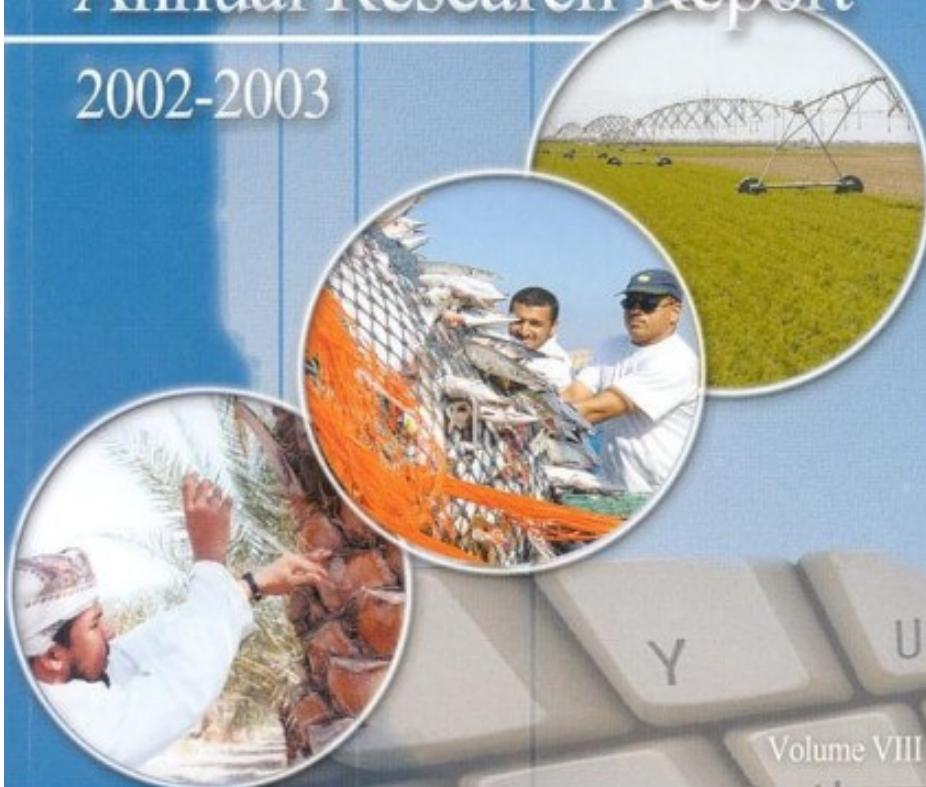




Sultan Qaboos University
College of Agricultural and Marine Sciences

Annual Research Report

2002-2003



Volume VIII

Table of contents

	Page
Forward -----	iii
Executive Summary -----	2
Research Projects and Budgets -----	2
His Majesty's Strategic Research Projects -----	11
Externally Funded Research Projects -----	12
Other Significant Activities -----	15
Selected Research Outcomes & Their Significance-----	17
Summary of Projects Awarded in 2003 -----	26
Graduate Program -----	38
Thesis Abstracts for Graduated Students -----	40
Publications in 2002 -----	50
List of Refereed Journal Publications for 2002 -----	52

Foreword

The College continued in its desire to be the center of excellence in agricultural and fisheries research in Oman and the region. The College's aim is to conduct basic and applied research in a broad range of disciplines that have immediate and long-term benefits resulting in the promotion of sustainable agricultural and fisheries development.

This Annual Research Report covers our work at CAMS in 2002/2003 and provides a record of achievements for staff and students. It is published as a source of information for the wider research community in Oman and beyond, and for those who may seek to cooperate with us in the future.

In this reporting period, 13 internally and 3 externally research grants with a total value of RO 230,220 have been awarded to CAMS. This is another exciting year for research in the College, with outstanding research outputs reaching 73 refereed journal publications in 2002.

Several other achievements served to strengthen the research and postgraduate programs in the College. The College was awarded a strategic research and development project in 2003 financed from His Majesty Research Fund. Another project was jointly financed by SQU and UAE University. Furthermore, 88 postgraduate students at the M.Sc. level were actively involved in the research programs. Eight of them graduated in 2002.

I pay tribute to staff, students and researchers who have made outstanding contributions to our research activities through the years. It is with great pleasure that on behalf of all members of the Research Committee, we express our deepest and most sincere sense of gratitude and appreciation to them.

Hamed Bin Said Al-Oufi
Assistant Dean for Postgraduate Studies and Research

Research Committee

Dr. Hamed Said Al-Oufi	<i>Chair</i>
Dr. Sanmugam Prathapar	<i>Co-chair</i>
Prof. Ehgen Jhonson	
Prof. Saiyed Ahmed	
Dr Houcine Boughanmi	
Dr. Mushtaque Ahmed	
Dr. Micheal Deadman	
Dr. Stefan Kasapis	

Executive Summary

The faculty and staff of the College of Agricultural and Marine Sciences (CAMS) actively pursues basic and applied research that covers a broad range of disciplines in the areas of agriculture, food systems, animal production, animal and human health and marine sciences and fisheries. The aim of CAMS's research program is to seek scientific and practical solutions for problems confronting the agricultural and fisheries sectors in Oman. CAMS makes great efforts to disseminate its research findings to government agencies, private companies, farmers and fishermen, scientific peers and to the community at large. Apart from being the leader in researching issues in agriculture, food systems and marine sciences, CAMS is also committed to transferring knowledge and skills to the broader food systems community through its research and graduate programs. The aim of the postgraduate program, for example, is to produce high caliber researchers who will maintain and enhance the country's position in regional food systems research and development. For these students, CAMS provides access to advanced laboratory facilities and leading researchers in their field of study.

Research Projects and Budgets

The cumulative research budget of CAMS in 2003 is 1,564,259 (Table 1). The budget includes funding for four projects supported by His Majesty's Strategic Research Fund (Table 5), 53 projects supported by SQU internal research fund and another 12 were funded by external agencies (Table 6). Out of the 53 projects supported by SQU, 12 were initiated in 2003 (Tables 2). Abstracts of new projects awarded to CAMS in 2002 are presented in pages 23-35. Another 31 projects are on going projects (Table 3). Remaining ten projects were completed in 2003 (Table 4).

Table 1. Summary of Research and Development Projects Held by the College in 2003

Source	Number of Projects	Total Budget (RO)
SQU funded projects		
• Completed by 2002	10	64,300
• Continuing	31	207,960
• Approved in 2003	12	74,830
• Strategic projects	4	448,600
Externally funded projects		
• Continuing	9	635,949
• Approved in 2003	3	132,620
Total	69	1,564,259

Table 2. Internally Funded Research and Development Projects Awarded in 2003.

