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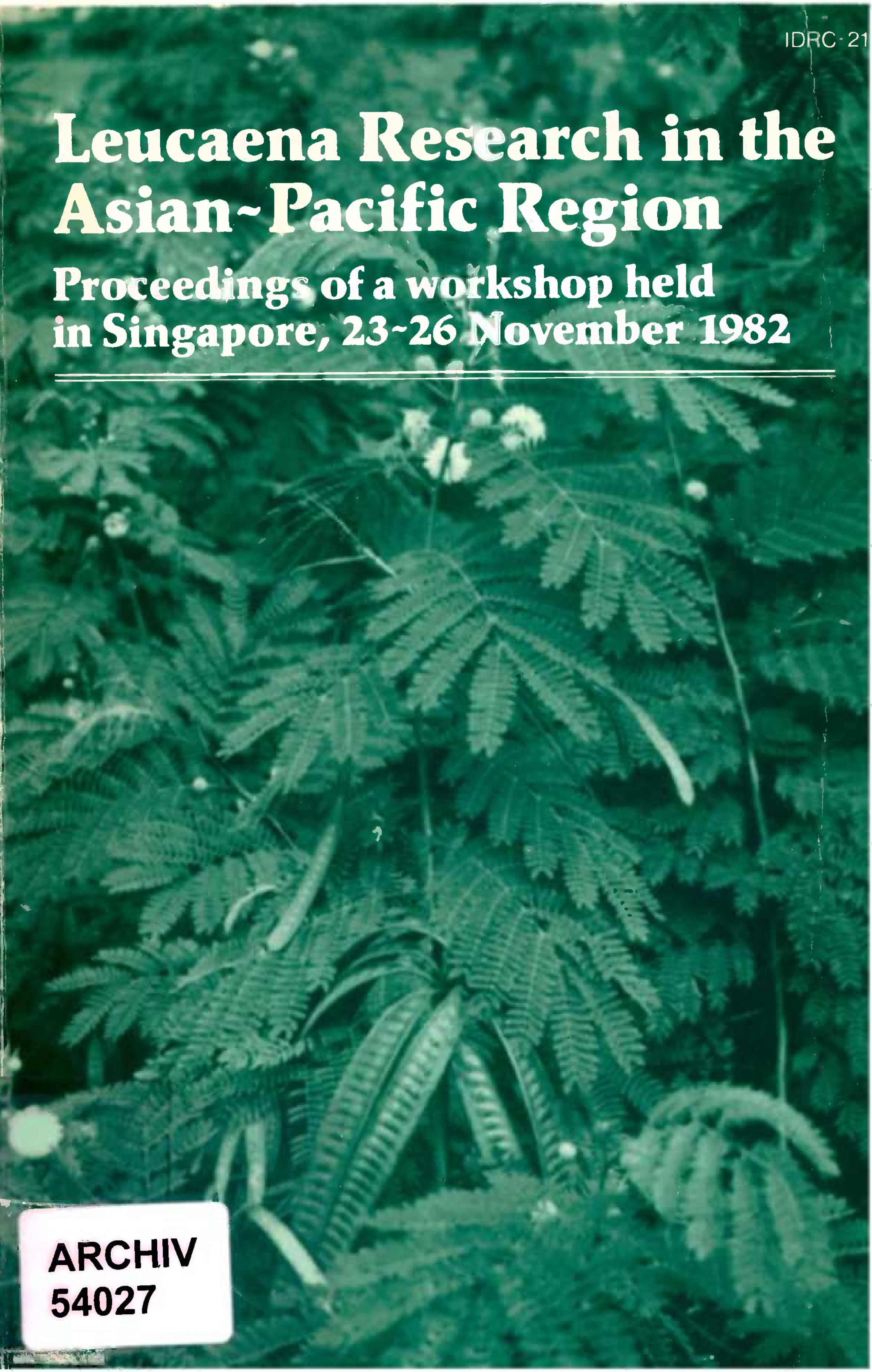
Leucaena Research in the Asian-Pacific Region

Proceedings of a workshop held in Singapore, 23-26 November 1982



Leucaena Research in the Asian-Pacific Region
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Proceedings of a Workshop Held in Singapore, 23–26 November 1982

Organized by the Nitrogen Fixing Tree Association and the International Development Research Centre

