UNIVERSITI PUTRA MALAYSIA

NUTRIENT OPTIMIZATION AND COMPUTERIZED DECISION SUPPORT PROGRAM IN RECIRCULATING INTEGRATED AQUACULTURE SYSTEM

HAMID KHODA BAKHSH

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By

HAMID KHODA BAKHSH

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

March 2005

DEDICATION

To my dearest parents

&

Beloved wife

For their boundless support, true love, attention and encouragement

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Doctor of Philosophy

NUTRIENT OPTIMIZATION AND COMPUTERIZED DECISION SUPPORT PROGRAM IN RECIRCULATING INTEGRATED AQUACULTURE SYSTEM

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Chairman : Professor Abdul Razak Alimon, PhD

Faculty : Agriculture

There are many research activities to improve sustainable aquaculture and agriculture production in the wide world. Sustainable aquaculture is referred to as production of aquatic commodities through farming activities with social, economic and environmental sustainability.

A series of experiments were conducted to compare different inorganic and organic fertilizers to improve production of *Macrobrachium rosenbergii* and to make a decision support program in an artificial sustainable aquaculture-agriculture system. Simply, nutrient wastes from culture tanks were used to fertilize hydroponics or terrestrial plants production via irrigation water. The sustainability and success functioning of the whole system were involved to manage and optimize the use of supplemented minerals, diet and desirable environment for each compartment (prawn, plant and microorganisms).

The first experiment was made to evaluate the tolerance of *M. rosenbergii* in different levels of inorganic fertilizer (EC) formulated in nutrient film technique (NFT) vegetable production system. Results of the first experiment indicated that desirable growth rate of *M. rosenbergii* was obtained using 0.1 to 0.5EC of supplemental liquid fertilizer. High concentration of potassium (117-177 mg l^{-1}), ammonia (0.72-1.05 mg l^{-1}) and copper (0.04-0.06 mg l^{-1}) inhibited the growth rate of *M. rosenbergii* in integrated culture system.

The second experiment was carried out to assess the effects of different nutrient and stocking density on different population of *M. rosenbergii* in polyculture system. A different range of inorganic and organic fertilizer was used in the polyculture of plant and freshwater prawn species. Overall results indicated that essential concentration of nutrients, source and *M. rosenbergii* stocking density have played a major role in the effectiveness of suitable range of minerals in integrated production system. The results also demonstrated that 0.5 EC liquid inorganic fertilizer was not suitable to provide optimum nutrients and chicken manure is still an important fertilizer even in indoor integrated culture system.

Finally, a comparative study was conducted to evaluate the optimum level of chicken manure and formulated inorganic nutrients in an artificial integrated culture system. The results indicated that high density culture of *M. rosenbergii* juveniles (380-400 individual m^{-2}) in fiberglass tanks is possible by the installation of artificial substrate and controlling of nutrient concentration in system. Moreover the addition of aeration tank significantly improved the quality of water (DO and pH) and freshwater prawn growth

(1343.0 g/tank) in recirculated polyculture system. The application of 70 g m^{-3} chicken manure alone encouraged growth of benthic and periphyton algae in culture tanks. The overall observation illustrated the desirable combination of supplemental liquid fertilizer and chicken manure is essential to obtain best growth for each compartment in sustainable polyculture system.

A visual expert program (IAAS) was adopted to improve managing and develop technical operation in an artificial integrated culture system. The operation of the polyculture system required the specific knowledge, developing and application of computer systems to excellent operation, control of water quality variables, dissolved nutrients and feed to avoid the production of toxic substance and increase self efficiency and sustainability of the culture system. The accuracy of IAAS expert program was evaluated by polynomial and linear regression techniques through additional experiment. The comparison of results (yield and survival) in expert and real culture system represents higher variation of survival, prawn and plant yields in abnormal culture system. Moreover the evaluation processes demonstrated succeed performance of IAAS expert program in prediction results of optimized integrated culture system (with low variation). In aquaculture, the success estimation of production depends largely on the state of physical and chemical parameters which define optimal culture conditions.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENGOPTIMUMAN NUTRIEN DAN PROGRAM SOKONGAN KEPUTUSAN BERKOMPUTER DALAM SISTEM INTEGRASI AKUAKULTUR KITAR SEMULA

Oleh

HAMID KHODA BAKHSH

Mac 2005

Pengerusi : Profesor Abdul Razak Alimon, PhD

Fakulti : Pertanian

Banyak aktiviti kajian telah dijalankan untuk meningkatkan pengeluaran akuakultur dan pertanian yang daya tahan di serata dunia. Daya tahan akuakultur dirujuk sebagai pengeluaran komoditi akuatik melalui aktiviti pengkulturan dengan sosial, ekonomi dan daya tahan persekitaran.

