General News

RHD after One Year in New Zealand

Last year *BNI* [**18**, 100N-101N] reported on the illegal introduction of the rabbit calicivirus disease RCD (now reverted to its original name of Rabbit Haemorrhagic Disease or RHD) into New Zealand. Readers will recall that in July 1997 the Ministry of Agriculture had declined an application to import the virus as a biological control for rabbits, largely because of the lack of certainty about its benefits and risks. The virus was imported by persons unknown, probably before the Ministry decision had been made, and released and spread by farmers in late August 1997 using a variety of bait concoctions. This blatant breach of New Zealand's border biosecurity system caused considerable anger in government agencies and among many members of the public, exacerbated by the cavalier attitudes of some farmers. However, I am happy to report that the initial stand-off between farmers and government reported in the earlier article has been ameliorated somewhat by their common need to find out how the disease has worked. Everyone wanted to know whether RHD, rabbits, and conventional control could be managed, or at least the outcomes of the disease predicted, so that benefits could be maximized and risks minimized.

New Zealand has major exotic vertebrate pest problems and invests about NZ$100 million a year on their control and on research. However, most of the impacts of these pests remain unresolved and biological control offers the only sustainable widespread solution for many of these problem animals. The use of RHD is the first modern attempt in New Zealand at biological control of a vertebrate pest, and it would be a great pity if the unfortunate way it was introduced blighted future consideration of other biocontrol agents. This, and the need to understand how it has worked, has overridden some of the anger at its origin and brought many of the stakeholders together in a common cause.

The Foundation for Research, Science and Technology, the Ministry of Agriculture and Forests, and regional governments initiated a research programme in August 1997. The programme is led by Landcare Research working on the field epidemiology of RHD, but includes a consortium of other research agencies (AgResearch, the Rural Futures Trust, and Massey, Auckland and Lincoln universities) investigating virology, vector behaviour, predation effects, epidemiology and modelling. Some results of Landcare Research's work to date are described here.

Status of RHD in New Zealand

The disease has been spread, by people and naturally, over most of the country with variable effects on the rabbits. Mortality rates, where measured, have varied from zero to 94% with reductions of around 60-70% being common. Generally, natural epidemics have been more consistently successful than the various attempts at using RHD on baits. Largely to avoid the haphazard use of concoctions of virus obtained from dead rabbits in the field, a known lethal strain of the virus is now commercially available to farmers in New Zealand.

Field Epidemiology of RHD

We compared the behaviour of RHD at two sites in Central Otago, one where RHD was released by mass aerial baiting (biociding), and the other where it arrived naturally. Indices of rabbit abundance declined by 67% (from 68 and 35 rabbits per spotlight kilometre, respectively) on both sites during the spring 1997 epidemic. Rabbit abundance remained static for the next three months and then declined at a rate greater than expected for that time of year to a low of ten and three rabbits per spotlight kilometre, respectively, in June 1998. Numbers have begun to increase again with the start of a new breeding season, and reached 16 and five per kilometre in August 1998.

At the biocided site, the daily death rate (indicated by the presence of fresh rabbit carcasses along fixed transects) peaked three days after the biociding, and few new carcasses were found after 40 days. Carcasses were found over the whole baited area soon after the baiting. At the natural epidemic site, the daily death rate peaked at day 20 and new carcasses were still being found up to 80 days after the first death was recorded.

Sera from shot rabbits were tested for antibodies to RHD using a competitive ELISA test developed in Italy[1]. We used a 1:40 dilution and assumed 'inhibition' levels above 50% indicated immunity to RHD. No rabbits (out of 60) were immune on the natural site before the epidemic, but this increased to 31% (n = 62) immediately after the epidemic. Eight per cent of rabbits (n = 60) were immune on the biocide site before the epidemic (presumably because the farmer did some spot baiting before mass biociding) and this increased to 43% (n = 60) immediately after. There were no differences in the levels of immunity between these two sites, but other studies have shown higher levels of immunity after biociding than after natural epidemics. The proportion of antibody-positive rabbits among the cohort that was alive before the spring 1997 epidemics has since declined on both sites, although the levels of antibodies in those that were positive remained high. One explanation for this might be that rabbits that survive infection have higher mortality rates than rabbits that were never infected, i.e. the disease is not without cost even if the animal lives. Challenge trials indicate that loss of antibodies does not necessarily mean loss of immunity to further challenge.

Fresh rabbit carcasses appeared in a down-wind direction on both sites, at a rate of about 100 m/day. A number of fly species were carrying RHD virus, and preliminary work by AgResearch showed some rabbits became infected and died when exposed to flies[2]. Scavengers presumably play a role in disseminating virus by opening carcasses and exposing infected tissues to flies. More fresh rabbit carcasses were scavenged during the natural epidemic (41%, n = 157) than during the biocide (18%, n = 127). Predicting the timing and intensity of epidemics will partly

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depend on understanding the role of vectors.

A unique symptom among seropositive survivors, observed only in New Zealand, is that a small proportion have lost their ears.

Antibody Status of Other Species

Feral cats, ferrets, harrier hawks, and to a lesser extent hedgehogs, use rabbits as a food source either by scavenging or predation. By eating rabbits that have died of, or are infected with, RHD they may produce antibodies in response to the virus, as occurs in foxes[3]. Our objective was to determine whether any predators, scavengers, or hares produced an antibody response when exposed to rabbits with RHD.

We collected serum samples from predators and scavengers, from an area of mass biociding and from spot-baited areas, during February and May 1998. The samples were tested for RHD antibodies using the competitive ELISA test at 1:40 dilution. We found that: 53% (n = 51) of cats, 10% (n = 51) of ferrets, 11% (n = 18) of hawks and 3% (n = 30) of hedgehogs were seropositive (those with greater than 50% inhibition); there was a bimodal distribution of antibody levels for all animals except cats; the proportion of seropositive animals was higher in February than in May; although about equal numbers of male and female ferrets were sampled, only female adults were seropositive. No juveniles were seropositive, which suggests ferrets had to be alive during the epidemic and that RHD was not active at these sites in 1998; no hares (n = 34) from the Mackenzie Basin, where RHD had occurred, were seropositive; and in areas where RHD had apparently not occurred, no predators or scavengers were seropositive.

