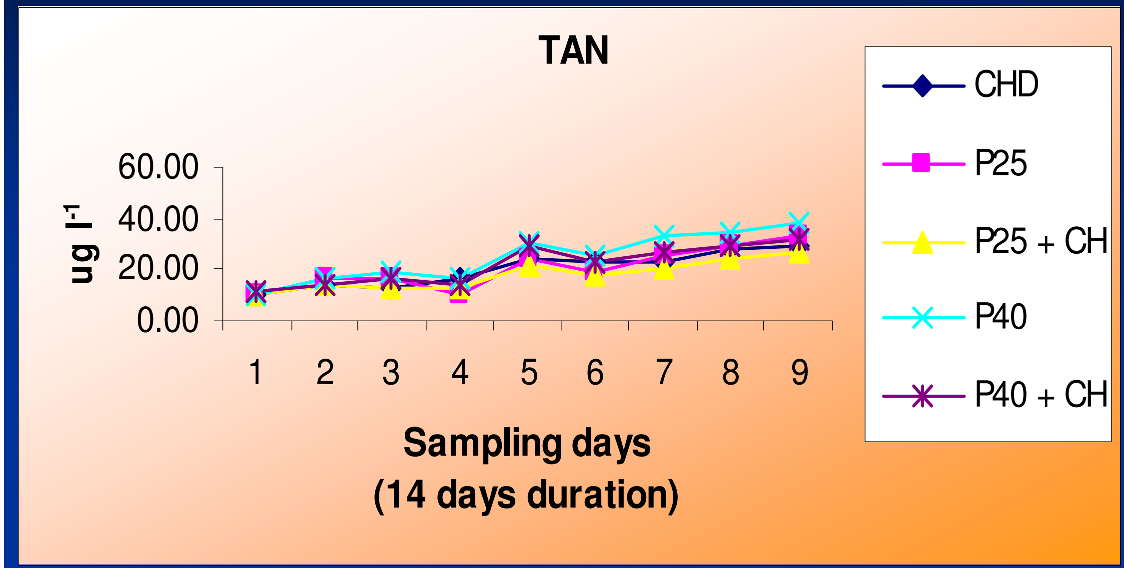
Treatments mean values in same row with different superscripts differ significantly ($P<0.05$)

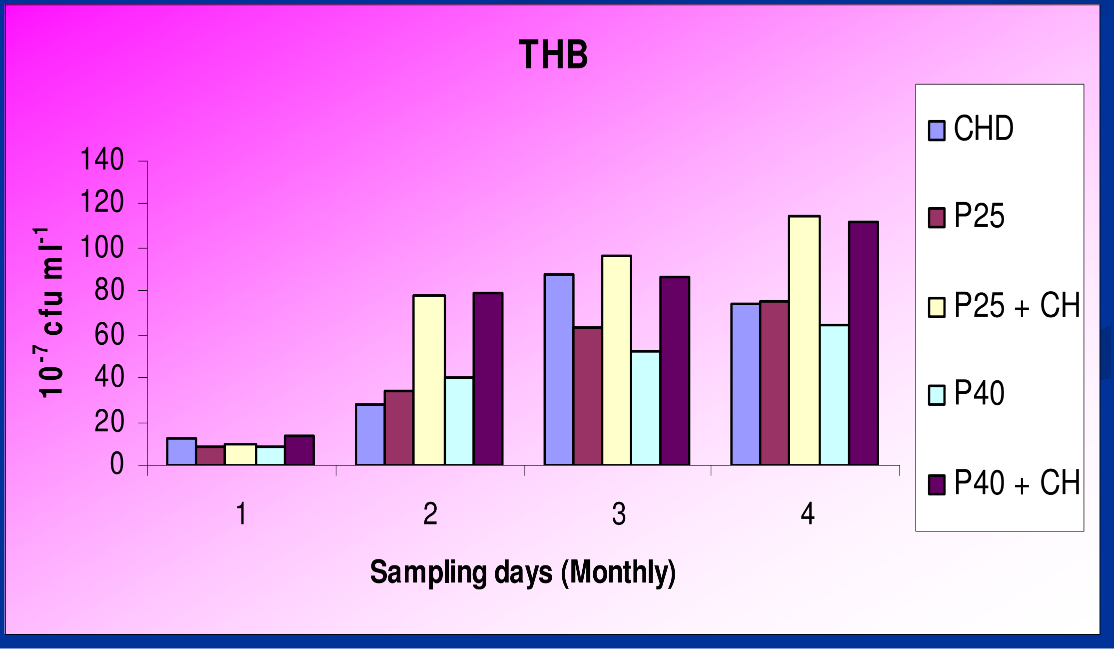
Water TAN and THB during the culture period





Sediment TAN and THB during the culture period





The difference in Shrimp growth

Effect of carbohydrate addition and protein levels on weight, shrimp yield, SGR, FCR, and survival of *Penaeus monodon* in Outdoor trial

Variable	Treatments (Mean ± SD)				
	CHD	P25	P25 + CH	P40	P40 + CH
Individual shrimp weight gain (g)	21.80 ± 1.18^{c}	21.11 ± 0.76^{c}	26.21 ± 0.45^{ab}	23.74 ± 0.29^{bc}	26.94 ± 1.70^{a}
Net shrimp yield (g m^{-2})	124.89 ± 10.24^{bc}	113.88 ± 10.72^{c}	148.44 ± 5.26^{a}	138.49 ± 7.52^{ab}	154.05 ± 7.93^{a}
Specific growth rate (SGR)	6.52 ± 0.05^{b}	6.49 ± 0.03^{b}	6.71 ± 0.01^{a}	6.61 ± 0.05^{ab}	6.73 ± 0.06^{a}
Feed conversion ratio (FCR)	1.40 ± 0.12^{ab}	1.54 ± 0.14^{a}	1.18 ± 0.04^{bc}	1.26 ± 0.06^{bc}	1.13 ± 0.05^{c}
Protein efficiency ratio (PER)	2.86 ± 0.23^{b}	2.56 ± 0.24^{b}	3.34 ± 0.11^{a}	1.94 ± 0.1^{c}	2.16 ± 0.1^{ab}
Feed conversion efficiency (%)	71.61 ± 5.87^{bc}	65.29 ± 6.15^{c}	85.10 ± 3.02^{a}	79.40 ± 4.31^{ab}	88.32 ± 4.55^{a}
Average daily weight gain (ADG)	0.17 ± 0.01^{c}	0.17 ± 0.01^{c}	0.21 ± 0.00^{ab}	0.19 ± 0.01^{bc}	0.22 ± 0.01^{a}
Net protein value (%)	23.60 ± 1.05^{cd}	21.43 ± 1.10^{d}	27.70 ± 1.25^{b}	25.50 ± 0.90^{bc}	28.50 ± 1.10^{a}
Survival rate (%)	81.75 ± 2.75^{a}	76.98 ± 4.96^{a}	80.95 ± 4.12^{a}	83.33 ± 0.01^{a}	81.75 ± 2.75^{a}