Abstract

Because of *Leucaena leucocephala*'s multiple uses as forage, fuelwood, poles, green manure, etc., this fast-growing, nitrogen-fixing tree has been the subject of much research in the last decade. The results have clarified the capabilities of the plant as well as its limitations. One main constraint to cultivation in vast areas of Latin America and Southeast Asia has been leucaena's inability to survive on acidic, aluminum-saturated soils. At low pH, the aluminum complexes with calcium, which is essential for good growth. Trials have shown that some varieties of *L. diversifolia* can make use of the calcium from the complexes and that crosses between these varieties and *L. leucocephala* perform well on acidic soils. The main constraint to use of leucaena as a forage derives from the plant's content of mimosine, a toxic, nonprotein amino acid. Although leucaena has proved to be a highly nutritious animal feed, the mimosine and its breakdown product, DHP (3-hydroxy-4[1H]pyridone), have caused toxicity among animals fed high levels of leaf meal. Scientists now have evidence that the mimosine is converted into DHP when brought into contact with an enzyme contained in some of the plant's cells harbouring mimosine. This finding needs follow up; it suggests that simple processing, such as chopping fresh leaves, will convert all the mimosine into the less-toxic DHP. Elsewhere, researchers have found that DHP can be metabolized by anaerobic microorganisms that have been found in the guts of ruminants in countries like Indonesia. They have successfully transferred the microorganisms to animals in Australia where toxicity from DHP has deterred graziers from using leucaena as forage. Other research has defined optimal approaches to breeding and genetic improvement of leucaena; characteristics of rhizobia that effectively provide the plant with nitrogen-fixing ability; biomass production under widely different soil conditions; effects on fish, poultry, cattle, goats, and sheep fed leucaena leaf meal; management and cultural practices for both large-scale and smallholder operations; etc. The results are the subject of this publication, which comprises 30 papers from researchers in the Asian–Pacific Region.

Résumé

Leucaena leucocephala a fait l'objet de nombreuses recherches au cours de la dernière décennie, cet arbre légumineux fixateur d'azote et de croissance rapide ayant de nombreux usages comme fourrage, combustible, poteau, engrais vert, etc. Ces études ont permis d'en délimiter les fonctions. L'un des facteurs limitants de sa culture dans de vastes régions de l'Amérique latine et de l'Asie du Sud-Est est l'incapacité de *Leucaena* de survivre dans des sols acides, saturés d'aluminium. Dans le cas d'un faible pH l'aluminium complexe le calcium, essentiel à une croissance régulière. Des essais ont démontré que certaines variétés de *L. diversifolia* peuvent utiliser le calcium présent dans les complexes et que les croisements entre ces variétés et *L. leucocephala* prospèrent dans des sols acides. Le principal obstacle à l'utilisation de *Leucaena* comme fourrage est sa teneur en mimosine, acide aminé non protéique toxique. Bien que ce fourrage soit hautement nutritif, la mimosine et DHP (3-hydroxy-4[1H]pyridone) ont provoqué des cas de toxicité chez les animaux consommant de grandes quantités de farine de feuilles. Les scientifiques ont découvert que la mimosine se décompose en DHP lorsqu'elle entre en contact avec une enzyme contenue dans certaines cellules où elle est présente. Cette découverte a permis de déterminer des moyens simples de neutraliser cette substance toxique, tel que le hachage des feuilles vertes qui décompose la mimosine en DHP moins toxique. Ailleurs, des chercheurs ont trouvé que le DHP peut être métabolisé par des microorganismes anaérobiques présents dans l'intestin des ruminants dans certains pays comme l'Indonésie. Ils ont réussi à transférer ces microorganismes à des animaux en Australie où les pasteurs refusent l'emploi du fourrage de *Leucaena* à cause de la toxicité de DHP. D'autres recherches préconisent une approche optimale: de la sélection et de l'amélioration génétique de *Leucaena*; des caractères des rhizobiums qui assurent la fonction de la fixation d'azote chez la plante-hôte; de la production de bio-masse dans diverses conditions de sols très variés; des effets des rations de farine de feuilles sur les poissons, les volailles, le bétail, les chèvres et les moutons; de la gestion et des pratiques culturales des opérations des petites et des grandes exploitations, etc. Tous ces résultats sont détaillés dans la présente brochure qui contient trente communications exposées par des chercheurs de la région du Pacifique asiatique.