Pre-existing Viruses

A non-pathogenic rabbit calicivirus, thought to be the ancestor of RHD, has been identified in Europe[4], and it appears to impart immunity to the pathogenic virus[5]. Before the arrival of RHD in New Zealand, the New Zealand Applicant Group conducted a serological survey of wild rabbits using various ELISA tests some of which showed high titres of 'factor x', and they concluded that this was evidence of a benign calicivirus being already present in a high proportion of wild rabbits[6]. The questions remain (a) whether this conclusion is correct, and, if so, (b) whether the factor is similar to the European non-pathogenic virus, and (c) whether it imparts any immunity to rabbits challenged with RHD virus.

In March 1998, we captured 64 rabbits from areas of New Zealand where RHD had not been reported. Serum from each was taken at capture, and one and six months after challenge with RHD. Each sample was tested at four dilutions (1:10, 1:40, 1:160 and 1:640) using both the competition ELISA specific for RHD and a less-specific indirect 'sandwich' ELISA used by the Applicant Group to measure the presence of any caliciviruses. All rabbits were orally dosed after the first sample of serum was taken and the survivors again after six months. Each dose was 50 LD_{50}s of the Czech-strain of RHD virus, obtained from the Elizabeth MacArthur Institute in Victoria.

We found that: 14 rabbits survived challenge including one that was seropositive before the first challenge and one that did not sero-convert at the first challenge but died at the second challenge; all but one of the survivors were positive to 'factor x', the negative survivor was a juvenile; all adult rabbits, both survivors and victims of the challenge, were positive to 'factor x', but only six of 22 juvenile rabbits, i.e. those born in the previous breeding season, were positive to 'factor x'.

'Factor x' clearly does not guarantee immunity to RHD, which means that it will not affect the outcomes resulting from the presence of RHD virus – unless it is a calicivirus and recombines with RHD virus. Lack of cross-immunity is not unexpected given the high prevalence of 'factor x' in the Applicant Group's survey yet high mortality rates during the initial RHD epidemics in New Zealand. The question remains whether 'factor x' is a calicivirus descended from the benign rabbit calicivirus.

Ecological Consequences of RHD

Rabbits are the main food of three predator species (ferrets, cats, and harrier hawks). Increased consumption of native prey of secondary importance in predators' diets is commonly observed after declines in rabbit abundance. This is corroborated by studies of predation on banded dotterels in braided riverbeds. The proportion of banded dotterel eggs lost to predators was 52% ± 7% shortly after the rabbits were controlled with baits poisoned with sodium monofluoroacetate (Compound 1080)[7]. This compared with only 23% ± 4% egg loss (averaged from 12 sites) during subsequent breeding seasons when no rabbit control was conducted. Preliminary data from the breeding season during the 1997 RHD epidemic indicated that 56% ± 10% (averaged from four sites) of eggs were lost to predators where rabbit abundance was originally high (up to 50 rabbits per spotlight kilometre) and population declines were pronounced (up to 90%). This is a similar predation rate to that reported after rabbit poisoning. The longer-term implications for dotterel populations, and for other native prey, are unknown. Continued monitoring during subsequent breeding seasons will quantify the longer-term effects of RHD on these native bird populations.

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Mikania Weed Broadens its Range

The tropical world is awakening to the creeping threat of the invasive weed mikania, *Mikania micrantha*. A perennial vine in the New World tribe Eupatoriaceae, which contains many other well-known weed species such as Siam weed (*Chromolaena odorata*), Crofton weed (*Ageratina adenophora*) and mistflower (*A. riparia*), it is now recognized as one of the world's most serious tropical weeds. Originating from Central and South America, mikania is widespread in tropical Asia, including India, Malaysia, Thailand and Indonesia, and has recently been reported from Nepal. It also occurs in Papua New Guinea, the Solomon Islands, the Philippines, Christmas Island in the Indian Ocean and Pacific Ocean islands including Fiji and Western Samoa. Earlier this year it was recorded for the first time from Australia, and subsequent investigations suggested it may have been in north Queensland for as long as ten years.

In India, mikania occurs in the northeast and southwest of the country. One major route of entry was its introduction as a cover crop and purportedly as camouflage for airfields in the 1940s in northeastern India where it has since become naturalized. It is now causing substantial yield losses in smallholder agroforestry systems, in tea, oil palm, rubber, teak and sal (*Shorea robusta*) plantations, and in many crops including bamboo, reed, plantains and pineapples. It has also invaded natural evergreen, semi-evergreen and moist deciduous forests and is threatening biodiversity in national parks, for example the Royal Chitwan National Park in Nepal. However, in its natural habitat mikania is a component of aquatic ecosystems such as marshes and riverbanks and is rarely seen outside of these. Surveys conducted in Karnataka and Kerala States by Kerala Forest Research Institute (KFRI) (in collaboration with CABI Bioscience) in 1997-98 indicated that the range of the weed is much greater than previously supposed; it is very variable in form and, in many areas, is extremely invasive. Its climbing habit enables it to reach and smother the canopy of small trees. Mikania can grow from the smallest of cuttings and almost any node touching the ground will root. It has a rapid growth rate and produces copious quantities of wind-borne seed from small, creamy-white, mildly scented tubular florets whose pollen and nectar attract large numbers of bees, wasps, flies and butterflies.

The damage caused by mikania's smothering growth characteristics may be compounded by allelopathic properties. Anecdotal evidence of this abounds, but the only firm evidence comes from studies on its impact in rubber in Malaysia, where the weed retarded plant growth through the production of allelopathic substances.

In the 1980s, the possibility of using insect agents for biocontrol of the weed was investigated, but these efforts were dogged by problems of predation of the agents after introduction. However, the potential of co-evolved exotic pathogens is now being recognized, and in particular there are exciting prospects for a highly specific neotropical rust fungus, *Puccinia spegazzinii*, collected during surveys in Trinidad and Brazil. Studies conducted by CABI Bioscience and Viçosa University (Minas Gerais, Brazil) have shown this species to be highly pathogenic to the Indian biotypes of the weed, and host specificity tests indicate that it is restricted to *M. micrantha* and does not extend its range to even closely related species within the genus *Mikania*. It thus has great potential for use in mikania's adventive range as a classical biocontrol agent.