Results from Tukey One-way ANOVA

Treatments with mean values in same row with different superscripts differ significantly ($P<0.05$)

On farm trials of shrimp aquaculture using

Biofloc Technology

Design of Experiment

		Replicates
Treatment - 1	Stocking density: 6 shrimps / m^2; Feed: 40% crude protein; Water exchange minimum (P40)	**4**
Treatment - 2	25% + addition of Carbohydrate source to the water column (20 g of CH will be added per g of $N\text{-}NH_4^+$ released) (P25 + CH)	**4**

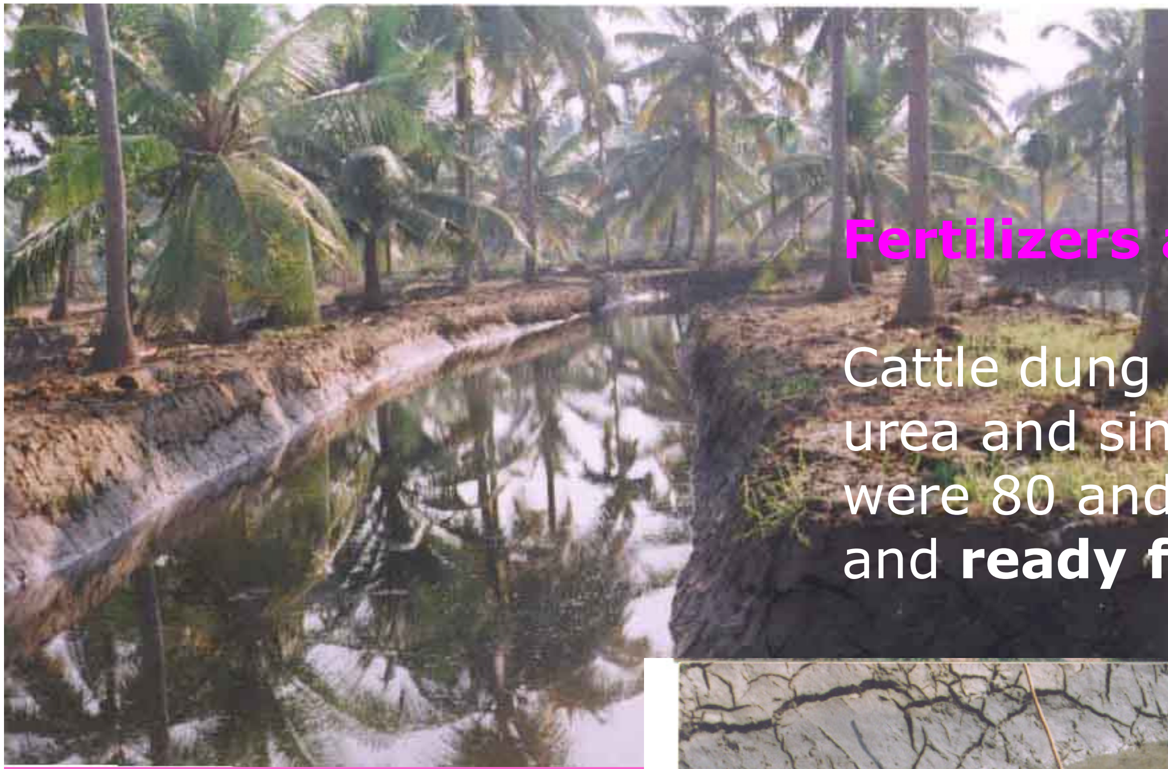
Eight earthen ponds with water spread area of 250 m^2 each

Ponds before preparation

Ponds preparing for the culture

Liming @ 250 Kg/ha

Water filling to the pond
24 ppt water



Fertilizers are applied :-

Cattle dung 1000 kg ha^{-1} $crop^{-1}$ urea and single super phosphate were 80 and 20 kg ha^{-1}, respectively and **ready for stocking**

Acclimatization and stocking

Carbohydrate application
@ 39g/ 100g, 25% shrimp feed

Harvesting 105th day of culture

Sub samples weighed and counted

Results

Daily water quality parameters in the on-farm tanks stocked with *Penaeus monodon*

Variable	Treatments (mean ± SD)	
	P40	**P25 + CH**
Temperature (^{0}C)	32.7 ± 1.0[a]	32.6 ± 1.8[a]
Water P^H	7.6 ± 4.2[b]	7.7 ± 4.6[a]
DO (mg l^{-1})	5.8 ± 2.3[a]	5.8 ± 1.3[a]
Salinity (ppt)	14.8 ± 1.3[a]	14.9 ± 1.3[a]
Secchi disk reading (cm)	60.9 ± 7.7[a]	59.4 ± 5.3[b]

Results from ANOVA Two factor without replication

Treatments mean values in same row with different superscripts differ significantly ($P<0.05$)

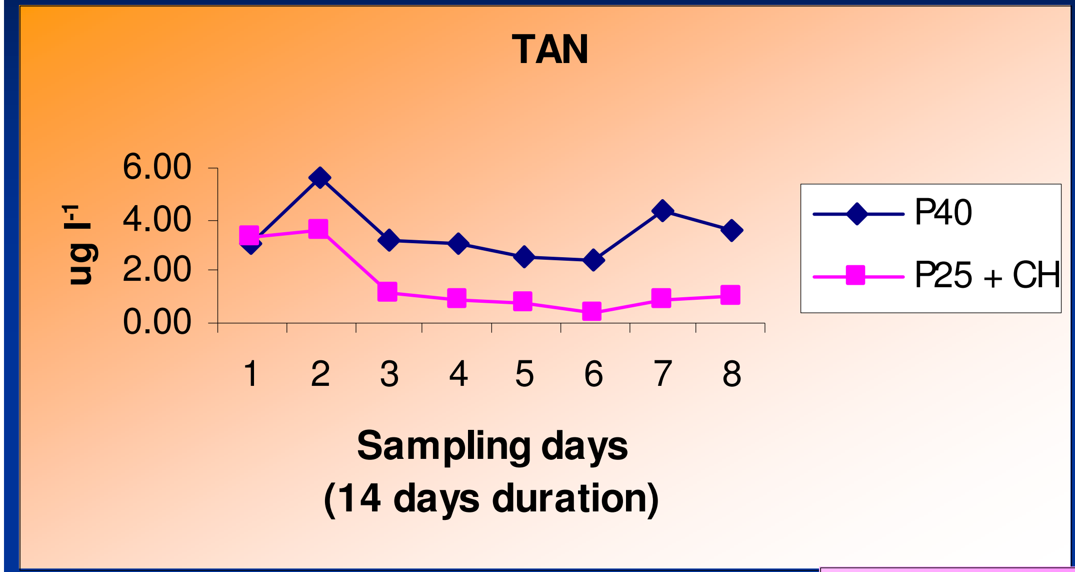
Effect of carbohydrate addition and dietary protein level on the water and sediment quality in on-farm