Title of Research	Grantee (s)	Amount (RO)
1. Study on the relationship between ascorbic acid supplementation and heat stress on poultry maintained in open-sided housing	I. Kadim	9,700
2. Three-dimensional fractal analysis of preferential flow paths using CT scanning	J. Perret	4,200
3. Use of selection grids to reduce discards in the demersal trawl fishery	H. Al-Oufi	9,900
4. Ripening profile of semi hard milk cheese standard goat	N. Guizani	6,000
5. Effects of king fish (<i>Scomberomorus commerson</i>) oil on atheroghebuc factors in rats	I. Mahmud	4,200
6. Introduction and evaluation of exotic germplasm of important solanaceous vegetable crops (tomato and peppers)	I. Khan	4,450

The Year in Review

Title of Research	Grantee (s)	Amount (RO)
7. Response of Chickpea (<i>Cicer arietinum</i> L.) to salinity stress	H. Esechie	4,400
8. Integrated management of fruit flies in Sultanate of Oman	K. Azam	4,200
9. Molecular and serological characterization of alfalfa phytoplasma	J. Khan	8,000
10. Evaluation of four water saving hydrophilic copolymers	H. AbdelRahman	380
11. Fractionation of heavy metals in calcareous soils amended with soils amended with sewage sludge	M. Al-Wardi	4,950
12. Desalination of soil by linking a novel solar heated process augmented water supply	P. Cookson	10,800
Total		74,830

Table 3. Internally Funded Research and Development Projects (2000-2003).

Title of Research	Grantee (s)	Grant dates, start-end	Status (Year)	Amount (RO)
1. Assessment of greywater reuse potential in Oman.	M. Ahmed	2002-04	Second	9,180
2. An examination of the life-history parameters of the common grouper, <i>Cephalopholis hemistiktos</i> , and its application to fisheries management.	J. McIlwain	2002-04	Second	10,650
3. Scientific and technological aspects in the development of confectionery and ice cream products using mixtures of gelatin and k-carrageenan.	S. Kasapis	2002-04	Second	10,800
4. A quantitative assessment of WTO negotiations on agriculture and food security in Oman.	H. Boughanmi	2002-04	Second	3,450
5. Analytical modeling of multiphase flows in porous media.	A. Kacimov	2002-04	Second	3,000
6. Solute transport in porous media: physical, analytical, and numerical modeling.	S. Al-Jabri	2002-04	Second	6,150
7. Assessment of concentration polarization in brackish and sea water reverse osmosis system.	M. Goosen	2002-04	Second	4,080
8. Assessment of high hydrostatic pressure blanching technique in food processing.	S. Sablani	2002-04	Second	3,900

Title of Research	Grantee (s)	Grant dates, start-end	Status (Year)	Amount (RO)
9. Textural properties and consumer preference: identifying optimum quality characteristics of dried dates by rheological profile analysis related to texture.	M. Rahman	2002-04	Second	4,100
10. Development and testing of a computer controlled, cyclic misted forced ventilation system for cooling dairy cows.	I. Haffar	2002-04	Second	4,000
11. Determination of commercial meat products quality in the Sultanate of Oman.	O.M. Gaafar	2002-04	Second	8,650
12. Collection and evaluation of native and exotic germplasm of important crops of Oman.	A. Al-Maskri	2002-04	Second	9,600
13. Heavy metals in coral skeletons.	M. Claereboudt	2002-04	Second	2,550
14. Environmental tolerance limits and physiological adaptations of the Arabian pup fish, <i>Amphanius dispar dispar</i> (Ruppell) to extremes in temperature, salinity and dissolved oxygen.	A. Sutterlin	2002-04	Second	3,750
15. Identification of anti-microbial substances in fresh commercially sold pasteurized milk	A. S. Kumar	2002-04	Second	3,300

Title of Research	Grantee (s)	Grant dates, start-end	Status (Year)	Amount (RO)
16. The development of e-commerce in the agro-food industry.	H. Boughanmi	2001-03	Third	8,400
17. Production, reproduction and clinical manifestations induced by low dietary levels of vitamin B12 in Omani goats.	E.H. Johnson	2001-03	Third	9,600
18. Improvement of carcass and meat quality characteristics of Omani goats.	I. Kadim	2001-03	Third	5,400
19. Investigation and optimization of humidification and dehumidification processes in greenhouse to produce fresh water.	J. Perret	2001-03	Third	8,400
20. Introduction and evaluation of lime somatic hybrids potentially resistant to Witches Broom Disease of lime.	I. A. Khan	2001-03	Third	9,500
21. Development of transgenic potato cultivars expressing d-endotoxin gene resistant against potato tuber moth.	A. J. Khan	2001-03	Third	10,400
22. Use of CT scanning for visualizing stress responses in roots.	M. Deadman	2001-03	Third	4,800
23. Quality assessment of fresh yellow-tuna at low temperature storage.	N. Guizani	2001-03	Third	9,400

Title of Research	Grantee (s)	Grant dates, start-end	Status (Year)	Amount (RO)
24. Roles of light and copper in the development of off-flavour in milk.	F. Consolacion	2001-03	Third	2,400
25. Prevalence of salmonella in/on eggs in the Sultanate of Oman.	A. Mothershaw	2001-03	Third	6,400
26. Nutritional status of Omani population.	S. Iqbal	2001-03	Third	12,400
27. Gill net selectivity in the sardine fishery.	H. Al-Oufi	2000-02	Extended	4,650
28. Identification of antimicrobial substances in fresh commercially sold pasteurized milk..	A.S. Kumar	2000-02	Extended	2,315
29. Development of a solar thermal-powered pumping system.	S. Al-Rawahy	2000-02	Extended	8,400
30. Development of a novel test for the rapid determination of protein quality for aquafeed ingredients.	S. Goddard	2000-02	Extended	9,800
31. Chlorophyll metering in forage corn.	H. Esechie	2000-02	Extended	8,535
Total				207,960

Table 4. Research and Development Projects Completed in 2002

Title of Research	Grantee (s)	Grant dates, start-end	Status	Amount (RO)
1. Measurement of rates of potential methanogenesis in sedimentary-gathering behind recharge reservoirs.	P. Cookson	2000-02	Completed	400
2. The role of agriculture in Oman's economic development: a general equilibrium framework.	H. Boughanmi	2000-02	Completed	3,500
3. Characterization of vitamin B12 deficiency in Omani goats.	E.H. Johnson	2000-02	Completed	5,000
4. Enhancement of quality and storage stability of dried abalone using freeze-drying technology.	S. Sablani	2000-02	Completed	12,000
5. Insecticidal properties of sub-tropical plant extracts against insects.	K. Azam	2000-02	Completed	5,375
6. Screening exotic potato germplasm for adaptation to the heat-stressed environments of Oman.	I. Khan	2000-02	Completed	5,100
7. Managing Witches' Broom disease of lime.	O. El Mardi	2000-02	Completed	3,925
8. Fish product development for export and the local market.	S. Kasapis	2000-02	Completed	12,000

The Year in Review

Title of Research	Grantee (s)	Grant dates, start-end	Status	Amount (RO)
9. Structural changes of biological materials during drying: a framework of developing quality fish products from raw agricultural materials.	M. Rahman	2000-02	Completed	12,000
10. Computer-assisted training in the marine sciences.	M. Claereboudt	2000-02	Completed	5,000
Total				64,300

His Majesty's Strategic Research Projects

In 2003, CAMS was awarded funding to a value of RO 97600 for a strategic project from His Majesty's Research fund to 'Evaluate the reuse potential of greywater in Oman'. This complements funding from His Majesty's Research fund provided for three other projects in previous years. In 2002, CAMS was awarded two strategic projects from His Majesty's Research Fund. The first, entitled "Development of fish products for export and the local market", was funded with a total budget of RO 96,000. The second, entitled "Utilization of greenhouse technology for water desalination and crop production", was funded with a total budget of RO 88,000. The College was awarded RO 167,000 in 2001 to enhance the production, quality and utilization of date palms (Table 5). This continuous generous support is aiding faculty and staff at CAMS to undertake the highest level of scientific research that will result in considerable benefits to the agricultural and fisheries industry in Oman in the years to come.