In Australia, mikania is one of the primary target weeds of the Northern Australia Quarantine Strategy and is a prohibited weed on Commonwealth and State lists. It is a threat to the narrow wet tropical coastal belt of northern Australia which includes prestigious national parks such as Kakadu. Some argue that its potential Australian distribution covers a broader area. However, at present mikania exists as a very small infestation (20-30 m² perhaps) and a few garden specimens around Mission Beach, north Queensland, where the climate is ideal for its establishment. The authorities are in the process of attempting total eradication. Most of the infestation has already been removed by the Department of Natural Resources (DNR). It is now a matter of monitoring the site and removing all the small plants that are regrowing from fragments – the plant is not easy to find especially while small.

Information on mikania, particularly in relation to the threat to Australia, can be found on the Internet at:
http://www.dpie.gov.au/aqis/homepage/public/industry/milemin.html

Further information on the Australian mikania infestations, plant identification, and some predictions for its spread are at:
www.agric.wa.gov.au/progserv/plants/weeds/climate/mikania.htm

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Eradication of White-spotted Tussock Moth in New Zealand

A two-year campaign costing US$12 million has resulted in the eradication of the white-spotted tussock moth (*Orgyia thyellina*) in New Zealand.

Native to Japan, Korea, Taiwan and China, the moth was found infesting Auckland's eastern suburbs in April 1996. Little biological information was available on the insect which is only occasionally a pest in its home range. Quarantine populations reared at Forest Research in Rotorua were used for life cycle studies, host determination, toxicity testing, pheromone development – and for rearing a field monitoring population. Feeding trials demonstrated that the caterpillars had a strong preference for members of the Rosaceae, including pip and stone fruit, and also maple, birch and willow. Given the history of destruction inflicted by other lymantriids (gypsy moth and

Douglas fir tussock moth) and the unpredictability of exotic insects in new environments, it was considered to be a serious threat to New Zealand's forests and trees – with amenity, shelter and garden trees primarily at risk, but horticulture and forests also threatened.

A response strategy was developed. As the infestation was confined to an area of 300 ha, which with a buffer zone gave an operational area to be treated of some 4000 ha, it was agreed that eradication should be attempted. Code-named 'Operation Evergreen', this began in spring 1996. The insect over-wintered as egg masses during 1996 on plants, fences, houses and outdoor furniture. These eggs were expected to hatch in the spring and the first generation of caterpillars to pupate producing flight-capable female and male moths. These would then give rise to two further generations over the summer, the final generation of flightless female adults laying over-wintering eggs.

Bacillus thuringiensis var. *kurstaki* (*Btk*) was found to be effective against the caterpillar, particularly instars I-III. However, the height of the trees meant that aerial application was necessary. The initial operational strategy was to treat the entire 4000 ha area with up to six aerial applications of *Btk* (as Foray 48B at 5 litres/ha) spaced a week apart and beginning soon after egg hatch. The aim was to ensure that all caterpillars were exposed to at least three applications of *Btk* before they entered the fourth instar. However, a protracted egg hatching period and the survival of some first generation larvae led to nine sprays by aircraft over the operational area, with a further 14 helicopter applications to the infested 300 ha area, finishing in April 1997. In addition, weekly ground spraying of more than 200 properties was carried out.

Spraying had an immediate impact on population levels, and ground searching for residual infestations became less and less effective. This problem had been foreseen, and a search for a more effective monitoring system had been given priority. Commercially available lymantriid pheromones proved ineffective, so efforts focused on the development of a synthetic pheromone. A pheromone was developed by collaborative work involving New Zealand and Canadian (Simon Fraser University) scientists, but this was too late for the 1996-97 spray programme, and monitoring during this season involved the use of live caged females. In the period December 1996 – January 1997, 68 first generation males were caught in 46 out of 250 traps, and these were all contained within the known infested area. A further six moths were caught in April, arguably late second/early third generation individuals. Monitoring continued into late June but no further moths were caught.

No spraying was conducted in the 1997/98 season, given the level of spraying the previous year and the absence of live moths since the previous April. Instead, 7000 synthetic pheromone traps were deployed over 2000 properties and risk sites, and these were inspected every fortnight from late December until mid June. No male moths were caught, and white-spotted tussock moth was declared eradicated from Auckland's eastern suburbs in June 1998.

The management of a programme which included aerial spraying in a populated area as an essential component was complex. It included features such as advanced flight control, mapping and aircraft monitoring techniques so that the public could be warned just minutes before aircraft passed over. Extensive health monitoring was also implemented. Above all, the programme was characterized by teamwork and collaboration – between researchers, operations people, policy specialists, communications staff, contractors and the Aucklanders.

Source: Hosking, G. (1998) White-spotted tussock moth – an aggressive eradication strategy. *Aliens* **7**, 4-5.

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Fire Ant Update

Last year we described how decapitating phorid flies were being released in the USA against the imported red fire ant, *Solenopsis invicta* [*BNI* **18(2)**, 23N-24N]. Here, we give more details of that work and also outline work behind the release of the first pathogen against *S. invicta* in the USA.

Off With Their Heads

The phorid now being released in Florida, *Pseudacteon tricuspis*, was one of eight species of fire ant decapitating flies studied in and around the Embrapa National Research Centre for Environmental Monitoring and Impact Assessment in Jaguariúna, Sao Paulo State in Brazil between January and June 1996. These flies are widely distributed, host specific, and also interfere with fire ant foraging, so were identified as promising prospective agents for a biological control programme. Seven of the species were reared from egg through to the adult stage, and all of them were found to pupate inside the head capsule of their host. Pupae and sexes of the species could not be distinguished morphologically at the pupal stage, except that females consistently emerged from larger hosts. Males of *P. tricuspis* readily mated with females while they were ovipositing in fire ant workers, but mating in the other species was not observed, so rearing methods were able to be developed only for *P. tricuspis*. However, *P. tricuspis* and *P. litoralis* were both sufficiently abundant to be exported to the US Department of Agriculture – Agricultural Research Service (USDA-ARS) in Florida from the Brazilian Quarantine Laboratory for host specificity testing.