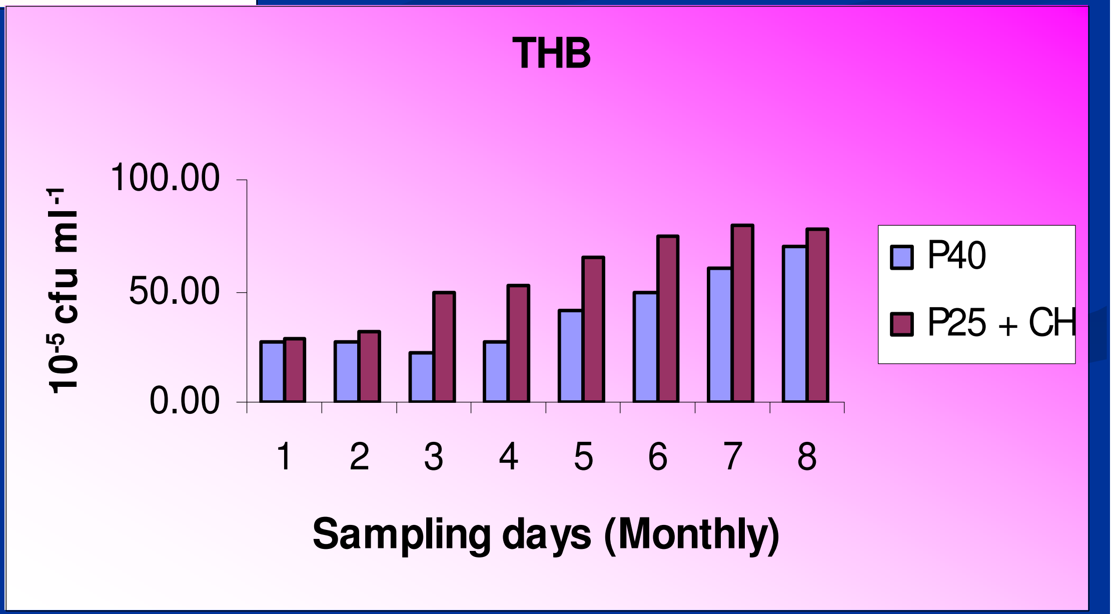
	Treatments (mean ± SD)	
	P40	**P25 + CH**
Water quality variable		
BOD (mg l^{-1})	4.4 ± 2.0^{a}	4.4 ± 1.6^{a}
Alkalinity (mg $CaC0_3$ l^{-1})	8.8 ± 1.8^{a}	8.6 ± 2.3^{a}
TAN (ug l^{-1})	3.4 ± 1.8^{a}	1.4 ± 1.3^{b}
Nitrite-N (ug l^{-1})	0.16 ± 0.08^{a}	0.14 ± 0.05^{a}
Nitrate-N (ug l^{-1})	0.95 ± 0.65^{a}	0.79 ± 0.61^{a}
THB (10^{-5}cfu ml^{-1})	40.59 ± 18.53^{b}	57.04 ± 20.7^{a}
Chlorophyll -a (ug l^{-1})	17.97 ± 15.7^{a}	18.89 ± 26.0^{a}
Sediment quality variable		
Soil pH	6.3 ± 0.1^{a}	6.3 ± 0.1^{a}
TAN (ug l^{-1})	26.6 ± 11.1^{a}	25.7 ± 8.9^{b}
Nitrite-N (ug l^{-1})	0.08 ± 0.06^{a}	0.08 ± 0.05^{a}
Nitrate-N (ug l^{-1})	0.14 ± 0.16^{a}	0.07 ± 0.07^{b}
Organic carbon (ug l^{-1})	19.6 ± 4.6^{a}	20.3 ± 5.6^{a}
THB (10^{-7}cfu ml^{-1})	41.5 ± 11.9^{b}	53.8 ± 17.3^{a}

Results from ANOVA Two factor without replication

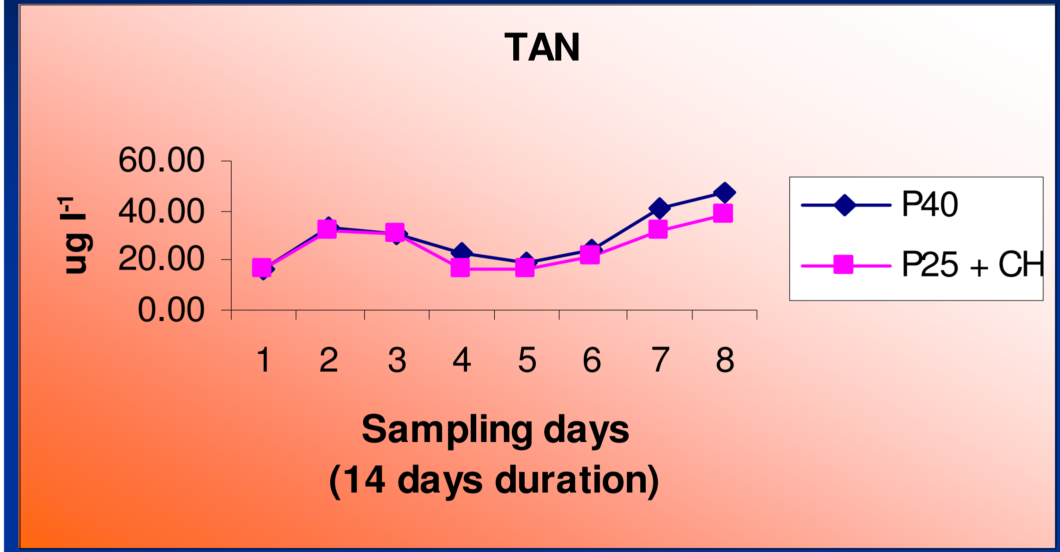
Treatments mean values in same row with different superscripts differ significantly ($P<0.05$)

