ROTHAMSTED RESEARCH

Iacr Report for 1998

Full Table of Content

World Partnerships

Rothamsted Research

Rothamsted Research (1998) *World Partnerships ;* Iacr Report For 1998, pp 41 - 46

World Partnerships

J.A.MANN

IACR has built partnerships with people in universities, national and international research institutes, non-governmental organisations and the private sector in more than 40 countries around the world. These have been developed at many levels. Staff have participated in strategic policy debates for agricultural research in southern countries, at a national and European level, as well as being involved in projects which develop, apply and disseminate new technologies and research methodologies appropriate to the needs of countries in the South. Training is vital throughout this process, and an area in which IACR continues to be actively involved.

IACR IN BRAZIL

Links with Brazil have been developed with a number of organisations. EMBRAPA the Brazilian Enterprise for Agricultural Research, is part of the Brazilian Ministry of Agriculture and has 37 research stations all over the country. IACR has developed strong links with several of these Institutes (Fig. 45).

Plant and human health

Cashew is a major export crop in north-east Brazil and also has numerous agro-industrial uses of importance to the economy of several states in the region. Major constraints to production include anthracnose disease, caused by the fungal pathogen *Colletotrichum gloeosporioides*, and several insect pests. Since 1996 IACR scientists have been collaborating with the University Federal Rural of Pernambuco, Recife (UFPRe), the University Federal of Alagoas (UFAL) and the agricultural agency EMBRAPA in north-east Brazil to develop improved methods of disease and pest management in the crop, especially in the more productive dwarf cashew clones now being extensively planted in the area. The project, funded through a British Council/CAPES link, has supported reciprocal visits by plant pathologists and entomologists, a workshop meeting on integrated crop protection in cashew held in Fortaleza in 1997, as well as a Brazilian PhD student working on pathogen variation and the resistance of different cashew clones in the Molecular Plant Pathology Group at IACR-Long Ashton. A further aspect, involving entomologists and natural product chemists in EMBRAPA, UFAL and the Biological and Ecological Chemistry Department at Rothamsted, is the development of semiochemical approaches to the control of cashew pests such as tip-borer. This collaboration has led to other joint areas of research including work on the chemical ecology of *Aedes egyptii*, the mosquito vector of dengue, a virus disease which is currently a serious threat to human health throughout the region.

John Lucas - (IACR-Long Ashton) and Mike Birkett - (IACR-Rothamsted)

Fig. 45 *Dr Ervino Bleicher, an EMBRAPA entomologist, outlining the major pest problems in perennial fruit crops in Ceara State. Looking on are, from left to right, Dr Emilson Cardoso, plant pathologist, Maria Diva Correa, Ana Lopez, a PhD student working at Long Ashton on anthracnose disease of cashew, and Professor Euzebio Sant 'Ana, a natural products chemist from UFAL*

Soil carbon modelling

Through a project in collaboration with the University of Sao Paulo, Brazil, colleagues have collected detailed data from Rondônia on tropical pasture sites that were converted from natural forest between 1972 and 1992. These data have been modelled at IACR using the Rothamsted Carbon Model. The model predicts a steady increase in soil carbon between 1972 and 1992. Data show that carbon derived from forest decreases sharply during the first nine years, but carbon derived from pasture increases more rapidly than forest carbon decreases. The total soil carbon after 20 years was about 20% higher under pasture than under native forest. Despite these increases in soil carbon, only about 10% of the total ecosystem carbon lost after deforestation (due to tree removal, burning etc.) can be recovered.