Further studies (1996-98) in Brazil and Florida showed that damp conditions are needed for pupation, and that total development time is 4-10 weeks, depending on temperature. Adults emerge in the morning, and are ready to mate and parasitize new hosts by midday. With current rearing methods, about 70% of larvae emerge as adults, and in Florida at the moment some 400-600 flies are being reared per day, with a growth of 30-40% in each generation. During 1997, flies were released in Florida at three sites near Gainesville (800 flies in July, 1200 in September and 1500 in September-October). Many first-generation flies were found at two sites, but they only appear to have been permanently established at the third site where they have been collected monthly since October 1997. So far, these flies have survived a winter and a summer drought. Observations indicate that about half the fire ant colonies at this site are attacked. The flies do not yet appear to have expanded out of the initial release area. Releases for 1998 are continuing at four additional sites.

Checking the Queen

Now USDA-ARS scientists have released fire ant brood infected with a microsporidian, *Thelohania solenopsae*, at sites in nine states (Arkansas, Oklahoma, Mississippi, Louisiana, Tennessee, South Carolina, Alabama, Georgia and North Carolina), following test releases in Florida. Originally identified in Brazil in 1973, it is the most common pathogen in fire ants in South America. It was discovered in the USA by ARS scientists in 1996 in fire ant colonies in Florida, Mississippi and Texas. This is the first micro-organism to be evaluated in South America as a potential biological control agent of the fire ant in the USA.

The pathogen infects fire ant colonies and chronically weakens them. Workers transmit the pathogen to the queen via food exchange. The disease slowly reduces her weight. She lays fewer and fewer eggs, all infected with the pathogen. Field work in Argentina indicated that fire ant mounds were less dense in a *Thelohania*-infested area, infected colonies had smaller mounds, and sexual brood was present less frequently than in uninfected colonies. It was also found that infection increased the mortality rate and shortened the longevity of fire ant colonies reared under laboratory conditions. Although colony elimination can take from nine to 18 months, infected colonies were found to be smaller than healthy colonies after only three months. The development of better infection techniques and methods to mass produce the microsporidian is now underway.

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For a new Internet manual, 'Microsporidia (Protozoa): a handbook of biology and research techniques' see: http://www.ars-grin.gov/ars/SoAtlantic/Gainesville/location.html

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Root-knot Nematodes: Could Biocontrol Replace Methyl Bromide?

It has been known since the early 1980s that some nematode pests can be controlled effectively by nematophagous fungi and bacteria. The most studied case of natural control concerns the cereal cyst nematode in cereal monocultures in northern Europe where two species of fungi, *Nematophthora gynophila* and *Verticillium chlamydosporium*, effectively control this widespread pest. These agents provide the most sustainable method of nematode management in intensive agriculture and today plant breeders no longer incorporate cyst nematode resistant genes into elite cultivars. However, such natural control is slow to establish and difficult to exploit.

Work continues at IACR-Rothamsted in the UK with *V. chlamydosporium* but with an isolate that is active against root-knot nematodes. All species of these major pests are found to be susceptible to the fungus which destroys the eggs and may reduce fecundity. The fungus is very variable and isolates which do not colonize the rhizosphere do not provide control. The host plant has a major effect on the efficacy of the fungus, affecting both the amount of fungus able to develop in the rhizosphere and the multiplication of the nematode. *Verticillium chlamydosporium* is most effective on plants which support extensive growth in the rhizosphere and on plants which are relatively poor hosts for the nematode and produce only small galls in response to nematode attack. The fungus is confined to the rhizosphere and on highly susceptible crops too many egg masses remain embedded in the large galls produced and so escape parasitism. A biomanagement strategy has been developed in which the fungus is applied to specific poor hosts in the cropping cycle to enhance their efficiency in reducing nematode infestations before the next susceptible crop. This strategy is being compared with the use of methyl bromide and an integrated control strategy using granular nematicides for the control of root knot nematodes on vegetable crops in southern Europe The programme is funded by the European Commission and includes laboratories in Crete, Italy, Portugal, Spain and the UK. Details of the programme can be found on the Internet at:
www.area.ba.cnr.itreO85acOl/bkfair3444.html

The programme began in March 1998 and a Workshop Manual has been produced which covers the methods used for working with *V. chlamydosporium*. The manual includes methods for the isolation, selection and evaluation of isolates in laboratory and field tests and describes studies on risk assessment and visualising the fungus in the rhizosphere. It is anticipated that the manual will be published by the International Organization for Biological Control (IOBC).

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News from India

Progress at PDBC

Highlights of research work conducted at the Project Directorate of Biological Control (PDBC) in Bangalore and at its 16 coordinating centres spread over different parts of India in 1997-98* included devising an acrylic, multicellular rearing unit for *Helicoverpa armigera*. The unit, which provides 80-90% larval survival, is transparent, durable, amenable to surface sterilization and made of indigenous materials.

Advances were also made in identifying and investigating organisms with potential for biocontrol in a range of systems. This included the description of new predatory coccinellids in the genera *Pseudoscymnus* and *Serangium*, and the development of an endosulfan-tolerant strain of *Trichogramma* [for details of this see: *BNI* **19(3)**, 74N-75N].

Entomophilic nematodes (*Steinernema* spp.) were isolated from elevations of 107-2200 m above sea level and were found to be predominant in sandy loam and clay loam soils. One isolate (PDBCEN 6.11) caused the death of

Plutella xylostella and *Opisina arenosella* larvae within a day of inoculation, and of *H. armigera*, *Spodoptera litura* and *Corcyra cephalonica* within two days.

A number of microbial agents were shown to have promising activity. *Pseudomonas putida* PDBC No. 19 was found to completely inhibit growth of *Sclerotium rolfsii* in dual culture. From a number of *Trichoderma* and *Gliocladium* isolates tested, *T. harzianum* isolate PDBC TH2 and *G. virens* gave greatest inhibition of mycelial growth in *S. rolfsii*. *Gliocladium virens* isolate Pl 1 (GV) was found to be a potent antagonist *in vitro* against *Fusarium oxysporum* f. sp. *gladioli*, which causes gladiolus corm rot and yellows.

The disease antagonist *T. harzianum* PDBC TH2 along with *T. koningii*, *G. virens* and *G. deliquescens* were all effective against the nematode *Meloidogyne incognita*, causing 94.5% mortality. Finally, seed germination and the seedling vigour index of parthenium weed were greatly reduced at different concentrations of culture filtrates of *G. virens.*

Around the Regions...