Table 5. Research and Development Projects Funded through His Majesty's Research Fund.

No	Title of Research	Principal Investigator	Year started	Amount (RO)
1.	Evaluation of greywater reuse potential for sustainable water resources management in Oman – Phase 1.	S. Prathapar	2003	97,600
2.	Fish product development for export and the local markets.	S. Kasapis	2002	96,000
3.	Seawater greenhouse development for arid climates: An innovative approach for water desalination and crop production.	S. Sablani	2002	88,000
4.	Improvement of date palm production and date quality in the Sultanate of Oman.	O. El Mardi	2001	167,000
Total				448,600

Externally Funded Research Projects

The faculty and staff have been very successful in attracting financial sponsorship for research from external agencies as well. In August 2003, CAMS was awarded funding to a value of RO 99,220 from the Fisheries Research Fund to study the grouper fishery of Oman. At present, researchers at the College hold 12 projects sponsored by external agencies such as the Fisheries Research Fund, Muscat Municipality, Petroleum Development Oman (PDO), and the Middle East Desalination Research Center (MEDRC) (Table 6).

Table 6. Externally Funded Research and Development Projects.

Title of Research	Grantee (s)	Agency	Start-end	Status (Year)	Amount (RO)
1. An assessment of the grouper fishery of Oman	J. McIlwain H. Al-Oufi	Fisheries Research Fund, MAF	2003-06	-	99,220
2. Evaluation of safety of poultry meat products in Oman	I. Kadim	Muscat Municipality	2003-04	First	3,400
3. Management of ground water resources in Oman and UAE	Anvar Kacimov	SQU/UAEU	2003-05	First	60,345
4. Production water clean-up and reuse: demonstration of high value crop growth using solar dew technology.	M. Goosen I. Haffar A. Al-Maskri A. Al-Nuaimi	Oman/ PDO	2001-03	Second	15,300
5. Aquafeed development from by catch.	S. Goddard	Fisheries Research Fund, MAF	2000-03	Third	160,000

The Year in Review

Title of Research	Grantee (s)	Agency	Start-end	Status (Year)	Amount (RO)
6. Elasmobranch fisheries of Oman.	H. Al-Oufi J. McIlwain	Fisheries Research Fund, MAF	2000-04	Third	98,000
7. Assessment of the composition of desalination plant disposal brines .	J. Oldfield M. Ahmed	MEDRC	2002-03	Second	2,700
8. Assessment of the innovative freezing-melting process for desalination of sea water in the Gulf countries.	M. Rahman & M. Ahmed	MEDRC	2000-03	Third	20,000
9. Reed bed technology for production water cleanup.	M.F.A. Goosen	PDO, Oman	2001-03	Second	8,700
10. Evaluation of a water saving high-absorbency copolymer.	H. Rahman S. Al-Rawahy	EPDC, Japan	2000-02	Third	3,310
11. Reed bed treatment and reuse of oil production water.	H. Rahman H. Esechie P. Cookson A. Kacimov O. El Mardi A. Al-Mahraki	PDO, Oman	2000-03	Third	26,594
12. Management of Oman's kingfish fishery.	H. Al-Oufi	Fisheries Research Fund, MAF	1999-02	Extended	271,000
Total					768,569

Seven externally funded projects were completed in 2003 (Table 7). A book on the management of the red palm weevil is under preparation as a direct result of the joint project between SQU and UAE University. This project was jointly funded in 1997 to study the effect of red palm weevil on palm trees in Oman and the United Arab Emirates.

Table 7. Externally Funded Research and Development Projects Completed in 2003.

Title of Research	Grantee (s)	Agency	Amount (RO)
1. Evaluation of mykoplant for Oman agriculture.	P. Cookson H. Rahman	Inst. Inov. Tech., Germany	1,500
2. Brine disposal methods used in PDO operated desalination plants.	M. Ahmed	PDO, Oman	15,729
3. Effects of processing on quality of local dried sardines and its use as animal feed.	O. Gaafar	Fisheries Research Fund, MAF	60,000
4. Management of red palm weevil.	K. Azam	UAE/SQU	28,000
5. Seawater greenhouse development.	S. Sablani M. Goosen W. Shayya	MEDRC	8,000
6. Water absorbing polymers in saline soil	P. Cookson	Ardenwerk, Gmbe, Austria	500
7. Mangrove conservation, restoration and afforestation	P. Cookson	MRME&WR, JICA (Japan)	700
Total			114,429

Other Significant Activities

CAMS researchers continue to play a significant role in Sultan Qaboos University's reputation as a leading center for research in Oman, the Gulf Region and beyond. Two of its faculty members have been appointed as Research Program Coordinators at the newly formed Water Research Center at SQU. The College has strong partnerships with the Ministry of Agriculture and Fisheries, and the Ministry of Regional Municipalities, Environment and Water Resources in conducting joint research. In addition, the faculty are involved in collaborative projects with the United Arab Emirates University and the University of Arizona, USA. Further, CAMS periodically hosts research students, faculty and staff for brief periods, ranging from weeks to months.

The College is actively involved in reaching out internationally to a larger audience, in sharing ideas and adapting new developments. For the past seven years, the College has published its refereed Journal - *Agricultural and Marine Sciences*. In an effort to disseminate new ideas and research findings, the College organizes symposia and international conferences. In January 2003, the College hosted the International Conference on Soil and Groundwater Contamination and Clean-up in Arid Countries. The proceedings of the conference were published in early 2003, as a special issue of the *Agricultural Sciences Journal*. A conference on post harvest technology is planned for 2005. Similarly, the College organizes a number of workshops, which involve participants from government ministries, private companies and from outside Oman.

SELECTED RESEARCH OUTCOMES & THEIR SIGNIFICANCE

1. Social Accounting Matrix

Dr. Boughanmi from the Department of Agriculture Economics and Rural Studies (AERS) developed a Social Accounting Matrix for Oman, which was used to investigate the link between agricultural and non-agricultural sectors and to simulate the effects various policy scenarios may have on the overall economic growth. Application of this tool showed that the diversification scenario by which agricultural and manufacturing exports are promoted has the highest impact on overall production, implying that policy makers should allocate more investment to these two sectors.

2. Food Security

Dr. Boughanmi and Professor Waelti (AERS) investigated the food security of Oman within the context of further trade liberalization imposed by WTO. Results indicate that cost of trade liberalization is small in terms of exchange rate variation, and economy-wide tariff elimination is more efficient than tariff elimination in the agricultural sector alone.

3. Liver Disease in Goats

Prof. Johnson from the Department of Animal Veterinary Sciences (AVS) and his collaborators established that cobalt deficiency was the leading cause of liver pathology in goats in the Sultanate causing hepatic lipidosis (fatty liver syndrome). This is contrary to the general belief that goats are extremely resistant to cobalt (vitamin B₁₂) deficiency. Subsequent to this finding the entire faculty and staff embarked on a joint effort and have established that cobalt deficiency results in impaired growth, poorer nutrient digestibility, inferior carcass quality, impaired red blood cell development and a weakened immune

system. This project is one of the most comprehensive studies of a mineral deficiency in small ruminants ever undertaken. The economic impact of this outcome is estimated to be enormous.