Pete Smith - (IACR-Rothamsted)

IACR IN CUBA

IACR has had links with Cuba for some years in the areas of crop protection and biotechnology. During the last three years, links with scientists at CENSA (Centro Nacional de Sanidad Agropecuaria) have been greatly facilitated by the support of the Cuban Embassy in London. Several visits to Cuba have been made by IACR scientists, and a Memorandum of Understanding between CENSA and IACR has recently been signed. Three areas have been identified for future collaboration: the biological control of plant parasitic nematodes; the chemical ecology of parasitoids and predators; and the development of natural pesticides. In 1996/97 a scientist from CENSA spent a period of 12 months at the Institute as a Rothamsted International Fellow, working on the development of *Verticillium chlamydosporium* as a biological control agent for root-knot nematodes. As a continuation of this collaboration a new Rothamsted International Fellow will spend six months in 1999 at Rothamsted, working on the diagnosis of cyst and root-knot nematodes. Work on non-chemical methods of pest control in vegetables in the peri-urban area surrounding Havana, is now ongoing through a joint PhD student. To facilitate this project, funding has been granted by the British Council for exchange visits over the next three years.

Biological control of plant parasitic nematodes

Root-knot nematodes (*Meloidogyne* spp.) are economically the most important nematode pests in the world causing annual yield losses valued at US$70m. These pests are a major problem in vegetable production in Cuba and sustainable methods for their management are being developed in a collaborative project initiated by Rothamsted International and developed with British Council support. Vegetable production in Havana is dispersed amongst the residential areas in intensively cropped smallholdings (1-2 ha). Production is normally in raised beds (Fig. 46) which are irrigated and the vegetables are sold to the local community from a farmshop on site. Nematode management uses crop rotation, solarisation and trap cropping and may be effective. However, additional control methods are being assessed because of the wide host range of root-knot nematodes and the difficulties of appropriate timing for the harvesting of trap crops. The nematophagous fungus, *Verticillium chlamydosporium*, under development as a biological control agent at Rothamsted, has been isolated from several root-knot nematode infested soils in Cuba. These isolates have been screened for their potential as biological control agents using methods developed at Rothamsted and the most promising selected. Local production of this agent is possible within small factories which currently produce microbial agents for insect control. Hence, the infrastructure for production and application is in place and formulations developed in Cuba are currently under evaluation in the field.

Brian Kerry - (IACR-Rothamsted)

IACR IN CHINA

IACR has developed strong links with The People's Republic of China. To facilitate collaboration, IACR scientists have made more than 50 visits to China over the past five years (Fig. 47), and 29 Chinese scientists have come to work at the Institute either for training or as part of a research project. The high quality of these links has been recognised. Researchers involved have been granted awards of the highest esteem by the Chinese government. Our links with China have provided the background necessary to attract funding for joint work.

Testing new wheat varieties to minimize the use of phosphate fertiliser

Phosphorus (P) has been described as 'the bottleneck of world hunger'. It is an essential element for all life. When a crop is harvested, P is removed with it and unless replaced, soil P concentrations decline until, eventually, soil degradation and total crop failure inevitably result. To exacerbate this problem, many soils in the developing world, e.g. in China and Africa, 'fix' P so strongly that it is almost completely immobile and unavailable to plants. Consequently, about 45% of all agricultural land in the world, and up to 60% in China, is P deficient.

Recently, there has been an exciting breakthrough by Professor Li Zhensheng and colleagues of the Institute of Genetics, Beijing, China. They have screened Chinese wheat varieties for more than 40 years, and have detected those which can produce good yields in soils of low P availability. Following an initial visit to Rothamsted, funded by the Royal Society, Professor Li invited a number of IACR scientists back to his Institute to discuss his findings in more detail. Subsequently, Professor Li has given us the seeds of seven of his 'P efficient' and 'P inefficient' wheat varieties for independent testing.

Rothamsted International will fund a Research Fellow for one year to perform both yield response tests and biochemical experiments. If successful, this could have enormous advantages, not only for the developing world, but also for organic farmers in Europe. Since organic systems cannot use soluble inorganic P fertilisers, a major management problem would be overcome if crops could utilise soil P more efficiently.