In cotton in Andhra Pradesh, Biointensive Integrated Pest Management (BIPM) excelled due to the significant role played by the beneficial insects, which increased through intercropping with groundnut. The seed cotton yield obtained through the BIPM strategy was highest at 1.827 t/ha. The incremental cost-benefit ratio (IBCR) in BIPM was high (10.07) compared to farmers' practice (1.55) and judicious use of insecticide (1.59).

In Gujarat, bud and boll damage, damage to locules and populations of sucking pests were significantly lower in BIPM modules compared with a control. Parasitism due to *Agathis* spp. was very high. The yield in BIPM plots was significantly higher and also gave a higher ICBR than insecticidal treatments and the control. Intercropping of maize with cotton enhanced the activity of *Cheilomenes sexmaculata* in BIPM blocks. Studies revealed that maize, *Cassia occidentalis*, parthenium weed, castor, sunnhemp, marigold, tobacco, etc., harbour various parasitoids/predators of cotton pests.

At Bangalore, an entomopathogenic fungus, *Paecilomyces farinosus*, was isolated from the spiralling whitefly *Aleurodicus dispersus*. The green lacewing *Mallada astur* was predominant on guava and about 230 nymphs of spiralling whitefly were consumed by a single larva in 10-12 days. The efficacy of *Cryptolaemus montrouzieri* in controlling the green shield scale *Chloropulvinaria psidii* on guava was demonstrated at Kestur village near Bangalore.

In Assam, successful control of water hyacinth was achieved by the exotic weevils *Neochetina eichhorniae* and *N. bruchi* in Disangmnukh area of Sibsagar district and less flowering was observed in the remaining water hyacinth areas of Sibsagar district.

In Kerala, *Orthogalumna terebrantis* has established over all the release sites giving partial suppression of water hyacinth.

Golden Jubilee Celebration

The Project Directorate of Biological Control celebrated 50 years of India's Independence by organizing monthly seminars, cultural programmes, group discussions and exhibitions running from 15 August 1997 to 15 August 1998. The seminars covered varied topics including: 'Success of biological control' [in Hindi], 'Management of agricultural research', 'Special statistical techniques', 'Cultural programmes', 'Pest management in horticultural crops', 'Entomophilic nematodes', 'Biological suppression of plant diseases, phytoparasitic nematodes and weeds using disease antagonists', 'Predatory mites' and 'A hundred years of *Cryptolaemus* in India'.

*PDBC (1998) Annual Report (1997-98). Bangalore, India; Project Directorate of Biological Control, 167 pp.

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Assessing Agent Risk

The ERBIC (Evaluating Environmental Risks of Biological Control) project was set up as a consequence of a workshop organized by the European Plant Protection Organisation (EPPO) and IIBC in 1996, which recognized that the new European guidelines for pest control did not take into account the risks of using exotic natural enemies, and proposed a new set of European guidelines which is now being developed by an EPPO panel. Both the EPPO-IIBC workshop and the EPPO panel stressed the urgency of needing scientific methods to evaluate the risks of introduced natural enemies to indigenous non-target species – EPPO already has pest risk analysis methods agreed and established for European plant protection services, into which new protocols for evaluating the safety of biological control agents could be fitted.

Coordinated by Professor Heikki Hokkanen (University of Helsinki) in collaboration with teams led by him and Dr Franz Bigler (Swiss Federal Research Station for Agroecology and Agriculture), Dr Jeff Waage (CABI Bioscience), Professor Giorgio Celli (University of Bologna) and Professor Joop van Lenteren (Wageningen Agricultural University), the project is focusing on the exotic biological control agents most widely used in Europe today. In-depth case studies and population modelling will be used to evaluate these. The effect of alien generalist and specialist predators and parasitoids will be studied on local non-target organisms, particularly key beneficial species. The effects of microbial natural enemies will also be evaluated.

The overall objective of this project is to facilitate the development of sustainable, biologically based production systems, in line with the commitments of many EU governments to reduce use of chemical pesticides. The specific objectives, which aim to ensure that the introduction and use of biological control agents for pest control – a key component of sustainable agriculture – is done in a way which does not put at risk non-target organisms are: (1) to determine the negative and positive effects of different types of biological pest control for agriculture, the environment and biodiversity in Europe, (2) to develop rapid and reliable methods to assess the potential risk of import and release of biocontrol agents in Europe and (3) to design specific European guidelines to ensure that biological control agents which are to be introduced are environmentally safe.

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Biorational

Integrated pest management (IPM) involves the use of many techniques, including biological control, to provide effective control of crop pests with minimum harmful side-effects. Those techniques which are compatible with the use of biological control or have little impact on natural enemies have been described as 'biorational'.

Seeds of Discontent

Arguments about transgenic crop technology were brought into focus this summer when an advertising campaign urged readers of European newspapers to embrace biotechnology as a means of feeding the hungry in Africa. In a move intended to close the North Atlantic rift in opinion and convert a transgenically sceptical Europe, Monsanto sought endorsement for genetically engineered food crops from African heads of state, and ran whole-page advertisements entitled 'Let the Harvest Begin', in which they asked readers to accept agricultural biotechnology so food production could be increased. They said, "Biotechnology is one of tomorrow's tools in our hands today. Slowing its acceptance is a luxury our hungry world cannot afford" [1]. Some representatives of the alleged 'hungry world' begged to differ. Delegates from 19 African countries who attended FAO negotiations on the International Undertaking for Plant Genetic Resources issued a statement in August that said they "strongly object that the image of the poor and hungry from our countries is being used by giant multinational corporations to push a technology that is neither safe, environmentally friendly, nor economically beneficial to us"[1].

However, the FAO delegates took advantage of the opportunity to voice their objection to one particular development in biotechnology in particular: "Rather than developing technology that feeds the world," their statement continued, "Monsanto uses genetic engineering to stop farmers from replanting seed and further develop their agricultural systems..." The biotechnology brainchild the delegates left firmly out in the cold was the so-called 'Terminator Technology'[2]. Developed by the US Department of Agriculture (USDA) and Delta & Pine Land Co. (DPL – now a subsidiary of Monsanto), it was granted a US patent in March entitled 'Control of plant gene expression'. This is a complex technology based on a series of genes which culminates in killing the second generation seed before it can germinate.