4. Cobalt Deficiency in Goats

AVS has been the first to experimentally reproduce caprine hepatic lipidosis by feeding low levels of dietary cobalt. The study found that there is a difference in the genetic susceptibility of different breeds of goats to cobalt deficiency. Batina goats are more susceptible and suffer more severe production and clinical manifestations than Jebel Akhdar and Dhofari goats. This finding has immediate benefit to the animal producer. In those areas of the country with very low levels of cobalt in the soil it would be advantageous to raise those breeds of goats that are more resistant to cobalt deficiency. These studies have conclusively established that supplying cobalt to goats during their post weaning growth phase when they are most susceptible to this nutritional deficiency can prevent the severe economic devastation of this disease.

5. Milk Quality

Dr. Srikandakumar (AVS) and his colleagues have established that four out of five commercially available milk products sold in Oman exhibited both anti-microbial activity as well as microbial contamination on a frequent basis. These alarming findings strongly suggest that milk sold in Oman must undergo stricter quality control during production, handling and processing. Failure to do so would have detrimental human and animal health implications.

Dried Abalone

Dr. Sablani From the Department of Bioresources Engineering (BAE) determined the procedure to produce high quality dried abalone using freeze-drying technology. In Oman, abalone is sun dried and the quality of sun-dried product is generally poor. The quality of air-dried abalone is inferior in terms of color and rehydrability when compared to freeze-dried abalone. Freeze drying experiments indicated that the shelf temperature has little influence on rehydrability of dried abalone. The adsorption isotherm results indicated the monolayer moisture content of 7.47% (d.b.). The results of this study should be able to help design, freeze and air drying processes for desired quality of dried abalone.

6. Dried Tuna

Dr. M.S. Rahman (BAE/FSN) developed a state diagram of dried Tuna, which has the potential to help the tuna industry to develop quality-dried tuna to enter or secure the lucrative overseas market. His study involved assessment of dried Tuna for their structure, microbiology, and chemical attributes; different drying methods, such as solar-, convection-, vacuum- and freeze-drying methods; and analysis of structural attributes such as density, shrinkage, and porosity. One of the significant finding was that the drying temperature of 50°C or below – which is the case in air-drying - is not lethal to the microorganisms.

7. Soil Preferential

Dr. Perret (BAE) and his colleagues have developed an innovative protocol for the characterization of soil preferential flow paths using fractal geometry. Knowledge of preferential pathways, and our ability to predict occurrence and behaviour of them is important to manage aquifers susceptible for

contamination. Dr. Perret and colleagues were able to determine a direct relationship between fractal dimension and macro-porosity. Once the fractal dimensions of the macro pore networks have been estimated, it is possible to create fractal macro pore structures over large field sites synthetically, and develop management strategies to prevent contamination of aquifers.

8. Insect Resistance Potato

Dr. Jamal Khan from the Department of Crop Sciences (CS) in collaboration with University of Ottawa, Canada, has succeeded in developing transgenic potato variety carrying insect resistance gene from the bacterium, *Bacillus thuringiensis*, for the first time in Oman. The insect resistant gene is coded for the expression of crystal protein, toxic to tuber moth insects – a major pest of potato in Oman. Transgenic potatoes producing crystal protein would be protected against tuber moth insects, thus avoiding the use of expensive insecticides, which are hazardous to human health and environment.

9. Mango infestation

Mango fruit production in Oman is under threat from a new disease. The Department of Crop Sciences is making a concentrated research effort to solve the problem and, in collaboration with the Ministry of Agriculture and Fisheries and the University of Pretoria, South Africa, has very recently identified a previously undescribed species of fungal pathogen. Tentatively named *Ceratocystis felix*, the pathogen is thought to play a major role in the disease epidemic affecting mango trees in Oman. It is thought that the pathogen is transferred between trees by bark beetle insects.

10. Fish Products

Department of Food Science and Nutrition (FSN) in collaboration with Oman Fisheries Co. and the Fish Quality Control Center (FQCC) of the Ministry of Agriculture and Fisheries, has improved texture and sensory properties of fish burgers and sausages. Traditionally, these are made with starch but fail to meet consumer expectations of eating quality characteristics. Improved formulations were made using milk protein, citrus pectin, bovine gelatin, soya protein, κ -carrageenan, frozen vegetables and dried fruits. A meeting was held at the headquarters of Oman Fisheries Co. to discuss opportunities for commercialization of these products and further developments are anticipated with the involvement of FQCC.

11. Vitamin Deficiency

The Department of Food Science and Nutrition studied the vitamin status of male and female young Omani adults to identify risk factors for several diet related disorders. The study identified several deficiencies originating from lack of awareness of a balanced diet and the influence of fast food culture in this population group. In collaboration with the College of Medicine, FSN will further disseminate the findings to the general populace.

12. Shark Fishery

Drs Aaron Henderson, Hamed Al-Oufi and Jennifer McIlwain from the Department of Marine Science and Fisheries (MSF) have identified shark, ray and guitarfish species that occur in Oman's coastal waters, as well as their relative importance to Oman's shark fishery. Work is in progress to assess growth and reproductive data collected over the last year and will soon be

in a position to describe the biology of the most abundant species. The discovery of two hitherto unknown guitarfish species, which we are in the process of describing is noteworthy.

13. Marine Processes

Dr. Claereboudt (MSF) identified statistical correlations between settlement rate and the presence of wind-driven upwellings along the northern coast of Oman. This is important because it proves that the arrival of planktonic larvae on the shore is driven in part by stochastic events such as upwelling and downwelling. Since wind strength and direction show strong inter annual variability, it is likely that recruitment of invertebrates and fish show also these inter annual fluctuations. The comparison of two years of data (with and without abundant upwelling events) confirmed this hypothesis. The implication in terms of fisheries (high recruitment years vs low recruitment years) is capital for the safe management of the fish stocks.

14. Marine Pollution

Dr. Claereboudt (MSF) determined that Omani beaches are cleaner than many international beaches. Beach debris contamination levels ranged from 7.8 to 75.44 g m⁻¹ of beachfront with a mean contamination of 27.02 g m⁻¹. In terms of numbers of items, plastic debris ranked first on all beaches followed by either wood items or other degradable material such as cigarette butts. Industrial debris remained few on all beaches (<10%). Most debris had a local origin and, in terms of numbers, was associated with beach recreational activities whereas fishing debris represented the largest proportion of the debris in terms of weight. There were notable differences between beaches in the relative abundance of recreation-related and fishing-related debris. These values remain low in comparison to values published internationally.

15. Water Contamination

Dr. H. A. Rahman from the Department of Soil and Water Sciences (SWS) and his colleagues showed that it is possible to reduce hydrocarbons in oil-production water by more than 98% and water volumes by 50%. There were no significant reductions in heavy metal concentration, while the salt concentration increased in proportion to the reduction in water volume. This finding has significant implications to the petroleum industry, which is facing an arduous task of disposing oil-production water.

16. Water Seepage

Dr. Kacimov (SWS) has developed novel analytical solutions for determination of transport parameters for flows in soils, aquifers and aflaj. Furthermore, he studied saturated and unsaturated seepage analytically with a focus on contaminant transport; expounded new infiltration regimes near falaj tunnels and macropores; and analyzed drainage and groundwater mound decay patterns. These solutions have provided additional insight into hydraulics and therefore have the potential to conserve and manage water better in future.