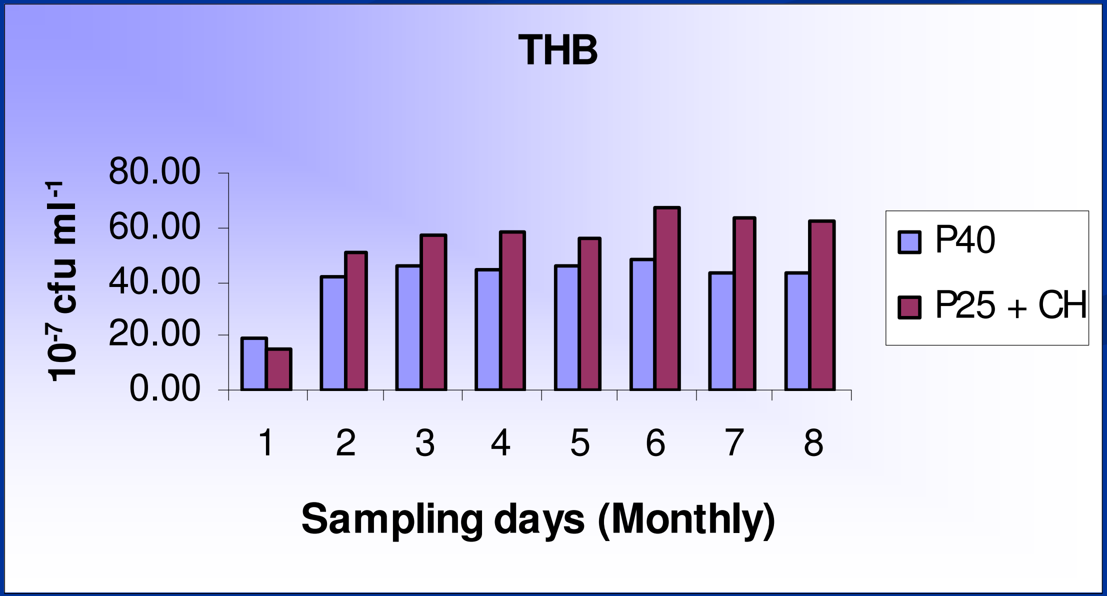
Water TAN and THB during the culture period





Sediment TAN and THB during the culture period





Effect of carbohydrate addition and protein levels on weight, shrimp yield, SGR, FCR, and survival of *Penaeus monodon* in On-farm trial

Variable	Treatments (Mean ± SD)	
	P40	**P25 + CH**
Individual shrimp weight gain (g)	21.0 ± 0.8[b]	25.7 ± 1.7[a]
Net shrimp yield (g m^{-2})	44.8 ± 7.8[b]	64.4 ± 12.2[a]
Specific growth rate (SGR)	7.6 ± 0.0[b]	7.8 ± 0.0[a]
Feed conversion ratio (FCR)	2.2 ± 0.0[b]	1.9 ± 0.1[b]
Protein efficiency ratio (PER)	1.01 ± 0.03[b]	2.00 ± 0.11[a]
Feed conversion efficiency (%)	43.9 ± 1.7[b]	53.6 ± 3.5[a]
Average daily weight gain (ADG)	0.22 ± 0.0[b]	0.27 ± 0.0[a]
Net protein value (%)	19.78 ± 3.4[b]	45.15 ± 7.5[a]
Survival rate (%)	35.5 ± 7.0[a]	42.2 ± 10.5[a]

Results from ANOVA single factor

Treatments with mean values in same row with different superscripts differ significantly (P<0.05)

Cost (Rs.) and economic analysis of on-farm experiment (per hectare)

Particulars	Quantity	Rate (Rs.)	Treatments	
			P40	P25 + CH
Variable cost				
Pond preparation	20 man days	150.0	3000.0	3000.0
Eradication	60 kg tea seed cake	30.0	1800.0	1800.0
Labour charge for eradication	4 man days	150.0	600.0	600.0
Lime	3200 kg	1.2	3840.0	3840.0
Cattle dung	1000 kg	0.5	500.0	500.0
Urea	320 kg	1.5	480.0	480.0
Super phosphate	80 kg	3.0	240.0	240.0
Shrimp seed	60,000 nos.	0.3	15000.0	15000.0
Shrimp feed (40% protein diet)	1320 kg	46.0	60720.0	0.0
Shrimp feed (25% protein diet)	1320 kg	26.0	0.0	34320.0
Tapioca flour	130 kg	10.00	0.0	1300.0
Salary of farm assistant	3 months	2500.00	7500.0	7500.0
Power cost	200 units	1.50	300.0	300.0
Harvest cost (Rs. kg^{-1})		5.00	2240.0	3222.0
Fuel cost	44 l	27.30	1200.0	1200.0
Total variable cost			**97,420.0**	**73,302.0**

Continued…

Particulars	P40	P25 + CH
Fixed costs		
Interest (5.83%)	5,680.0	4,274.0
Depreciation (1.94%)	1,890.0	1,422.0
Total fixed costs	7570.0	5696.0
Production		
Total shrimp yield (kg ha^{-1})	447.9^{b}	644.3^{a}
Price of shrimp (Rs. kg^{-1})	280.0	300.0
Economic analysis		
Total production costs	1,0,4990.0	78,998.0
Gross return (Rs.)	$1,25,412.0^{b}$	$1,93,290.0^{a}$
Net profit (Rs.)	$20,422.0^{b}$	$1,14,292.0^{a}$
Benefit / cost ratio	$\mathbf{0.2^{b}}$	$\mathbf{1.4^{a}}$

Results from ANOVA single factor

Treatments with mean values in same row with different superscripts differ significantly (P<0.05)

Results

- Water and sediment TAN level in treatment P25 + CH shows significantly low ($P<0.05$) concentration when compared with the treatment P40
- Water and sediment THB population in P25 + CH shows significantly higher ($P<0.05$) when compared with treatment P40
- In the shrimp harvest result shows significantly higher ($P<0.05$) individual weight, yield, SGR, FCR, PER, FCE, ADG and NPV in treatment P25 + CH
- The cost of feed and carbohydrate source for P25 + CH was lower than P40
- The total revenue from the harvested shrimp was 54% higher in treatment P25 + CH than in P40.

Conclusion

- Farming more economically viable by the reduction of dietary protein level by the addition of carbohydrate to the water column

- The added carbohydrate facilitated increased THB population while augmenting shrimp production

- The study improved the extensive shrimp farming system more ecologically sustainable

- The technology benefited the extensive farming practices by
  - Increasing production
  - Reducing feed cost
  - Reduced toxic inorganic nitrogen in the pond


Thankyou
for
Your kind
attention

Objectives

- Evaluation of efficiency of various cheap carbohydrate sources in controlling carbon / nitrogen ratio.

- Evaluation of enhancement of heterotrophic bacterial population in various carbohydrate added treatments.