For the Curious...

The following explanation of how 'Terminator' works is based on a description by Dave Culley[3]. A gene, consisting of a DNA sequence coding for a protein toxic to the plant and a promoter sequence (a 'switch' that controls production of the protein), is inserted into the plant's DNA. The 'Late Embryogenesis Abundant' (LEA) promoter used in this instance, as its name suggests, causes abundant quantities of the toxin to be produced at the late embryo stage, which kills it. To produce a viable F_1 seed from these plants, a spacer sequence is added to separate physically the promoter from the toxin coding sequence, which prevents the promoter from switching on toxin production. The spacer sequence can be cut out by a recombinase enzyme to bring the toxin and promoter sequences back together. But to control when the spacer is removed, the recombinase gene is itself put behind another promoter that is only expressed during late *germination* – so the recombinase protein is expressed only after the F_1 seed has germinated. The plant grows normally – until the reactivated toxin gene is expressed late in the development of the second generation (F_2) seed, and kills the embryo inside it.

For hybrid seed production, the LEA-toxin construct (or gene sequence) is put in one parent and the recombinase construct in the other, which means that when the parent seeds germinate the recombinase enzyme produced in one parent is neatly kept apart from the toxin gene in the other. However, the F_1 seed they produce when crossed contains both the toxin and recombinase sequences. So the recombinase produced when this seed germinates excises the spacer from the LEA-toxin sequence to bring the toxin and promoter back together, and at F_2 seed maturation the toxin is produced which kills the seed.

But what of self-and open-pollinated plants? The latter group includes crops such as maize and sorghum which are fundamental to food security in Africa. The parental plants used to produce the seed that will be planted by the farmer must contain both toxin and recombinase sequences, so how are viable seeds to be produced? The answer is that a control sequence is added to the promoter of the recombinase gene, which allows it to be turned off in the presence of a repressor protein. The repressor coding sequence is inserted behind a promoter which is active when the recombinase is produced, but can be turned off by the application of a (so far unspecified) chemical – and this allows the recombinase to be produced, which ultimately leads to toxin production. Plants will germinate, grow and produce viable seed which will germinate – unless they are treated with this chemical. Once this is done, the next generation seed will behave as described for hybrid seed above: it will germinate (and produce recombinase at this time which excises the spacer from the toxin sequence); it will grow as normal, but the next generation seed will die during the late stages of maturation of the seed on the plant (as toxin production is activated by the LEA-toxin construct).

Why 'Terminator'?...

In simple terms, this technology enables a seed company to alter seed genetically so that seed saved at crop harvest will not germinate if the farmer plants it the following season. So far it has been shown to work in cotton and tobacco, but the US patent covers plants and seeds of all species, transgenic and conventionally bred. Patent applications are pending for the technology throughout the world.

The USDA's motive in developing seed killer technology is apparently very simple – to regulate the unauthorized use of American transgenic technology and to protect US intellectual property rights. The goal is "to increase the value of proprietary seed owned by US seed companies and open up new markets in Second and Third World countries", a USDA spokesman said[2]. Melvin Oliver, a USDA molecular biologist and primary inventor of the technology explained that his main interest was protection of American technology.... "Our mission is to protect US agriculture, and to make us competitive in the face of foreign competition"[2].

DPL explained that their aim is to stimulate investment and plant breeder interest in small grain crops such as wheat and rice, and in cotton and soyabeans where the production of hybrids has proved difficult; they say that they have already had much interest from seed companies in licensing the system. A press release issued in March said that the technology has "the prospect of opening significant worldwide seed markets to the sale of transgenic technology for crops in which the seed is currently saved and used in subsequent plantings"[2]. DPL argue that the development will "broaden access to continuing agricultural improvements", and say that the practice of saving seed has locked farmers into "obsolete (i.e. old-fashioned, low-yielding) varieties"[4].

...And Why Not?

Seed killer technology probably sounded like good economic sense in the board room, where looking for a return on the industry's massive investment in transgenic technology is understandably a preoccupation. (Currently, 80% of crops in the developing world are grown from farmer-saved seed[4].) But it has sent shock waves rippling out into the rest of the world, and has especially caused alarm in the developing world, already suspicious about the motives of the agrochemical industry in invading such resource-poor markets. The FAO African delegates' statement was damning in its criticism: "The only aim of this technology is to force farmers back to the Monsanto shop every year, and to destroy an age old practice of local seed saving that forms the basis of food security in our countries... We do not believe that such companies or gene technologies will help our farmers to produce the food that is needed in the 21st century. On the contrary, we think it will destroy the diversity, the local knowledge and the sustainable agricultural systems that our farmers have developed for millenia and that it will thus undermine our capacity to feed ourselves"[1].

Although proponents of 'Terminator Technology' argue that small farmers will be unaffected, many are unconvinced of this. In Bratislava this May, the Conference of the Parties to the Convention on Biological Diversity recommended that the precautionary principle be applied to the 'Terminator Technology'. The Conference also directed its scientific body to examine the technology's impact on farmers and biodiversity. In July, India pre-emptively banned import of any seed containing the 'Terminator' genes because of the potential threat to Indian biosafety. In October the Rural Advancement Foundation International (RAFI) launched an international campaign to urge US government officials to stop negotiations on 'Terminator Technology' with Monsanto's subsidiary DPL and to halt all commercial development of it[2].

Capital in the developing world is scarce, and, it is argued, transgenic seed is expensive particularly when licensing fees are taken into account. Small farmers in Africa characteristically minimize their risks and production costs. For them, it is good economic and agricultural practice to save seed from the best plants for the following season. This minimizes planting costs and allows farmers to practise farm-level varietal selection. It is also argued that the introduction of transgenic crops, and seed-sterile cultivars in particular, would increase monocultures and ultimately lead to a decrease in the crop biodiversity that farm-level selection has preserved. The Food and Agriculture Organization of the UN have estimated that some 1.4 billion people – 300 million in Africa – rely on farmer-saved seed for planting[4], and 'Terminator Technology' is seen as a threat to the food security of these, the most vulnerable. Many – both governments and pressure groups – have said that such technology is inappropriate for the developing world, and that investment in research should be about developing appropriate production technologies suited to the needs of small farmers, based on traditional practices and integrated techniques. They argue that current problems centre on poverty and poor food distribution, not lack of sophisticated seed and breeding technology. The Monsanto fact sheet stated that enough food is currently produced to supply 3800 kilocalories each day to every person in the world[1]. But, the Monsanto advertising campaign argued, it is the predicted growth in world food population that is the problem – and they say that biotechnology is the answer. They say that it will: allow more food to be produced on less land, and thus both reduce pressure on marginal land and safeguard biodiversity; reduce post-harvest losses and improve food nutritional quality; displace resource- and energy-intensive inputs (fuel and chemicals); encourage a change to more sustainable agricultural practices; and stimulate economic growth[4].