Resumen

Debido a los múltiples usos de la *Leucaena leucocephala* como forraje, combustible, madera, abono, etc., este árbol, de rápido crecimiento y habilidad para fijar el nitrógeno, ha sido objeto de abundante investigación en la última década. Los resultados han aclarado las capacidades de la planta, así como sus limitaciones. Uno de los problemas para su cultivo en vastas áreas de Latinoamérica y el Sudeste Asiático ha sido su incapacidad para sobrevivir en suelos ácidos, saturados de aluminio. A niveles bajos de pH, el aluminio forma complejos con el calcio que es esencial para un buen crecimiento. Las pruebas han mostrado que algunas variedades de *L. diversifolia* pueden usar el calcio de los complejos y que los cruces entre estas variedades y la *L. leucocephala* se desempeñan bien en suelos ácidos. El principal inconveniente para usar la leucaena como forraje proviene de su contenido de mimosina, un aminoácido tóxico no proteínico. Aunque la leucaena ha probado ser un alimento animal altamente nutritivo, la mimosina y su producto de descomposición, el DHP (3-hydroxy-4[1H]pyridone), han causado toxicidad entre los animales alimentados con altos niveles de harina de follaje. Los científicos tienen ahora evidencia de que la mimosina se convierte en DHP cuando entra en contacto con una enzima que se encuentra en algunas células de la planta que contienen mimosina. Este hallazgo necesita seguimiento, pero sugiere que un simple procesamiento, como picar las hojas frescas, convierte toda la mimosina en el menos tóxico DHP. En otras partes, los investigadores han encontrado que el DHP puede ser metabolizado por microorganismos anaeróbicos que han sido hallados en el intestino de rumiantes en países como Indonesia. Ellos han traspasado con éxito los microorganismos a animales en Australia donde la toxicidad del DHP ha impedido que los ganaderos empleen la leucaena como forraje. Otras investigaciones han definido los enfoques óptimos para el fitomejoramiento de la leucaena, las características de la rizobia que efectivamente dotará a la planta de la habilidad de fijar nitrógeno, la producción de biomasa bajo condiciones edáficas ampliamente distintas, los efectos sobre los peces, las aves, el ganado, las cabras y las ovejas alimentadas con harina de hoja de leucaena, las prácticas culturales y de manejo para las actividades a gran escala o del pequeño agricultor, etc. Los resultados son el tema de esta publicación que abarca 30 trabajos de investigadores en la región Asiopacífica.

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Contents

Feeding Leucaena to Mozambique Tilapia and Indian Major Carps[1]

Sudhir D. Ghatnekar, D.G. Auti, and Vijay S. Kamat *Bio-Technology Group, Research and Development, Ion Exchange (India) Ltd, Ambarnath, Maharashtra, India*

Feed is the costliest factor in fish culture. It is, therefore, necessary to develop balanced, inexpensive feed, preferably from local resources. This is an evaluation of the suitability of leucaena leaf meal in the culture of Mozambique tilapia and Indian major carps in monoculture and polyculture systems. Leucaena leaf meal at 30–60% of the daily feed in both systems had no adverse effects on growth, metabolic, or reproductive behaviour. Carps and tilapia in polyculture existed in harmony.

L'alimentation est l'élément le plus coûteux de la pisciculture. Il importe donc d'élaborer pour les poissons un régime alimentaire à la fois équilibré et économique, de préférence à partir de ressources locales. On trouvera ici une appréciation de la valeur de la farine de feuilles de Leucaena *dans la production de tilapies au Mozambique et de grosses carpes en Inde, en élevages simples ou mixtes. La farine de feuilles de* Leucaena, *à raison de 30 à 60 % de la ration journalière dans les deux procédés, n'a eu aucun effet défavorable sur le développement, le métabolisme ou le processus de reproduction. En élevage mixte, les tilapies et les carpes ont coexisté dans l'harmonie.*

La alimentación es el factor más costoso en la piscicultura. Por tanto, es necesario desarrollar alimentos balanceados y económicos, preferiblemente a partir de recursos locales. Esta es una evaluación de la harina de hoja de leucaena en sistemas de monocultivo y policultivo de tilapia de Mozambique y carpas mayores de India. La harina de hoja de leucaena al 30–60% del alimento diario en ambos sistemas no presentó efectos segundarios sobre el crecimiento, el metabolismo o el comportamiento reproductivo. Las carpas y la tilapia convivieron armoniosamente en policultivo.

[1] This paper was presented by G.S. Ranganathan, President, Ion Exchange (India) Ltd, at the workshop.