Phil Brookes, Ruth Gordon-Weekes and Peter Barraclough - (IACR-Rothamsted)

Soil bioremediation

In China, approximately 10 million ha of agricultural land are polluted by inorganic or organic pollutants (about 50/50). Estimated yield losses are over 10 million tonnes each year. These areas are particularly concentrated in the most productive areas in the eastern coastal regions and midlands. Major metal pollutants are Hg, Cd, Zn, Cu, Pb, Cr, Ni and As. This is due to the use of sludge or urban composts, pesticides, fertilisers and emissions from municipal waste incinerators, car exhausts, residues from metalliferous mining, and the metal smelting industry. Metal concentrations found in contaminated soils frequently exceed necessary or background levels, resulting in accumulations in plants to unacceptable levels (health risk), causing reductions of crop yields and killing the soil microorganisms (reduced plant litter decomposition, lack of mycorrhiza).

A Joint Open Laboratory on Soil and Environment has been established by the Institute of Soil Science in Nanjing and the Hong Kong Baptist University Institute for Natural Resources and Waste Management. Steve McGrath has been involved in setting up the Global Network of Soil Remediation Centres since 1994. IACR are actively setting up links with the Asian Center of Soil Remediation and recently, Dr Bo Sun from Nanjing has been awarded a one year Rothamsted International Fellowship, and will perform research related to soil pollution and remediation at Rothamsted in 1999.

Steve McGrath - (IACR-Rothamsted)

IACR IN EAST AFRICA

Sub-Saharan Africa, including East Africa, depends more on its environmental resource base for its economic and social needs than any other region in the world. Two-thirds of the region's people live in rural areas and depend primarily on agriculture and other natural resources for their income. To them, severe environmental and food production problems are critical concerns. The case for engaging the scientific and agricultural expertise of developed nations in combating these problems is overwhelming.

Stem-borer and striga control in resource-poor cereal farms

Stem-borer pests, which comprise the larvae of various lepidopterous (moth) species, particularly *Busseola fusca* and *Chilo partellus*, are being controlled with an intercropping regime in resource-poor cereal farms in Kenya[1]. Two grass species, Sudan grass, *Sorghum sudanensis*, and Napier grass, *Pennisetum purpureum*, showed extremely high levels of oviposition (egg-laying) by the stem-borers and were planted experimentally as trap crops. Two resistant plants, molasses grass, *Melinis minutiflora,* and the legume silverleaf, *Desmodium uncinatum*, were intercropped as putative repellents for adult stem-borers. Initially, the 'push' of the repellent intercrops and the 'pull' of the trap crops were tested separately in experimental trials at the field site of the main collaborator, the International Centre of Insect Physiology and Ecology (ICIPE), at Mbita Point on the banks of Lake Victoria, and at the field station of the Kenyan Agricultural Research Institute at Kitale. Excellent results were obtained on-farm in 1997. An unexpected bonus was that the chemical cues produced by maize when it is fed upon by stem-borers, and which cause increased foraging and attack by parasitic wasps, were found to be released by the molasses grass intercrop. Furthermore, intercropping with silverleaf achieved dramatic suppression of the witchweed *Striga hermonthica* (Scrophulariaceae), which in some regions can cause even greater losses than

Fig. 46 *Peri-urban vegatable production in Havana, Cuba where root-knot nematodes cause significant yield losses in irrigated, raised beds*

the stem-borer pests. In 1998, in the Suba District for example, push-pull systems involving maize grown with a trap crop of Sudan grass and an intercrop of silverleaf reduced the striga rating to less than 5 % of that for control plots. On a particularly poorly yielding farm, the silverleaf/Napier grass regime increased yields from 1.8 to 3.0 t ha^{-1}. In addition to on-farm trials, Farmers' Days have been held in which the farmers, already keen to experiment, acquired basic information on the cultivation of the 'push' and 'pull' crops and advice on optimising the value of these plants as cattle forage and as a source of saleable seed (Fig. 48).

(1)Khan, Z. R. et al. (1997). *Nature* **388**, 631.

John Pickett - (IACR-Rothamsted)

IACR IN INDIA

Over the past two years strong links have been developed with a number of Indian institutes many of which many are within ICAR (Indian Council of Agricultural Research). These good relations have enabled us to develop links with scientists within the Indian Institute of Soil Science (IISS), Haryana Agricultural University, Pantnagar University, Punjab Agricultural University, Pusa Agricultural University and many others.