17. Ground Water Contamination

Dr. Ahmed (SWS) found the groundwater quality in agricultural areas of Batinah is threatened by nitrate contamination. With the aid of a numerical model 'LEACHN', he found that reduction in fertilizer and water input, split application of fertilizers and cultivation of crops with higher rooting depth will reduce nitrate leaching. Furthermore, he determined that movement pesticides towards groundwater can be slowed if water input is lowered and organic matter is added to the top

soil. Adoption of these findings need to be promoted in the Batinah region to protect the aquifer.

18. Brine Disposal

Dr. Ahmed (SWS) assessed brine disposal methods at desalination plants and confirmed the technical feasibility of treating reject brines from RO desalination facilities in simple processing routes, using the SAL-PROC technology. Based on this analysis, it is clear that various types of salts including Gypsum, sodium chloride, magnesium hydroxide, calcium chloride, calcium carbonate, sodium sulphate could be produced. Since the PDO operates 14 desalination plants at 8 locations with installed capacity to produce more than 7,000 m³/day of freshwater, this finding is of financial and environmental significance to the PDO.

Integrated Management of Fruit Flies in Sultanate of Oman

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P.O. Box 34, Al-Khod 123, Sultanate of Oman and ² Ministry of Agriculture &
Fisheries,

Duration: 3 years

Budget: RO 4,995

Summary

Fruit flies are the most potentially damaging fruit pests in Oman. They attack sound or damaged fruits by depositing the eggs in the pericarp and the larvae feed inside the tissues resulting in the rotting of fruits and premature fruit drop. Oman, with a tropical climate, is a rich center of diversity of fruits and vegetables including citrus, guava, mango, papaya, melon, zizuphus, banana, and squash etc., which are severely attacked by species complexes and possibly new and undescribed species. Only one species of fruit fly, *Bactrocera (dacus) dorsalis* has been reported in Oman and no sound control measures have been suggested, resulting in significant losses in yield and quality.

The aim of this project is to control fruit flies of major economic importance in Oman, thus promoting the production of quality fruits and vegetables. The activities under this project will be:

1. Detection, determination and monitoring of native species of fruit flies.
2. Determination of damage caused by different fly species and their hosts.
3. Census of hosts and fruit flies.
4. Establishment of a strategy for integrated management of fruit flies.

The outcome of the project in the form of scientific publications, reports etc. will be made available to agriculturists and farmers in Oman.

Response of Chickpea (*Cicer arietinum* L.) to Salinity Stress

H. Esechie and S. Al-Khanjari

Department of Crop Science, College of Agricultural and Marine Sciences,
P.O. Box 34, Al-Khod 123, Sultanate of Oman

Duration: 3 years

Budget: RO 4,999

Summary

Chickpea, an important leguminous crop in Oman, is used for food, feed and forage. Grain yield in this country varies from 1.0 to 1.5 t/ha, which is very low compared to yields in other parts of the world. The low yields have often been attributed to salinity stress, especially along the Batinah Coast where most of the chickpea farms in Oman are located. While breeding of salt tolerant species may be a good solution, this approach requires an understanding of the physiology of salt tolerance. Our study will identify certain physiological traits associated with salinity tolerance, which can be used by the breeder in a follow-up breeding program.

Molecular and Serological Characterization of Alfalfa Phytoplasma

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³Department of Plant Pathology, Univ. Bologna, Italy.

Duration: 3 years

Budget: RO 8,000

Summary

Alfalfa witches'-broom disease (AWBD) is an increasing constraint on the production of Oman's major commercial fodder crop. AWBD is associated with a phytoplasma pathogen. Molecular characterization of the phytoplasma, identification of its vector and any alternate weed hosts are important steps towards the formulation of economically sustainable production and crop protection measures. The aims of this project are to gather data on the current status of AWBD in Oman, mapping of AWBD phytoplasma chromosome to characterize the immunodominant membrane protein gene and to develop serological method of detection for the pathogen. This project aims :

1. To survey the alfalfa growing areas in Oman; to assess the losses due to AWBD; to produce a distribution map for the disease and data on the economic life expectancy of infected crops.
2. To identify and collect putative insect vectors from the field. Presence of the phytoplasma will be confirmed in vectors and by DNA amplification and or southern hybridization.
3. To collect and identify weed species near alfalfa fields and test them for the presence of AWBD phytoplasma by DNA amplification to ascertain if there are alternate reservoirs for the pathogen.
4. To develop polyclonal antibodies phytoplasma chromosome will be purified by Percoll/CsCl₂ gradient and or pulsefield gel electrophoresis.

Fractionation of Heavy Metals in Calcareous Soils Amended with Sewage Sludge

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Duration: 3 years

Budget: RO 4,950

Summary

Sewage sludge, a residual solid material from wastewater treatment plants, is organic rich solids that contain sufficient nutrients, such as N and P, and organic matter to make them potentially useful agricultural amendments. However, sewage sludges contain not only nutrients and organic matter but also contaminants such as heavy metals discharged into sewers from industries and industrial products. Therefore, land application of sewage sludge could introduce potentially toxic heavy metals into agricultural soils. Whether these metals will become detrimental to plant growth or to the consumers of the harvested crops depends on the amounts and chemical forms present in the soils and/or sludges. Since the municipalities in Oman and Sultan Qaboos University are considering recycling sewage sludge and utilizing it as a fertilizer, it is important to gather data and acquire information on the bioavailability of heavy metals in Omani soils amended at various rates with sewage sludge obtained from different treatment plants in Oman. This project aims to study the content and chemical forms of some heavy metals in selected soils and sludges of Oman and sludge-amended soils.

Evaluation of Four Water Saving Hydrophilic Copolymers

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Sciences, P.O. Box 34, Al-Khod 123, Sultanate of Oman

Duration: 2 years

Budget: RO 450

Summary

Synthetic polymers have been developed to alleviate the water shortage problems in arid and semiarid climates. In these trials four new high-absorbency copolymers will to be tested for their water saving capabilities. Laboratory tests will first be conducted on the copolymer to determine their hydraulic characteristics, then soil columns will be used to evaluate the reduction in evaporation losses and hence amounts of water conserved.

Ripening Profile of Semi Hard Standard Goat's Milk Cheese

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Marine Sciences, P.O.Box 34, Al-Khod 123, Sultanate of Oman

Duration: 3 years

Budget: RO 6.400

Summary

In Oman, goat's cheeses are manufactured traditionally at home by small farmers and are consumed as fresh. These cheeses are made manually from raw goat's milk coagulated with a crude aqueous extract of dried fruit of the plants *Solanum incanum* L. or *Solanum nigrum* L. or the aqueous crude extract of the dried digestive tract of king fish, without a deliberately added starter culture. The safety of the product obtained is uncertain as milk used is not pasteurized to destroy pathogens and the production conditions are not controlled. The present project will deal with the quantitative changes of the microbial flora and the main physicochemical, biochemical and rheological properties during ripening of standard semi hard cheese made from pasteurized goat's milk and aged under controlled conditions. The results of the present study will be used to set up small industries in the main goat's milk producing areas to produce a standard type of cheese in a semi-artisanal way, but taking into account the hygiene and health regulations legally established for this kind of product. The traditional process of cheese making has to be abandoned, as pasteurization, the use of starter cultures and the control of ripening conditions are now necessary for the production of safe products with high quality.