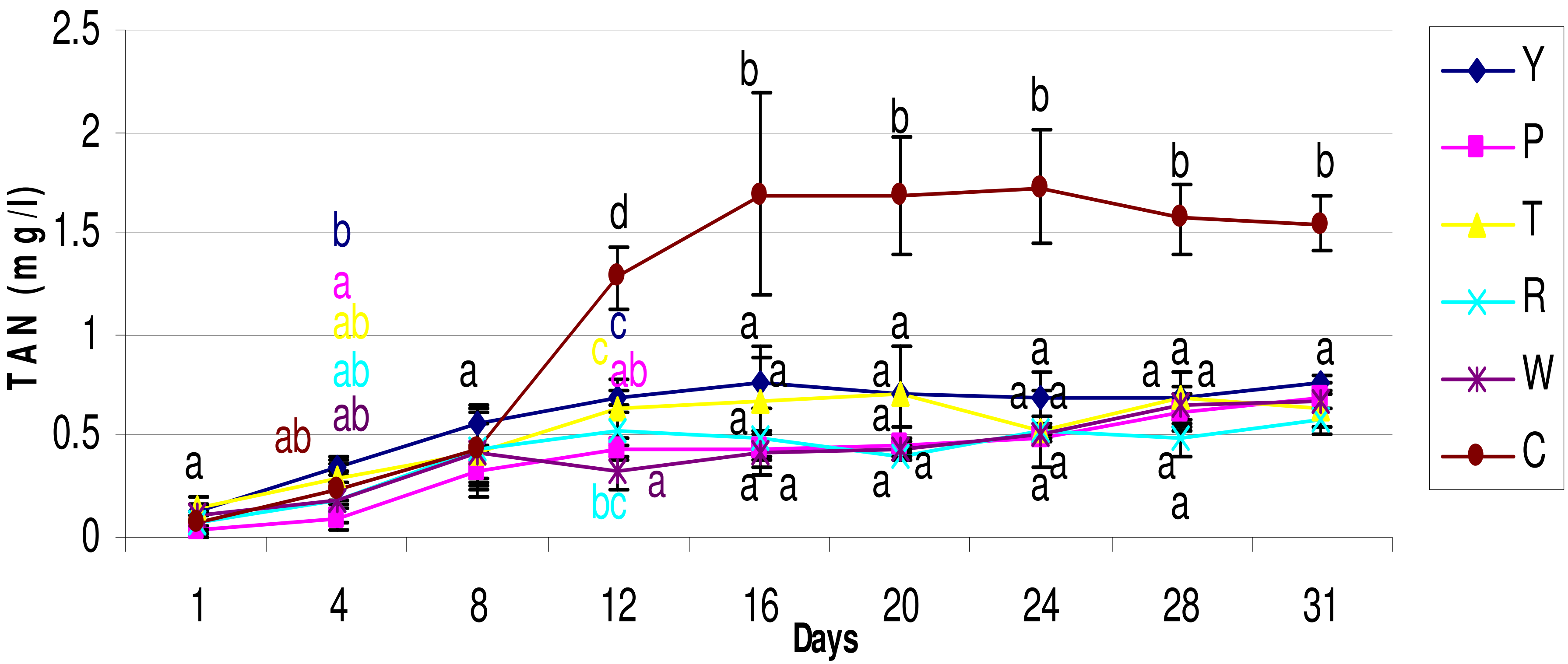
- Evaluation of post larval production in each carbohydrate source.

Treatment	Carbohydrate source
T1	Potato flour
T2	Yam flour
T3	Rice flour
T4	Wheat flour
T5	Tapioca flour
C	No carbohydrate

Results

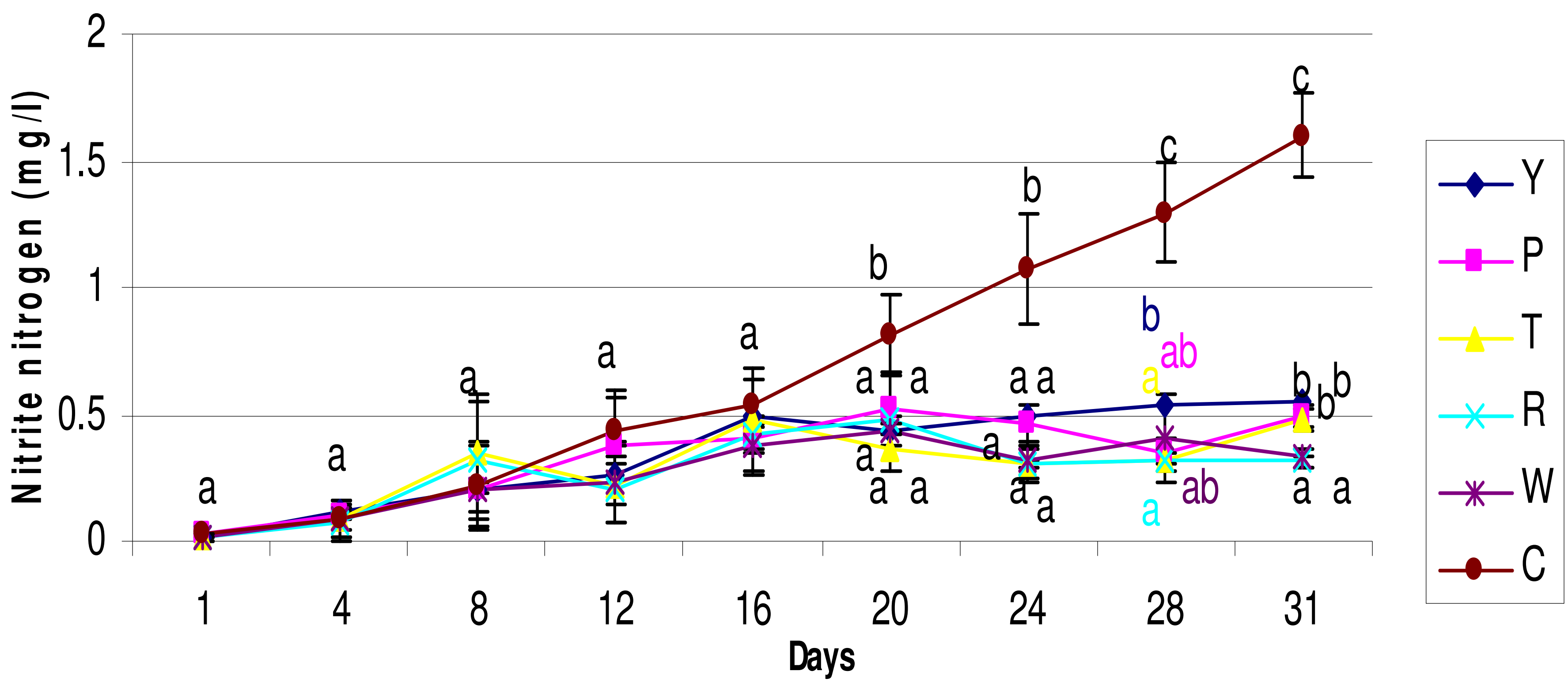
Ranges of various water quality parameters						
Parameters	Treatments					
	T1	T2	T3	T4	T5	C
Temperature (^{0}C)	26.5 – 28	26.5 – 28	26 – 28	26.5 – 28	26.5 – 28.5	26.5 – 28
pH	7.72 – 8.21	7.86 – 8.22	7.79 – 8.19	7.89 – 8.18	7.78 – 8.25	7.76 – 8.17
Salinity (ppt)	12-13	12-14	12-14	12-14	12-14	12-14
Dissolved oxygen(mg/l)	7.27 – 7.83	7.25 – 7.84	7.34 – 7.75	7.35 – 7.79	7.2 – 7.83	7.34 – 7.87