Satu siri eksperimen telah dijalankan untuk membandingkan perbezaan baja organic dan bukan organic untuk meningkatkan pengeluaran *Macrobrachium rosenbergii* dan menghasilkan satu program sokongan keputusan dalam sistem artifisial akuakultur – pertanian yang berdaya tahan. Iaitu, nutrien bahan buangan dari tangki kultur digunakan untuk menyuburkan hidroponik atau pengeluaran tanaman terestial melalui saliran air. Daya bertahan dan kejayaan fungsi keseluruhan sistem yang terlibat adalah untuk mengurus dan mengoptimakan kegunaan mineral tambahan, diet dan keadaan

persekitaran yang sesuai untuk setiap satu bahagian (udang, tanaman dan mikroorganisma).

Eksprimen pertama dihasilkan untuk menilai daya ketahanan *M. rosenbergii* untuk kepekatan baja bukan organik (EC) yang berbeza diformulasi dalam teknik filem nutrien (NFT) sistem pengeluaran sayuran. Keputusan kajian ini menunjukkan bahawa kadar pertumbuhan yang diperlukan untuk *M. rosenbergii* diperolehi dengan menggunakan 0.1 hingga 0.5 EC baja tambahan dalam bentuk cecair. Kepekatan potassium yang tinggi (117-177 mg l^{-1}), amonia (0.72-1.05 mg l^{-1}) dan tembaga (0.04-0.06 mg l^{-1}) menghalang kadar tumbesaran *M. rosenbergii* di dalam sistem kultur intergrasi.

Eksperimen kedua telah dijalankan untuk menilai kesan nutrien dan densiti stok yang berbeza ke atas populasi *M. rosenbergii* yang berlainan di dalam sistem polikultur. Satu julat bja organic dan bukan organic digunakan di dalam polikultur tanaman dan spesies udang airtawar. Keseluruhan keputusan menunjukkan bahawa kepekatan nutrien yang perlu, sumber dan kadar densiti untuk *M. rosenbergii* memainkan peranan utama di dalam keberkesanan julat mineral yang sesuai untuk sistem pengeluaran intergrasi. Keputusan turut menunjukkan bahawa baja cecair bukan organik 0.5 EC adalah tidak sesuai sebagai penyumbang nutrien optima dan najis ayam masih satu baja yang penting walaupun untuk sistem kultur intergrasi secara tertutup.

Kajian perbandingan dijalankan untuk menilai takat optima najis ayam dan formulasi nutrien bukan organik dalam sistem polikultur intergrasi artificial. Keputusan menunjukkan bahawa kultur *M. rosenbergii* juvenile dengan densiti tinggi (380-400 individual m^{-2}) dalam tangki gentian kaca boleh dijalankan dengan pemasangan substrat artificial dan mengawal kepekatan nutrient di dalam sistem. Lebih lagi dengan penambahan tangki pengudaraan jelasnya akan meningkatkan kualiti air (DO and pH) dan tumbesaran udang air tawar (1343.0 g/tangki) di dalam sistem kultur intergrasi kitar-semula. Penggunaan najis ayam yang lebih tinggi (70g m^{-3}) akan menggalakkan tumbesaran alga benthik dan periphyton di dalam tangki kultur.

Keseluruhan pemerhatian mengambarkan kombinasi baja cecair tambahan dan najis ayam adalah perlu untuk mendapatkan tumbesaran terbaik untuk tiap satu kompartmen di dalam sistem polikultur berdaya-tahan.

Satu program visual pakar (IAAS) telah digunakan untuk memperbaiki pengurusan dan membentuk operasi teknikal di dalam sistem kultur intergrasi artifisial. Operasi sistem polikultur memerlukan pengetahuan yang spesifik, membentuk dan mengaplikasikan penggunaan sistem komputer untuk operasi yang terbaik, mengawal pembolehubah kualiti air, nutrien terlarut dan makanan untuk mengelakkan penghasilan bahan toksik, meningkatkan kecekapan diri dan daya-tahan sistem kultur tersebut. Ketepatan program pakar IAAS telah diuji dengan teknik polynomial dan regresi linear melalui eksperimen tambahan. Perbandingan keputusan (hasil dan kemandirian) untuk sistem pakar dan kultur sebenar menunjukkan variasi yang tinggi dlam kemandirian, udang, dan hasil tanaman dalam sistem kultur abnormal. Lebih lagi kerana proses penilaian menunjukkan kejayaan dalam persembahan program pakar IAAS dalam menjangka keputusan untuk sistem kultur intergrasi yang optima (dengan variasi rendah). Di dalam akuakultur, kejayaan dalam menjangka pengeluaran banyak bergantung kepada keadaan parameter fizikal dan kimia yang mentafsirkan keadaan kultur yang optima.

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I certify that an Examination Committee met on 18 March 2005 to conduct the final examination of Hamid Khoda Bakhsh on his Doctor of Philosophy thesis entitled "Nutrient Optimization and Computerized Decision Support Program in Recirculating Integrated Aquaculture System" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the senate of Universiti Putra Malaysia and has been accepted as fulfilment for the requirements for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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HAMID KHODA BAKHSH

Date:

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