Participatory research methodologies

DFID supported visits to Rothamsted by scientists from India involved in the All India Co-ordinated Research Projects to review aspects of project design and management. DFID also funded IACR to facilitate a research prioritisation exercise within ICAR. This was in reponse to the ICAR's National Workshop on Long-term Soil Fertility Management through Integrated Plant Nutrient Supply, held at Bhopal in April 1998, where the lack of adoption of technologies generated by scientists was recognised as a constraint to the improvement of crop production. In response to this, scientists from Rothamsted, together with partners in India, proposed a new research methodology. Participatory research, including farmers as partners in target areas, forms the core of the process and an integral part of demand identification. Satellite research and links to target institutions provide strategic research to address constraints identified by stakeholders and clients during the participatory research process.

The complex nature of sustainable livelihoods poses particular challenges to the management and implementation of strategic research. The widely held assumption that a combination of competent planning, strategic and adaptive research, coupled with effective transfer of technology and sound economic management would lead to improvement in livelihoods is now questioned by scientists, farmers and policymakers alike. The outputs of the process outlined above take the form of tools and knowledge products that will enable our clients to make better informed decisions. We anticipate that our efforts in developing countries will increasingly involve applying our expertise as appropriate in the implementation of, or participation in, such research processes.

John Gaunt - (IACR-Rothamsted)

DFID Indo-UK collaboration on oilseed brassicas

India has the largest area of cultivated oilseeds in the world, and the group rapeseed-mustard accounts for about 32% of the national output (Fig. 49). Rapseed-mustard includes mustard or rai (*Brassica juncea*), toria, yellow sarson, brown sarson (*B. rapa*) and oilseed rape (*B. napus*). The average consumption of edible oils in India has reached almost 6 kg per person per year, but this is still well below the minimum nutritional norm of 14 kg per year prescribed by the Indian Council of Medical Research, and far below the average consumption in EU countries of 49 kg. There are four major diseases of rapeseed-mustard: alternaria blight (*Alternaria brassicae*), white rust (*Albugo candida*), downy mildew (*Peronospora parasitica*) and sclerotinia stem rot (*Sclerotinia sclerotiorum*). Under favourable conditions, these diseases can cause 50-70% yield loss. Work has been ongoing since 1989 to support an Indian breeding programme for disease resistance in rapeseed-mustard. The first phase of this project (1991-1998) was a collaboration between IACR-Rothamsted and GB Pant University of Agriculture and Technology (India). Work focused on resistance to downy mildew and its interaction with white rust. Host pathogen specificity was determined and the genetic factors determining resistance in some lines identified by the programme were analysed. By combining genetic factors from different lines, resistance to downy mildew has now been developed. A major component of the project has been to provide training in epidemiology, micrometeorology and natural plant defence compounds for Indian research workers. The second phase of the project (1999-2006) is just beginning. This phase will involve collaboration with GB Pant University of Agriculture and Technology, the recently

Fig. 47 *IACR scientists on a recent visit to China*

established National Research Centre for Rapeseed-Mustard, and, from the private sector, TATA Energy Research Institute. Work will focus on breeding for resistance to white rust and alternaria, breeding for drought tolerance (which may cause up to 50% yield loss), and the development of rapeseed-mustard throughout the DFID-supported rainfed farming and water-shed projects in India.

Nash Nashaat - (IACR-Rothamsted)

IACR IN SOUTH AFRICA

South Africa is a country of considerable contrast, having some regions which are highly developed and others that can rank among the poorest in the world. IACR has had a number of links with South Africa for many years.

Natural plant products for alternative pest control

During the past year, a strong link has been developed with a South African consortium led by CSIR, Pretoria. An agreement, fully compliant with the International Biodiversity Convention, was signed to facilitate a bioprospecting programme based on South African natural products. Subsequently, a successful application was made to the South Africa/UK fund to underpin aspects of this collaboration. The aim is to identify and assess natural bioactive molecules for a variety of uses, but particularly for the control of pests in agriculture. Selected plant extracts and their constituent compounds will be examined in detail to establish structure-activity relationships with a view to developing synthetic analogues with enhanced targeted activities. Interestingly, the major component of the very first plant extract to be studied (Thomac Oil) was recognised to be (*E*)-β-farnesene, previously identified in 1972 as being the major aphid alarm pheromone component.