Effect of addition of various carbohydrate sources on total ammonia nitrogen in various treatments during the experimental period in the larviculture of *M. rosenbergii*



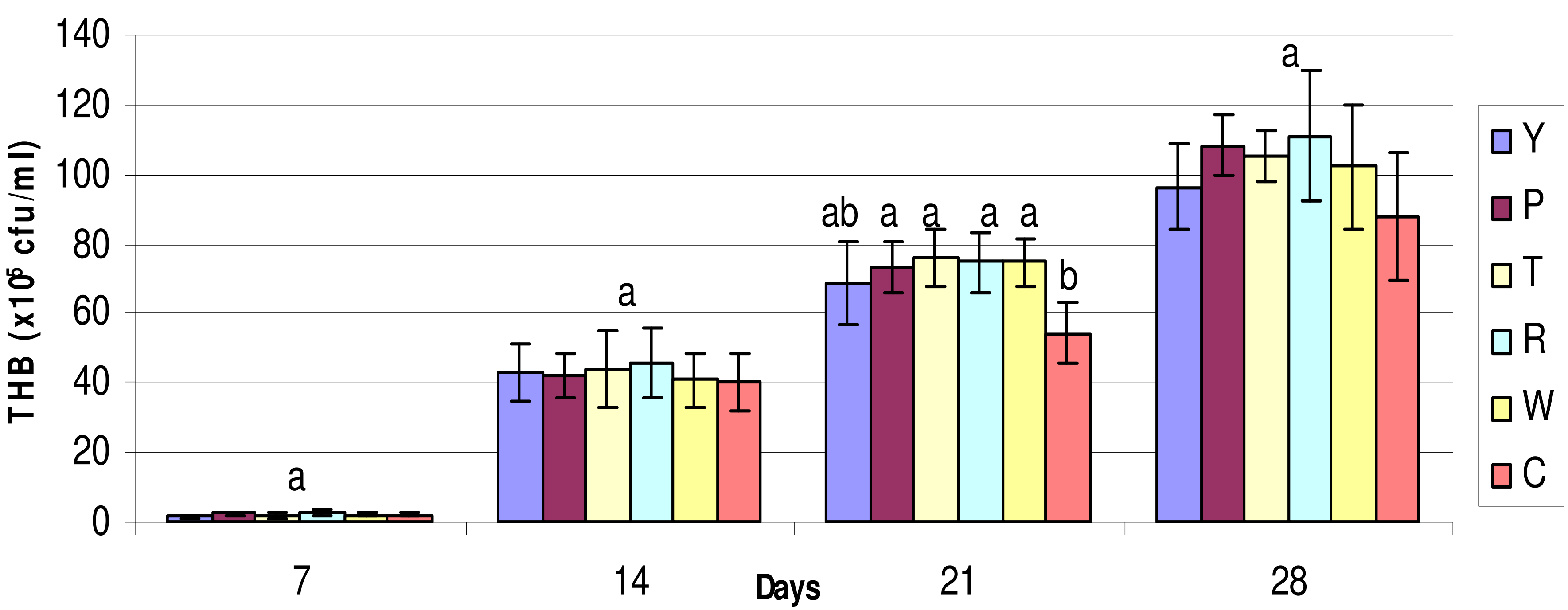
Vertical lines represent s.d. Means in each day with identical letters or represented by a single letter(a) are not significantly different .

Effect of addition of various carbohydrate sources on nitrite nitrogen in various treatments



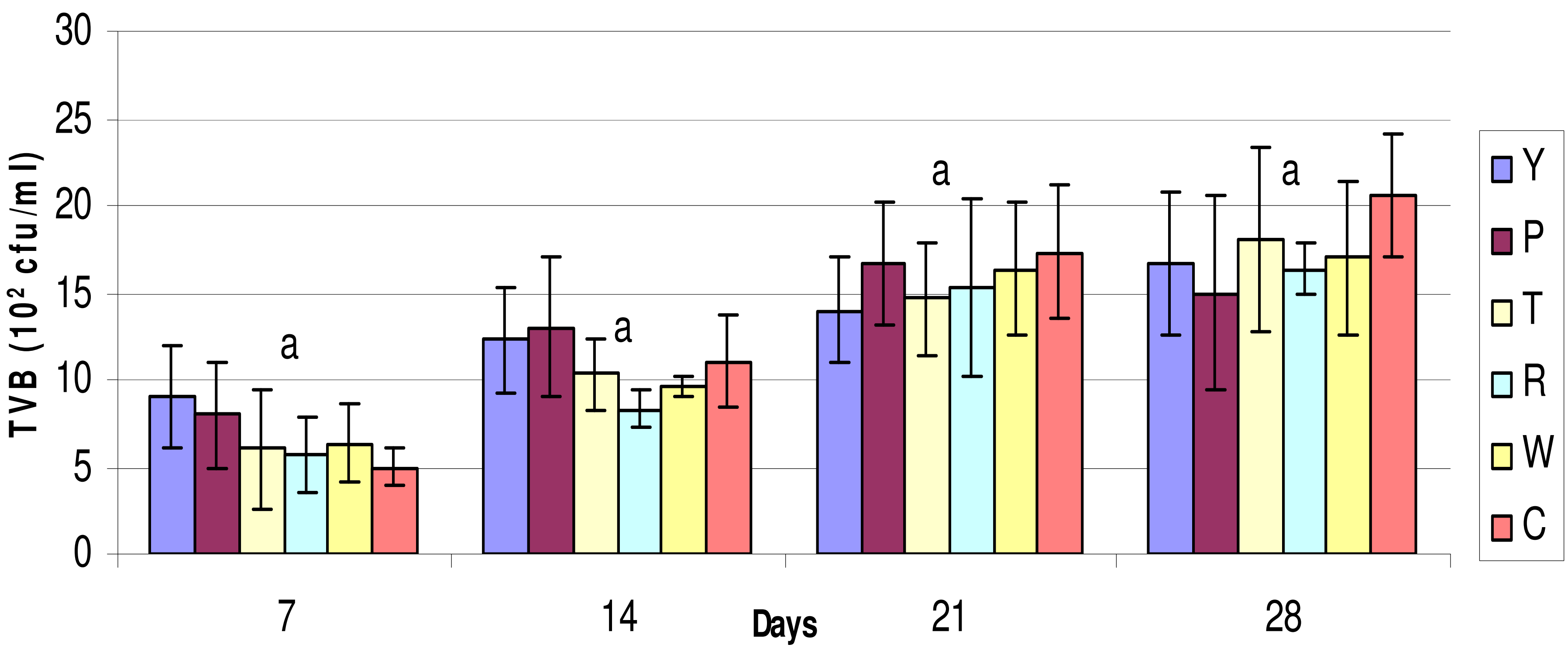
Vertical lines represent s.d. Means in each day w ith identical letters or represented by a single letter(a) are not significantly different .