To develop low-cost feeds suitable for fish culture, the Bio-Technology Group of Ion Exchange (India) Ltd undertook trials with leucaena leaf meal fed to tilapia and Indian major carps in monoculture and in polyculture systems. Different sizes of aquaria, plastic collapsible pools, and mild-steel (MS) tanks were used. Semifingerlings of *Sarotherodon mossambicus*, *Labeo rohita*, and *Cirrhinus mrigala* were procured from the Aarey Fish Farm. Fingerlings of *Catla catla* were obtained locally. Three sets of experiments were conducted. Also, a polyculture pond in which fish were fed leucaena meal was observed. For each set, a control was used for comparison. The various feeds were autoclaved at 1.05 kg/cm^2 (15 pounds/square inch) for 40 min. In addition to pelletized feed, *Hydrilla* culture was introduced at the beginning of each experiment. Percentage survival, weight gain, and reproductive behaviour were monitored. Aeration in all these sets was for 4–6 h/day, and water was changed every 10–15 days.

In the first set of experiments (polyculture), four carps and six tilapia were introduced into a rectangular aquarium 0.9 m × 0.425 m × 0.3 m containing 75 L water. The daily feed consisted of 65% leucaena leaf meal, 30% standard balanced pellets, and 5% fish feed at 5% total body weight. The composition of the standard balanced pellets was protein 36%, fat 2%, fibre 6%, acid-insoluble ash 4%, lysine 2%, methionine and cystine 1%, calcium 3%, phosphorus 1%, and fillers 45%. The metabolizable energy was 2500 kcal/kg. The composition of fish feed was: bone meal 65% and fish meal 35%.

The feed in the control set consisted of 95% standard balanced pellets and 5% fish feed at 5% body weight daily. The experiments lasted 104 days.

The second set of experiments, also a polyculture system, comprised 8 carps and 42 tilapia in circular, plastic, collapsible pools 1.8 m in diameter, 1.2 m high, each containing 2120 L water. The treated feed was leucaena leaf meal 50%, groundnut-oil cake 25%, and wheat bran 25% at 5% body weight. The control feed was groundnut-oil cake and wheat bran in equal proportions. The experiments lasted 160 days.

The third set of experiments comprised 26 tilapia in an MS tank 1.2 m in diameter, 0.9 m high, with 590 L water. The treated feed was 30% leucaena leaf meal and 70% standard balanced pellets. The control feed was 100% standard balanced pellets. The experiments lasted 120 days.

In addition, the effects of leucaena leaf meal were observed in the fattening pond (19.5 m × 9.0 m × 1.8 m, water depth of 0.55 m). A polyculture of 185 carps and 15 male tilapia was established. The daily feed was 50% leucaena leaf meal, 25% wheat bran, and 25% groundnut-oil cake at 5% body weight (in the form of cakes 2.5 cm × 2.5 cm × 2.5 cm that dissolve in 4–6 h). These cakes were tied to a string at three water levels — bottom, middle, and surface. *Hydrilla* culture was introduced in January 1982. First, the pond was fertilized with 50 kg cowdung, 2 kg urea, and 2 kg superphosphate (November 1981), and six ducks manuring the pond helped produce plankton. Sampling was done monthly so that morphological parameters could be monitored. Two rows of leucaena seedlings were transplanted (1 m × 1 m) around the pond in January 1982 so that the leaf litter could be easily added.

Results and Discussion

In the first set of experiments, the feed uptake and growth of the leucaena-fed carps and tilapia (in 104 days) did not differ significantly from those of the controls (Table 1). Survival rate was 100%. After 95 days, tilapia hatched in both the control and the treated aquaria. The number of fry per female in both was about the same. Leucaena leaf meal at 65% level had no adverse effect on weight gain, reproductive behaviour, or general metabolism. From semifingerling stage to maturity, fish in the treated tank seemed to like nibbling leucaena feed tablets. Carps and tilapia existed in harmony.

In the second set of experiments, leucaena leaf meal at 50% in the treated tank had no observable adverse effects on the growth of carps or tilapia (Table 2). Survival rate was about the same for the leucaena-fed and control groups. Hatching occurred in 95–100 days in both control and treated pools. The number of fry was about the same. The metabolic behaviour, i.e., movement and excreta, was normal in both cases. Carps and tilapia were in harmony. The experiments indicated that fish, fed 50% leucaena leaf meal

Table 1. Average growth of fish fed leucaena leaf meal (65% of the diet) compared with controls, each group comprising four carp and six tilapia in an aquarium (9 m × 0.425 m × 0.3 m).