**Effects of Kingfish (*Scomberomorus commerson*) Oil on
Atherogenic Factors in Rats**

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P.O. Box 34, Al-Khod 123, Sultanate of Oman

Duration: 1 year

Budget: RO 4,200

Summary

Marine fish oil contains high amount of unsaturated fatty acids which are involved in the maintenance of membrane fluidity, changes in the membrane fluidity modulates function of various cell types, including platelets, which play important role in the development of arterial thrombosis and atherosclerosis. Cholesterol also interferes with platelet function and platelets from patients with hypercholesterolemia have an increased sensitivity to aggregating agents. Unsaturated fatty acids are also reported to increase plasma insulin level. It could be that increased plasma insulin level is due to changes in membrane fluidity of beta cells of pancreas induced by fish oil. Thus the effect of king fish oil on platelet aggregation, glycemic status lipid profile etc. will be investigated.

**Use of Selection Grids to Reduce Discarding in the Demersal
Trawl Fisheries of Oman**

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and C. Radcliffe²**

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Agricultural and Fisheries, Sultanate of Oman

Duration: 2 years

Budget: RO 10,400

Summary

Selection grids are proving to be a powerful tool in both size and selection of species caught in demersal trawls. There is considerable evidence to support the fact that mesh size alone is not effective in releasing juvenile fish in a multi species trawl fishery. This project aims to explore the possibility of undertaking size selection of a range of species caught in Omani waters by using selection grids in the extension of a trawl and optimising the bar spacing.

Three-dimensional Fractal Analysis of Preferential Flow Paths using CT Scanning

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Duration: 3 years

Budget: RO 4,200

Summary

Development of management systems based on accurate models, which take preferential flow paths into account, is crucial in order to decrease the adverse impacts on water quality. Many efforts have been made to understand the factors affecting leaching of chemicals such as pesticides and fertilizers into soil and groundwater. Leaching can be greatly accentuated by the presence of preferential flow paths. Knowledge of soil structure, along with a suitable technique for measurement of flow characteristics of water and associated solutes through soil, is essential to understanding the mechanisms of preferential flow. Unfortunately, progress in this area has been severely limited by difficulties associated with direct and non-destructive measurements of soil structure. Consequently, questions concerning the geometry, morphology and topology of soil preferential flow paths, and how these parameters affect water flow through soil, have largely remained unresolved.

This study was undertaken to develop an innovative protocol for the characterization of soil preferential flow paths using fractal geometry. The three-dimensional evaluation of fractal dimension is still in its infancy and remains unexplored in soil science. Previous attempts to investigate 3-D fractal geometry of preferential paths have not been made. With the combination of CT scanning and the development of computer programs in the PV-WAVE language and Visual Basic, the fractal dimension of soil preferential flow paths will be characterized to level that has not been possible before.

**Study on the Relationship between Ascorbic Acid
Supplementation and Heat Stress on Poultry Maintained in Open-
sided Housing**

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Waheebi and R. Al-Busaidi**

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Duration: 2 years

Budget: RO 9,700

Summary

Hot environmental temperatures are a major limiting factor in poultry production in Oman. The use of standard commercial stocks in open-sided housing in Oman may result in large economic losses because genotypes selected in temperate climates may respond differently to high ambient temperatures. Any practices which can alleviate the deleterious effects of heat stress on poultry performance in open sided-housing, will be of major benefit to the poultry industry. It has been reported that ascorbic acid is actively transported into tissues and that the utilization and demand for ascorbic acid increases during periods of heat stress. Therefore, poultry exposed to environmental heat stress might require larger amounts of ascorbic acid (Pardue and Thaxton, 1986). The present study will investigate the effects of supplemental stable and reliable sources of ascorbic acid on the performance of commercial broiler chickens in open-sided housing during the summer (June), fall (October) and spring (February) in Oman. A factorial design in a 4 X 3 arrangement using four doses of ascorbic acid (000, 100, 200 and 300 ppm) and 3 seasonal temperatures (summer, fall and spring) will be used. Day-old broiler chickens (Cobb 500, n= 384 and Cobb100, n= 384) will be obtained from two commercial stocks and randomly allocated to 48 pens containing 16 birds per pen with 6 replicates per treatment during each of the three seasons. All birds will receive a standard starter diet from 1 to 21-d old and then finisher diet from 21 to 42-d old. The ascorbic acid will be added to the standard commercial diets. Body weight, feed intake and rectal temperature will be recorded at 0, 7, 14, 21, 35 and 42-d of age. Internal organ weight, carcass and meat quality and mortality will also be evaluated. The health status of the chickens will be evaluated by assessing hematological and serum biochemical parameters.

Desalinating soil by Linking a Novel Solar Heated Process to an Augmented Water Supply

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Duration: 3 years

Budget: RO 10,800

Summary

Coastal farms in Oman are suffering from increasing soil salinity and deteriorating water quality. By combining two novel technologies, this project aims to restore productivity to land wasted by salinity in coastal farms of Oman. Soil desalinization will be achieved by a solar heated process developed at SQU in combination with a reliable and effective dew collecting system. Interior surfaces of soil pits in salinized farms will be treated with a hydrophobic barrier and an effective 'one way' water valve constructed near the soil surface. The 'water valve' is designed to allow unidirectional (upwards) flow of salty water. During subsequent leaching salty water will be directed laterally away from the root zone. Subsurface irrigation will be supplied using fresh water fed from a dew-collecting device. Trees will be planted in the newly desalinated area and sustainably irrigated with dew-collected water. After rigorous initial testing at the Agricultural Experiment Station, the combined system will be transferred to a coastal farm near SQU to assess its on-farm applicability

Graduate Program

Sultan Qaboos University is the national university of Oman, and as such pursues every opportunity to build additional scientific and technological capabilities. Apart from its leading edge research activities in agriculture, food systems and marine sciences, CAMS is also committed to transferring knowledge and skills through its graduate program. Since its beginning in 1997, the M.Sc. program has gained momentum and achieved successful results. The College offers M.Sc. programs in Crop Protection, Crop Production, Marine Science and Fisheries, Animal and Veterinary Sciences, Agricultural Economics, Soil and Water Management, Bioresources Engineering and Food Sciences. There are 88 postgraduate students currently involved in the program and, since 1997, 34 M.Sc. students have graduated. Thesis abstracts for students who graduated during this reporting period are presented in pages 39-47. A proposal to embark on a Ph.D program with more comprehensive requirement for research and productivity is under preparation.