Average THB in treatments with different carbohydrate sources

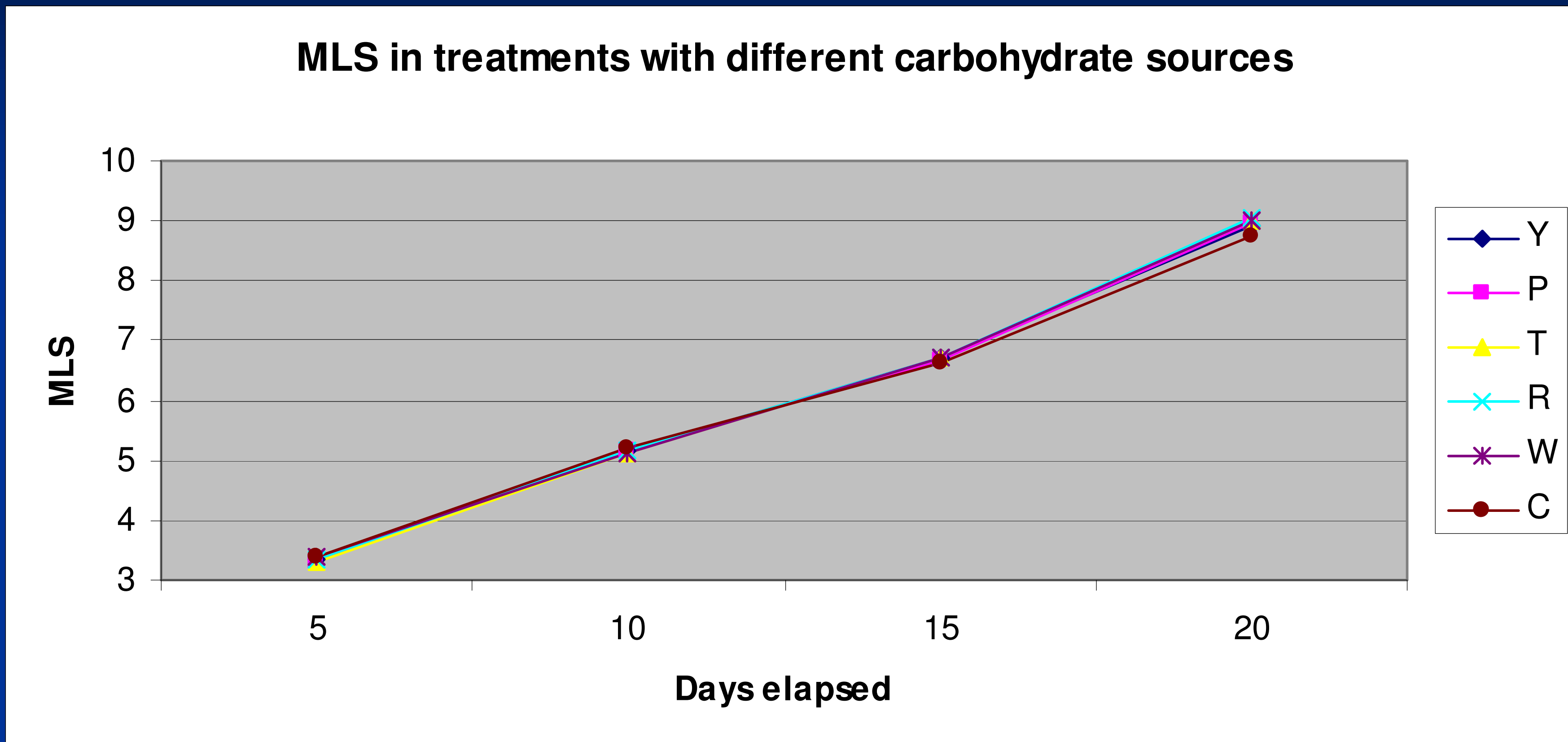


Vertical lines represent s.d. Means in each day with identical letters or represented by a single letter(a) are not significantly different .

Average TVB in treatments with different carbohydrate sources

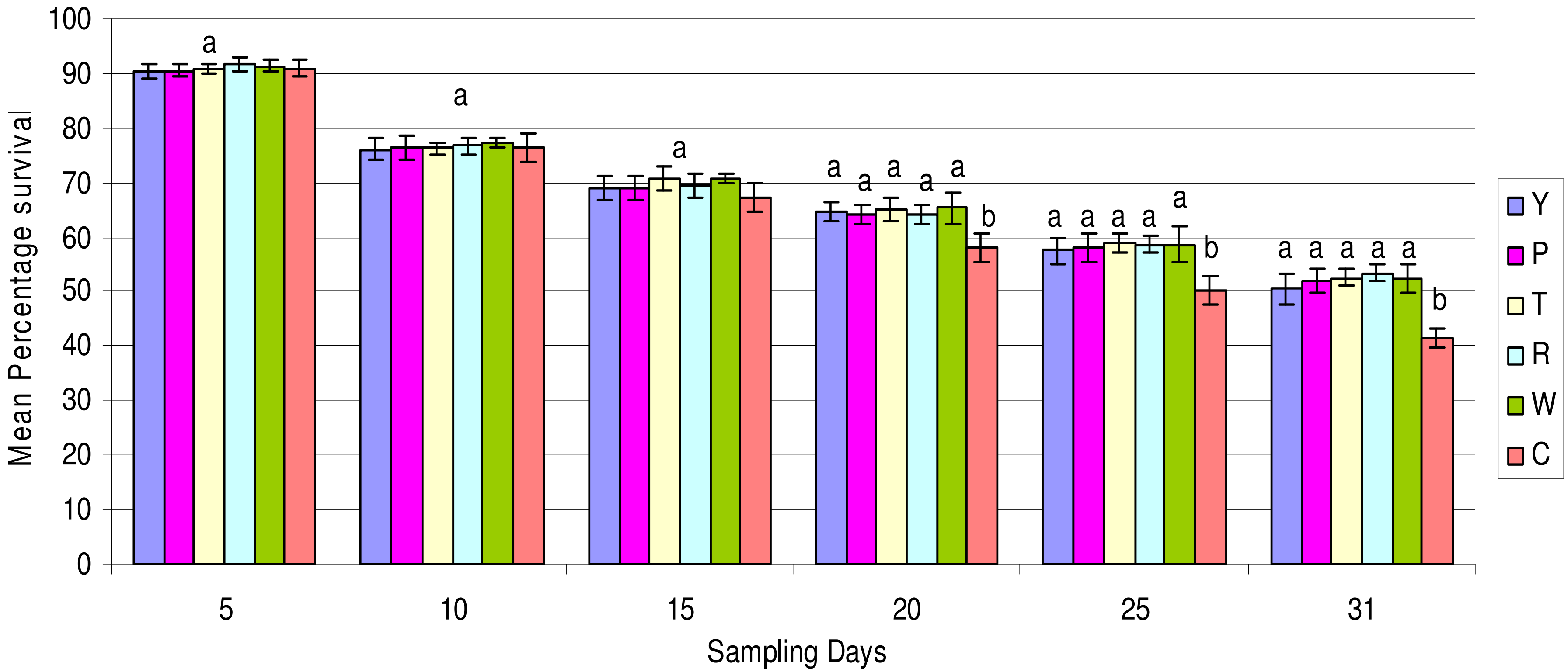


Vertical lines represent s.d. Means in each day with identical letters or represented by a single letter(a) are not significantly different