Date (day/month/ year)	Control			Treated		
	Length (cm)	Breadth (cm)	Weight (g)	Length (cm)	Breadth (cm)	Weight (g)
11/1/82	3.0	0.82	3.1	3.2	0.87	3.18
11/2/82	4.5	0.97	4.95	4.8	1.06	5.10
11/3/82	7.9	1.40	8.85	8.1	1.80	9.15
11/4/82	9.85	2.60	15.00	10.00	2.65	16.70
25/4/82	10.25	2.72	20.80	11.00	2.78	22.20

Table 2. Average growth of fish fed leucaena leaf meal (50% of the diet) compared with controls, each group comprising 8 carp and 42 tilapia in a plastic pool.

Date (day/month/ year)	Control			Treated		
	Length (cm)	Breadth (cm)	Weight (g)	Length (cm)	Breadth (cm)	Weight (g)
14/1/82	3.18	0.75	3.20	3.02	0.74	3.15
14/2/82	5.60	1.25	5.90	5.50	1.30	5.00
14/3/82	10.80	1.85	11.23	10.36	1.70	10.95
14/4/82	11.08	2.12	20.22	11.10	2.15	20.50
14/5/82	13.50	2.80	26.80	13.80	2.78	26.66
14/6/82	14.60	2.95	36.45	14.56	2.90	35.50
24/6/82	15.00	3.10	42.50	14.96	3.04	40.60

Table 3. Average growth of tilapia fed leucaena leaf meal (30% of the diet) compared with controls in mild-steel tanks (1.2 m diameter × 0.9 m high).

Date (day/month/ year)	Control			Treated		
	Length (cm)	Breadth (cm)	Weight (g)	Length (cm)	Breadth (cm)	Weight (g)
14/1/82	2.9	0.75	3.20	2.98	0.78	3.22
15/2/82	5.02	1.10	6.85	5.28	1.22	7.45
15/3/82	12.08	1.50	14.50	13.08	1.65	15.09
15/4/82	14.06	2.85	28.00	15.08	2.90	30.50
15/5/82	15.85	2.96	36.80	16.20	3.10	38.90

Table 4. Average length and weight of fish fed leucaena leaf litter from trees (at 1 m × 1 m spacing) around the fattening pond (19.5 m × 9.0 m × 1.8 m).[a]

Date (day/month/ year)	*Labeo rohita, Cirrhinus mrigala*		*Catla catla*		*Sarotherodon mossambicus*	
	Length (cm)	Weight (g)	Length (cm)	Weight (g)	Length (cm)	Weight (g)
8/12/81	3.90	4.10	9.40	27	9.60	10.50
8/1/82	10.25	12.50	12.50	60	11.50	15.60
8/2/82	11.75	16.68	16.65	80	12.90	25.70
8/3/82	13.60	30.80	17.85	120	13.85	40.60
8/4/82	14.80	56.20	18.90	250	14.08	59.20
8/5/82	16.56	70.40	25.50	335	16.90	75.40
8/6/82	17.80	88.60	28.96	400	17.50	98.20
8/7/82	19.60	103.24	30.28	468	18.90	118.00

[a] Polyculture included 90 *L. rohita*, 80 *C. mrigala*, 6 *C. catla*, and 15 (males only) *S. mossambicus*.

at 5% body weight daily, experienced no adverse effects.

Similarly, in the third set of experiments, leucaena leaf meal (30% of feed) had no adverse effects on the tilapia (Table 3). Reproductive behaviour and metabolic rate in control and treated tanks were similar. Hatching in both tanks occurred about the same time, and fry were almost the same in number. The excreta pattern and survival rate of leucaena-fed fish were also similar to those of controls.

In the fattening pond, fish grew well on 50% leucaena leaf meal (Table 4); the duck manure produced the anticipated plankton bloom, and the planting of leucaena around the pond provided shade and reduced the temperature of the water.

Conclusions

The findings from these studies indicate that leucaena leaf meal from 30% to 65% total diet may be included in tilapia and carp feeds with no adverse effects on growth, metabolic, or reproductive behaviour. Similar observations were recorded by Cruz and Laudencia (1978), when they found that Nile tilapia showed normal gain and fertility when leucaena leaf meal was placed inside feeding rings at levels of 2% and 4% of body weight daily. Furthermore, Brewbaker and Hutton (1979) suggested planting leucaena trees around aquaculture ponds to provide desirable shade, protection from wind, and leaf litter that would add nitrogen to the ponds. In the present investigation, planting leucaena around the pond seems to have been beneficial.

We are grateful to G.S. Ranganathan, President, Ion Exchange (India) Ltd, for outlining the program of work and providing guidance, as well as editing this paper. We acknowledge the earlier efforts of the late Vinod D. Pathak in these investigations.