No Such Thing as Bad Publicity?

The publicity surrounding the awarding of the 'Terminator' patent and the 'Let the Harvest Begin' advertisements increased the public profile of the transgenic crops debate, and served to highlight concerns about their appropriateness for small-scale farmers practising traditional agriculture – and in a wider context, the role of biotechnology in sustainable agriculture.

Not surprisingly, the faith Monsanto declared in biotechnology for solving agriculture's problems has been endorsed by other agrochemical companies. In August RAFI announced that UK-based Zeneca was applying for patents for a chemically activated seed killer (dubbed 'Verminator Technology' because one application involved an uncoupling protein gene isolated from rat brown adipose tissue)[2]. However, Nigel Poole of Zeneca says[5] that the patent was granted in 1994, but the system has not been worked on since 1992, and he denies that they have any interest in seed killer technology. He said that their research interests centre on 'switches' which turn genes on and off, and cites three applications with big potential benefits: to prevent premature sprouting (and therefore losses) in tuber crops such as potatoes; to control flowering time in field and fruit crops; and to improve targeting for toxins incorporated into transgenic crops, for example so as to turn 'on' transgenic fungal toxin genes only when the plant is affected by the target disease.

Among supporters of biotechnology being transferred to Africa is the International Service for the Acquisition of Agri-biotech Applications, (ISAAA). The Executive Director, Anatole Krattiger, points out in his introduction to their 'Strategy for Africa'[6] that Africa has the highest population growth and highest level of malnutrition, and faces the highest challenge in feeding its people. "Provided they are properly integrated into production systems", he argues, biotechnology applications offer new opportunities to increase productivity... "and often allow users to switch to a more sustainable and ecologically friendly system with reduce dependence on chemicals". He goes further and claims that "some of the more sophisticated applications such as transgenic crops are the only hope for millions of farmers for overcoming problems that have proved intractable" and cites the current collaborative development of genetically modified virus-resistant sweet potato in Kenya, based on eight local varieties and technology donated by Monsanto.

The phrase "*Provided they are properly integrated into production systems*" presumably rules out 'Terminator Technology', but what of transgenic crops such as the virus-resistant sweetpotato, for example? Opponents argue that only a minority will benefit: those who can afford the seed, and of course the seed companies. What of the rest?

Krattiger[7] disputes the argument that transgenic seed is too expensive. He says that it all depends on value; farmers the world over are far from stupid, and they will be prepared to pay for something only if they can be convinced that there is a return on it. He argues that African farmers have thus far been largely denied access to any inputs, for example fertilizers, or choice in the seed market at any price. He suggests that opening the market to commercial interests will help to redress this. Krattiger also argues that every farmer will always have the option to stay with traditional varieties and farm-saved seed, a point he says is ignored by opponents of transgenic crops. He points out that subsistence farmers aren't interested in maintaining their way of life – they want to increase their income and improve their situation, and that biotechnology can help them to do this.

According to Krattiger, the rationale of the projects ISAAA is developing is that there is room for both commercial and non-commercial biotechnology transfer from North to South. Although the cost of developing transgenic crops is high, the cost of putting the traits into many different varieties is far less. His vision is for national capacities in biotechnology to serve the areas for which lack of commercial viability makes them unattractive for industrial development, which he says covers most of developing country agriculture. To this end he has already persuaded companies such as Monsanto, Novartis, AgrEvo and Zeneca to donate biotechnology.

Transgenic Crops and Safety

It is not only queries about the socioeconomics of transgenic crops that are at issue. Although it is too early to say whether benefits or fears about transgenics will materialize, the technology raises many questions of science, law, ethics and economics[4].

Safety regulations and legislation relating to biotechnological developments in agriculture are still not fully developed in Africa – only South Africa and Egypt have adopted legislation (and transgenic crops have now been planted in both countries) while Kenya is in the process of developing regulations. The tortuous recent history of biotechnology legislation in Europe is not likely to convince those involved in the same process in Africa that it will be easy. The testing and registration processes, which countries have to undertake for the transgenic varieties independently, are lengthy and expensive.

There are more extreme concerns about the potential ability of a handful of multinational giants to control the harvests and thus the food security of large parts of the world – and the potential for seed to be withheld as a political weapon. As the Monsanto fact sheet pointed out, only 15 crop plants provide 90% of the world's food energy intake[1]. These could be a potent weapon in the wrong hands.

There are still questions about the environmental safety of transgenic crops. Critics argue that biotechnologists are too focused on the crops they are developing and pay too little attention to the environmental context in which they will be grown[4]. Issues surrounding the use of *Bt* crops were dealt with in a recent article (*BNI* **19(2)**, 38N-39N) and there are related queries about herbicide-tolerant and disease-resistant transgenic cultivars. In summary, queries about the reliability/stability of these crops have not yet been satisfactorily answered; there is evidence that out-crossing into non-transgenic varieties and related weedy species may occur; the transgenic traits may have a direct adverse impact on the ecosystem, biodiversity and beneficial species in particular; and there are worries over the efficacy of resistance management plans for slowing the development of resistance to pest-resistant transgenics. Opponents say testing has been inadequate on all these counts. They also dispute that chemical inputs will be reduced and raise fears about health risks[4]. To the criticism that such views suggest a wholesale rejection of biotechnology, the answer is simple: convince us before introducing it.

For seed killer technology, the issue of possible outcrossing is highly significant. DPL say that one positive aspect of their 'Terminator Technology' is that it would circumvent problems arising in the event of transgenic crops outcrossing into weeds – any hybrids would be sterile[2]. Martha Crouch[8] argues that depending on 'Terminator' to prevent transgenic traits from spreading unintentionally is unrealistic: she says that recombinase activation [see 'For the Curious', above] and therefore 'Terminator' expression is unlikely to be 100% effective, in which case 'Terminator' and other transgenic traits in the parent plant could be passed on. A phenomenon known as 'gene silencing', whereby genes are not expressed for some reason, but can still be passed on, could have the same consequences.