Collaboration with the Chemical Ecology and Molecular Structure and Biological Activity Groups within IACR will explore new opportunities for discovering novel crop protection agents and strategies both for resource-poor farmers and for low-input agriculture.

Bhupinder Khambay - (IACR-Rothamsted)

Fig. 48 *Farmers day in Trans-Nzoia District of Kenya. Staff from the Kenyan Agricultural Research Institute, Kitale, discuss stem borer damage with local farmers*

Marama bean as an alternative crop

Legumes have great potential for improving the quality of life in the African continent, through their use as a source of protein, timber, animal-feed or soil-improving biofertilisers. Many are underutilised. The marama bean (*Tylosema esculentum L.*), found mainly in Southern Africa, is an example. It is a wild legume with very high nutritive value as the grain contains 30-39% protein and about 36% oil, comparable to soybean and groundnut respectively. The beans command a high price in local markets and, since they are gathered in the wild, the survival of the plant is threatened(fig. 50). Additionally, the plant produces very large edible tubers (up to 100 kg) which contain about 9% protein, almost twice that of conventional root crops like potato. The size of the tubers is probably an important factor in the plant's ability to withstand very prolonged dry conditions. The foliage is very nutritious for livestock, and is produced at times when other fodder is sparse and of poor quality.

Marama bean has been studied by Dr F. Dakora (University of Cape Town) and David Lawlor through funding from the UK/South Africa Research Fund. They have shown that marama is a C3 plant, with rapid rates of photosynthesis in hot conditions, but saturating in light intensity of about half of full sunlight in its natural environment. The leaves are heliotropic, tracking the sun in the early morning and late evening, but avoiding exposure during the brightest period of the day, when paired leaflets close together and align themselves parallel to the sun. Such behaviour protects the leaves under adverse conditions. Nitrogen metabolism of marama bean has also been examined. The species studied is found predominantly in sandy soils with very low organic matter, N-poor and of low-nutrient content, particularly in dry environments such as the Kalahari desert. Its accumulation of high concentrations of N as protein suggests that it has access to sources of N other than those in the soil. Because marama is a legume, this would be expected to be through *Rhizobium* N_2 fixation. Ascertaining its symbiotic status with N_2 -fixing rhizobia is essential for improving the crop. However, data collected and experiments suggest that marama does not nodulate. Its N isotope composition shows that instead of fixing atmospheric nitrogen it obtains N from the soil. This may be because nitrate concentrations in soil water are larger than expected, and exploited by the plant for synthesis of protein. Thus, marama is an ideal potential crop for dry, N poor environments and should be further examined.

David Lawlor - (IACR-Rothamsted)

SUPPORT FOR DEVELOPING COUNTRIES THROUGH RESEARCH MANAGEMENT

IACR supports DFID's aid to developing countries through management of the Crop Protection Programme. This is done through contracts with Natural Resources International Ltd whereby Brian Kerry is an advisor to the programme and John Terry manages the Semi-Arid Production System. The semi-arid tropics are characterised by cropping systems containing sorghum, millet and cotton, all of which have pest problems that can dramatically reduce yields. Migrant pests, such as locusts, Quelea birds and armyworm, can devastate crops when they develop into plagues. John Terry manages research on these crops and pests to support DFID's policy of alleviating poverty in developing countries. Particular emphasis is given to pest problems in Tanzania, Kenya, Malawi, Zimbabwe and India, but all research has regional impact and is leading to improved livelihoods for resource-poor farmers in the developing world.

John Terry - (IACR-Long Ashton)

Fig. 49 *A regional farmer co-ordinator for the Oilseed Rape Breeding Programme, Uttar Pradesh, India*

Fig. 50 *Excavating a tuber of marama bean from the sandy soils of natural, grazed pastures at Sandveldt, east of Ghoubabis, Namibia, on the fringe of the Kalahari desert*