Title : Nutritional Ecology of the Arabian oryx (*Oryx leucoryx*) in Jiddat Al-Harasis Sanctuary in the Sultanate of Oman

Student Name : Salah Saeed Hamoud Ali Al-Mahdhoury

Advisor : Dr. Isam Tawfik Kadim

Department : Animal and Veterinary Sciences

Abstract

The feeding ecology of the Arabian oryx (*Oryx leucoryx*) was evaluated in the Arabian Oryx Sanctuary (AOS) in the Sultanate of Oman. Fecal and forage analysis were used to evaluate the diet composition eaten by the oryx. The plant and fecal samples were collected from various sites within the sanctuary between July 2000 to July 2001 in seven sampling visits. The samples were examined using microhistological analysis to identify the plants eaten by the oryx and to estimate the occurrence of the cuticular fragments in the oryx fecal samples. Nutritional parameters such as dry matter (DM), crude protein (CP), crude fiber (CF) and total ash were estimated by chemical analysis of the most selected plant species by the oryx (five grasses and two browse species) and of the oryx fecal samples. The microhistological analysis and chemical composition of the plants and feces were both used to interpret oryx foraging habits in response to the seasonal variation. The diet of the oryx consisted of a mixture of grasses, forbs, herbs and shrubs. Microhistological analysis of the oryx fecal samples revealed that the Arabian oryx is predominantly a grazer ruminant. Of the total epidermal fragments identified in the oryx feces throughout the study period, monocotyledons and dicotyledons were 62% and 37%, respectively. Out of 41 different plant species in the AOS, twenty plant species of which ten were monocotyledons and ten dicotyledons were positively identified in the oryx feces. The occurrence of plant species in the oryx feces appears to follow the rainfall pattern. During the rainy period, consumption of the monocotyledon species increased while the dicotyledon species decreased, whereas an opposite trend occurred during the dry period. This was accompanied with the seasonal variation in the chemical composition of the DM, CP, CF and total ash levels of plants and feces. During the dry period, the DM, CF and total ash were at their highest levels while the CP was at its lowest levels in both the plant and fecal samples. An opposite trend was observed during the wet period. The microhistological analysis of feces showed that the oryx changed its foraging habits from one period to another. During the dry period, monocotyledons and dicotyledons were 23% and 77%,

whereas during the wet period they were 81% and 19%, respectively. Generally, dicotyledons had higher CP and lower DM, CF and ash levels than monocotyledon species during both dry and wet periods. This study showed that the plant species selected by the Arabian oryx is probably a function of forage availability and palatability.

Title : An Evaluation of Microbiological Status and Development of Hazard Analysis Critical Control Points (HACCP) Plan for the Central Slaughterhouse, Muscat, Sultanate of Oman

Student Name : Ahmed Nouri Al Raisi

Advisor : Dr. Ann Mothershaw

Department : Food Science and Nutrition

Abstract

The Central Slaughterhouse is the only slaughterhouse in the Muscat area. In this study, possible sources of microbiological contamination onto carcasses in the Central Slaughterhouse were studied and a Hazard Analysis and Critical Control Point (HACCP) system were designed based on microbial observations. Microbiological profiles of two sites (brisket and dorsal) on the animal carcasses were determined, using both swabbing and sponge techniques, at different stages during slaughterhouse processing. Microbiological contamination of equipment, the environment and workers' hands and aprons was also evaluated. The mean count recovered by swabbing ($\log_{10} 1.83 \pm 0.38$ cfu.cm⁻²) was significantly higher ($P < 0.05$) than that obtained using the direct sponge technique ($\log_{10} 1.31 \pm 0.38$ cfu.cm⁻²). The mean total bacterial count determined at $20 \pm 2^{\circ}\text{C}$ was not significantly different from that obtained at $35 \pm 2^{\circ}\text{C}$. *Salmonella* spp., *Staphylococcus aureus*, *Pseudomonas* spp. and *E. coli* were all recovered from carcasses. The total bacterial count from aerosols did not vary significantly between different processing locations. However, when animals were present, the proportion of Gram-negative organisms increased dramatically. Results of a questionnaire demonstrated that most of the workers have low educational standards and very limited knowledge about food safety and hygiene. Also, sampling of workers' hands gave a 100% frequency of contamination with *Staphylococci* spp. This indicated a major role for workers in cross-contamination of carcasses. The cutting board surface was also identified as a major source of contamination. The average mesophilic bacterial count was $\log_{10} 5.56$ cfu.cm⁻² and 50% of samples were *Salmonella* spp. and *Staphylococci* spp. positive. *Penicillium* spp. molds were recovered and even in some cases showed visible growth on the board. Microbial contamination of equipment was high, the mean total count (\log_{10} cfu /one side of blade) of knives were between <3.00 to 5.90 and <3.00 to 3.78 \log_{10} cfu.cm⁻² for aprons. A HACCP plan was designed for the slaughterhouse based on the microbiological evaluation and the seven principles of HACCP. Three critical control points

were identified as evisceration, inspection and chilling. Implementation of this plan will reduce the levels of microbial and physical contamination and improve the safety and shelf-life of the meat.

Title : The Application of a Blocking-ELISA for a Serological Study of Contagious Caprine Pleuropneumonia (CCPP) in Three Regions of Oman.

Student Name : Abdumajeed Homoud Habib Al-Rawahi

Advisor : Prof. Eugene H. Johnsn

Department : Animal and Veterinary Sciences

Abstract

Contagious Caprine Pleuropneumonia (CCPP) is a severe disease affecting goats in Eastern Africa and the Middle East, caused by *Mycoplasma capricolum subsp. capripneumonia* (Mccp). It was previously classified as a member of so-called mycoplasma mycoides cluster and termed as (F38 group). CCPP has been described as the most serious devastating infectious disease of goats in the Sultanate. It is characterized clinically by fever (41-43 °C) and severe respiratory manifestations. The morbidity rate may reach up to 100 % and mortality up to 70 % when no control measures are taken. The diagnosis of the disease by means of characterization of the clinical signs is difficult, as many diseases have similar clinical manifestation. Diagnosis of CCPP on the basis of isolation and identification of the causative agent is also difficult, as the pneumonic lesions are often mixed with other pathogens. Many serological tests have been used to evaluate the antibody status of affected goats, however, the specificity of these tests is usually poor as they detect antibodies against antigens of mycoplasma which are shared by other species of the mycoides cluster. Hence the interpretation of the results is often difficult. A blocking ELISA (B-ELISA) is a new diagnostic tool that was designed for the specific detection of antibodies developed against Mccp in serum of infected goats. It is reported to be highly specific and sufficiently sensitive. In this study, B-ELISA was utilized to evaluate the presence of Mccp-antibodies in 535 serum samples collected from both vaccinated and non vaccinated animals (495 from non-vaccinated animals from Barka, Nizwa and Bahla and 40 samples from vaccinated Batina female animals from Sohar). Goats were selected from various age groups, sexes and breeds from three regions of the Sultanate. The results demonstrated that 47 % of non-vaccinated animals were seropositive for Mccp. There were no significant differences due to age, sex, breed or the three regions. These results are indicative of the widespread presence of Mccp in the Sultanate. Vaccinated animals showed a similar ($P \geq 0.05$) percentage (50 %) of seropositive cases, suggesting either an inability of the B-ELISA to differentiate between the non-vaccinated and vaccinated animals or that the epitope employed in the B-ELISA is not expressed in the vaccine or that there was vaccination failure.