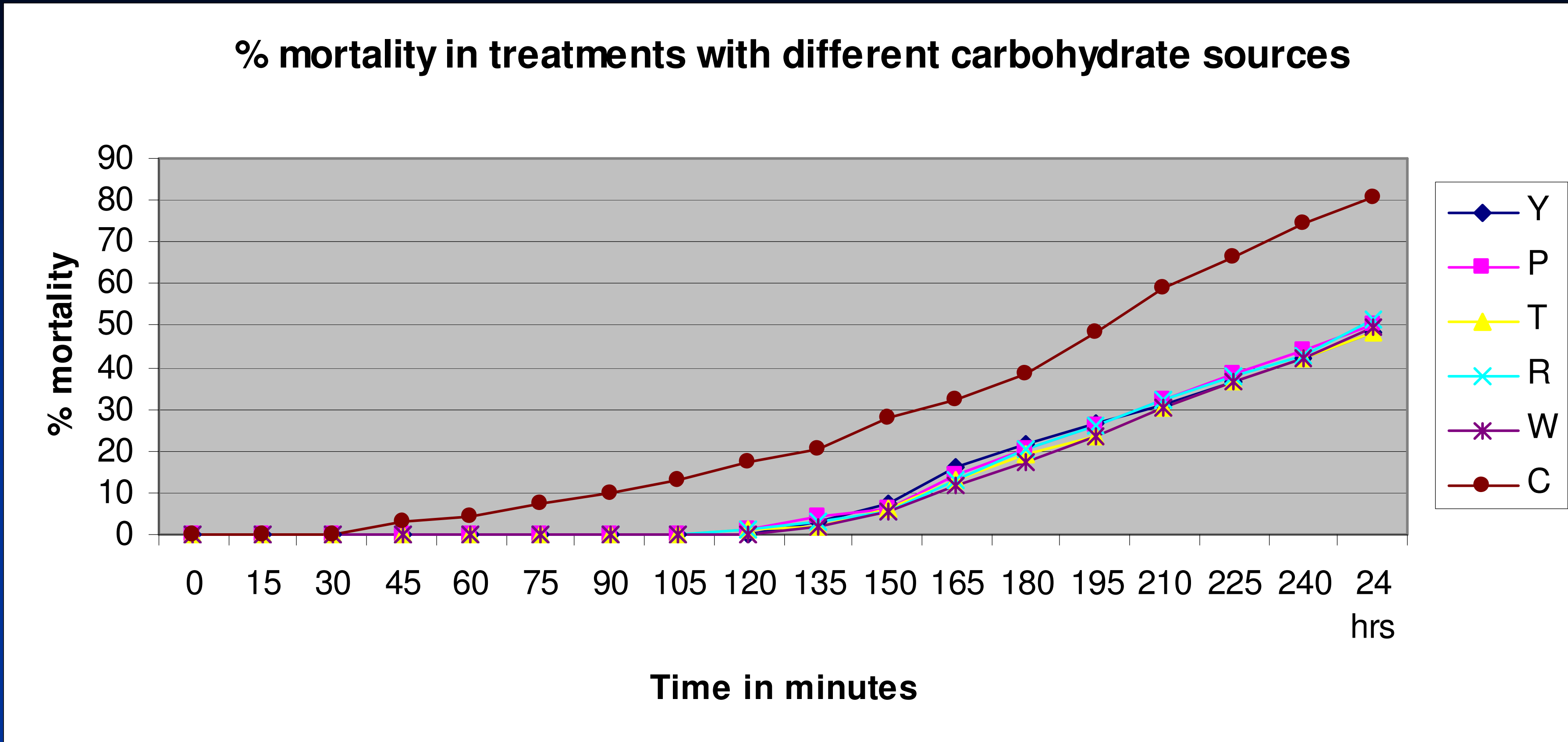


MLS in treatments with different carbohydrate sources
10
9
8
7
6
5
4
3
MLS
5
10
15
20
Days elapsed
Y
P
T
R
W
C

Effect of addition of various carbohydrate sources on the survival of *M rosenbergii*



Vertical lines represent s.d. Means in each day with identical letters or represented by a single letter(a) are not significantly different



Treatments	CMI 0ppt	CMI 7ppt
Y	468.08 ± 64.26[a]	24[a]
P	484.33 ± 85.44[a]	32 ± 13.86[a]
T	457.25 ± 51.36[a]	24 ± 24[a]
R	472.33 ± 84.37[a]	24[a]
W	452.58 ± 47.28[a]	32 ± 13.86[a]
Control	896 ± 34.83[b]	96 ± 24[b]

Table 5. Production details of *M rosenbergii* post larvae in various treatments						
Treatments	Stocking density(larvae/litre)	% survival	Appearance of first post larvae(days)	Duration(Number of days for more than 95 % post larval settlement)	Total length(mm)	Wet weight (mg)
Y	100	50.53 ± 2.9^{a}	19^{ab}	29 ± 1^{a}	9.64 ± 0.05^{a}	9.92 ± 0.05^{a}
P	100	51.97 ± 2.37^{a}	18.3 ± 0.6^{a}	29 ± 1^{a}	9.65 ± 0.09^{a}	9.93 ± 0.09^{a}
T	100	52.53 ± 1.5^{a}	19 ± 1^{ab}	28.3 ± 0.6^{a}	9.75 ± 0.09^{a}	10.03 ± 0.09^{a}
R	100	53.47 ± 1.36^{a}	18.3 ± 0.6^{a}	28.6 ± 0.6^{a}	9.67 ± 0.24^{a}	9.95 ± 0.24^{a}
W	100	52.4 ± 2.55^{a}	18^{a}	29 ± 1^{a}	9.3 ± 0.13^{a}	10.02 ± 0.13^{a}
Control	100	41.6 ± 1.83^{b}	20 ± 1^{b}	31 ± 1^{b}	9.29 ± 0.16^{a}	9.62 ± 0.16^{b}

Mean ± s.d of 3 replicate groups. Means in each column not sharing a common superscript letter are significantly different ($P<0.05$)

Conclusions

- Carbon source material have the ability to reduce the inorganic nitrogen accumulation
- The five carbohydrate sources viz. potato, yam, rice, wheat and tapioca powder are equally effective in controlling the nitrogen production with no significant difference in post larval production.
- For the larvicultue to be more cost effective any of the cheap carbohydrate source can be used.