Title : Water Use Efficiency and Ater Use Efficiency and Yield of Cucumbers (CUCUMIS SATIVUS) Under Greenhouse and Field Conditions

Student Name : Hamdan Salem Said Al Wahaibi

Advisor : Dr. Hayder AbdelRahman

Department : Soil and Water Sciences

Abstract

Water is the primary limiting factor in agriculture in Oman. The combination of aridity, extensive urbanization and expansion of irrigated farming have brought about substantial water demand increase and intensified the gap between rising water demand and limited existing water supply. There is still significant potential to improve the efficiency with which water is used. Previous studies indicated that water application exceeds irrigation water requirements. As such significant savings in water consumption could be achieved through improved water application and management. Experiments were conducted at the Agricultural Experiment Station at Sultan Qaboos University to determine the effect of four irrigation treatments (1, 2, 3 and 4 mm/day in greenhouse) and (3, 4, 6 and 8 mm/day in field) on the yield of greenhouse and field cucumbers, and to study the effect of evaporative cooling on the yield, total water use efficiency and total water cost. Greenhouse cucumber yields were increased quadratically as the irrigation water quantity increased from 1 mm/day to 4 mm/day. Results indicated that 2 mm/day in greenhouse is the best for optimum cucumber yield. Application of 3 mm/day maximized yield, with no significant difference being observed from 2 mm/day application. The yield increased by 49 % when irrigation was increased from 1 mm/day to 2 mm/day. Field cucumber yields increased linearly as the irrigation water increased from 3 mm/day to 8 mm/day. Yield was optimized at 6 mm/day application. The 8 mm/day maximized yields but fell short of the optimum yields obtained in the greenhouse. Optimum yields were obtained at an average crop factor of 0.52 and 1.55 in the greenhouse and the field respectively, indicating that water requirements for the greenhouse cucumber is about one third of the water requirements in the open field. Results also indicated that the irrigation water use efficiency was higher in the greenhouse than that of the open field because of the lower water requirements and higher yield of cucumbers in the greenhouse. But the

total water use efficiency was higher in open field than that of the greenhouse because of the high quantity of water used for evaporative cooling of the greenhouse. The average pad water use was found to be 79.1 liter/ day/m² of pad. For greenhouse treatments, Irrigation water use efficiency was the highest with 2 mm/day application (80 Kg/m³), whereas in the open field the highest irrigation water use efficiency obtained was 19 Kg/m³ for the 6 mm/day applications. The initial EC values of the soil saturation extract of the greenhouse and field decreased with soil depth and the top layer (0-10 cm) had the highest EC value. Results also indicated that below the drippers salts were more effectively leached as the irrigation water was increased. The EC values of the saturation extract of the greenhouse soil was high close to the cooling pad of the greenhouse. The EC values then decreased as the distance from cooling pad increased.

Title : Modification of a Quonset Greenhouse to a Humidification-Dehumidification System: Design, Construction and Pilot Testing

Student Name : Abdulrahim Mohammed Al-Ismaili

Advisor : Dr. Johan Perret

Department : Bioresource and Agricultural Engineering

Abstract

Prolonged aridity in the Sultanate has resulted in freshwater deficit in some parts of the country. In coastal areas, the aridity coupled with over-pumping of groundwater have often resulted in seawater intrusion. Looking for alternatives to provide freshwater for domestic, industrial and agricultural purposes is an ultimate goal for the government. An overview of these alternatives is described in this study. The use of solar radiation in greenhouses to desalinate saline/brackish water was proposed as an alternative to provide freshwater for irrigation. This study aims at constructing and preliminary testing a humidification-dehumidification system in a Quonset greenhouse for producing freshwater. The greenhouse was constructed and tested at the Agricultural Experiment Station (AES) of Sultan Qaboos University. This greenhouse was modified to work with two humidifiers (i.e., evaporating pads), to increase water vapor inside the greenhouse as much as possible, and two dehumidifiers (i.e., condensers) to condense this water vapor. After evaporation, water leaving the humidifiers was cooler than the incoming water. This cooled water was pumped to the two dehumidifiers and acted as a coolant. Preliminary testing of the performance of the greenhouse showed an increase in the amount of water vapor after the second humidifier. The temperature of the dehumidifiers was always lower than the dew-point temperature of the air passing through them. This meant that there was a potential for condensation. However, condensation was insufficient to result in a measurable quantity. Possible reasons for this insufficient condensation were investigated. Finally, recommendations for improvements of the humidifiers and dehumidifiers were suggested.

Title : Water Conservation in Greenhouse Management Using Soil Water Holding Material

Student Name : Rashid Khalfan Al Subhi

Advisor : Dr. Peter Cookson

Department : Soil and Water Sciences

Abstract

Sandy soils are known for having low water holding capacities, which present problems in irrigated farming systems. Sandy soils tend to dry quickly between irrigation events, resulting in reduced yields. To keep sandy soils wet, farmer resort to frequent irrigation, which often results in low efficiency of water use by plants. Better soil water conservation can be achieved if soils are amended with synthetic materials that absorb water. The effects of amending a loamy sand soil with a water holding material (AS-Combisorb) on soil water release characteristics, evaporation and infiltration were investigated in laboratory studies. Amending soil at the rates of 5 and 10% (w/w) of AS-Combisorb resulted in the mixtures having water-holding capacities 29.4 and 70.2% higher than un-amended controls, respectively. Rates of evaporation were increased by AS-Combisorb amendments and infiltration rates decreased. Cucumber (*Cucumis sativus*) plants were grown on a loamy sand soil amended with a water holding material (AS-Combisorb) at three rates of irrigation in a cooled greenhouse during warm season in Oman. The irrigation rates of 171, 132 and 100 l/plant/warm season were imposed to provide optimal, sub-optimal and water stressed soil conditions, and resulted in average fresh marketable yields of 6.6, 5.3 and 3.9 kg/plant, respectively. Soil was amended with 2 and 4 kg/m² of AS-Combisorb placed to a depth of approximately 17 cm either as a layer at the base of cultivated ridges or uniform by mixed with soil. The salinity and water content in soil were monitored during the growth period. AS-Combisorb amendments significantly reduced salinity and increased water content in the soil. Yield responses of plants to AS-Combisorb amendment at 2 kg/m² compared with un-amended soil were not consistent under stressed and sub-optimal irrigation. However, with optimal irrigation, AS-Combisorb amendment increased yields relative to un-amended soils from 5.50 to 7.54 kg/plant, i.e. a 37% increase. Increasing the rate of AS-Combisorb amendment from 2 to 4 kg.m² had no additional benefit on yield increase. In terms of an average size greenhouse (40 x 8m) the yield increase due to AS-Combisorb application was equivalent to 1,860 kg, in the optimal irrigation.

Publications in 2002

The year 2002 was an exciting one for researchers in terms of the number publications. A total of 73 refereed publications were recorded in 2002, a slight increase over that recorded in 2001. Figure 1 highlights the number of refereed publications during the period 1994-2002. This represents published refereed journal papers only, and excludes manuscripts being in press, accepted or prepared at present.

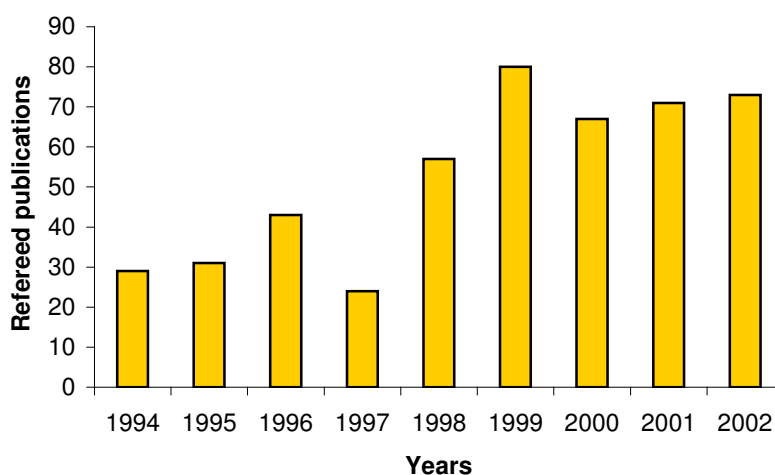


Figure 1. Number of refereed journal publications from CAMS over the past nine years

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