'Terminator' outcrossing with non-transgenic/non-'Terminator' crops in adjacent fields would be highly undesirable: neighbouring farmers could find their yields falling over a number of years if a portion of their seed stocks were rendered sterile – and crops such as maize and sorghum normally have a high level of outcrossing. It is probably not possible at this time to predict the likelihood of the 'Terminator' trait 'escaping' into adjacent fields, because many factors including genetic compatibility, crop proximity and plant maturation timing affect this, but it is reasonable to be concerned[3]. According to Crouch[8] it is likely to happen under some conditions, and although it would almost always be confined to one generation (as hybridized seeds would be sterile), she suggests that in exceptional circumstances the trait could be inherited. On the other hand, Krattiger[7] argues that hybrid maize has been grown for decades next to open-pollinated (traditional) varieties, and that there has been no problem with outcrossing.

Krattiger also dismisses some other safety concerns: he suggests that arguments over resistance management plans going on in North America may be irrelevant to Africa: agriculture is much less monocultural and if adoption rates vary it is possible that no such management plans will be necessary. He also suggests that problems of decreasing biodiversity related to the deployment of transgenic varieties should be considered in the context of losses in biodiversity and environmental degradation that would result from an increasing population encroaching further and further into marginal land to grow more crops.

Biotechnology, IPM and Biocontrol

Krattiger[7] argues that biotechnology is here to stay, and that the billions of dollars of investment in it can be harnessed in many different and complementary ways, by private companies and through private-public partnerships. However, the problem with this, as perceived by some biocontrol and IPM practitioners, is how this is being done. They argue that biotechnology as it is now used in the agricultural context is potentially detrimental to sustainability, and that a major refocusing is needed if it is to make a positive long-term contribution to world agricultural production and food security. They point to the failures of past attempts to improve agriculture and suggest that lessons learned there have yet to be understood by the biotechnology sector. Professor Swaminathan, respected agronomist and 'father' of India's 'Green Revolution', supports yield-enhancing research including biotechnological approaches, since, he argues, there is no alternative for countries with limited land and large populations but to produce more food on the same land. He firmly believes that biotechnology can have an important role, so long as it is developed and introduced as part of an holistic system of environmental and socioeconomic sustainability[4].

In a recent paper[9], Jeff Waage argued that although biotechnology can potentially bring a great deal to IPM, the current agrochemical industry approach is a mixture of technological conservatism mixed with opportunism; biotechnology is being used merely to stretch the boundaries of markets already served by other technologies. In an examination of the pest-resistant transgenic crop sector, he pointed out that they were using two already over-exploited and non-sustainable paradigms: the pesticide model and the total vertical resistance model for plant breeding. In particular, two key aspects of biocontrol – persistence and self-renewal – are incompatible with current bioengineering approaches. The current focus of biotechnology in the areas of host plant resistance and biocontrol is narrow and locked into single-technology systems, which are incompatible with IPM, Waage argued, and instead of attempting to provide a one-stop answer to pest problems, biotechnologists need to rethink, and redirect their energies and investment into those areas where biotechnology could make a significant contribution to sustainable systems: for example, mass production systems for predators, parasitoids and pathogens, and altering the specific properties of these organisms to enhance their impact, dispersion and persistence; so far biotechnology seems to have focused on reducing these capabilities in organisms used as biopesticides.

At the Overseas Development Institute, London in September, Hans Herren, Director-General of the Nairobi-based International Centre for Insect Physiology and Ecology (ICIPE) and a former winner of the World Food Prize, said[10] that "too much hope and expectations are entrusted in [transgenic crop] technology, at the detriment of more conventional and proven technologies and approaches". He said he did "not see the likelihood of transgenic varieties making an impact on food production in Africa within the next 15 or 20 years" and dismissed transgenic varieties as "not affordable by the average farmer". He also questioned the narrow genetic base of most transgenic varieties, particularly in the African context of a wide variety of agro-ecosystems and the history of crop failures in recent years.

Herren argued that there are other cheaper, proven and sustainable ways of improving crop abundance, and that these would be a more appropriate channel for the funding now pouring into biotechnology research from both commercial and public sources. He called for the goals of biotechnology research to be rethought, and suggested that the most useful role for transgenic crop research could be to improve crop quality once problems of abundance have been addressed. He pointed to the irreconcilability of profit sustainability (of which 'Terminator Technology' is the latest development) and agricultural sustainability: in marketing terms, product sustainability is often a bad thing, in agricultural terms it is a good thing.

In summary, Herren concluded, although biotechnology may in the end give us better quality seed, unless current approaches are changed, this will be at the expense of the economic stability of small farmers, the sustainability of the African farming system, and the continued evolution of land races on which food security depends – and from which the genetic material now being exploited by the agrochemical industry came.

Martin Kimani, IPM programme coordinator for the CABI African Regional Office in Nairobi, speaking at a Panos Institute public debate in October[11], said that in Kenya the 'Genetic Modification Revolution' was in danger of repeating the mistakes of the 'Green Revolution' of the 1970s, and reintroducing an inappropriate high-cost high-input agriculture. Currently working to reintroduce a 'mosaic of crops' which he believes is central to a traditional agriculture, Kimani emphasized that crop management should take into account experience passed down from generation to generation and include simple remedies to develop an organic system of agriculture tailored to local needs and conditions. He argued that funding for transgenic crop development would be better put into developing organic methods of agriculture. He focused also on the importance of making this a demand-led process – in this way, he said, farmers would be encouraged to participate, combining their indigenous knowledge with recent technologies, to create a 'bottom-up' effect whereby local needs govern the processes of development. He expressed concern that current pressures for developing and introducing transgenic crops are mostly commercial, and that farmers need to know and understand the risks involved and make the decisions.

Beyond 'Terminator'

It would not be unreasonable for others in the biotechnology sector to be quietly furious with Monsanto. The main outcome so far of the 'Terminator' debate and the 'Let the Harvest Begin' debacle has been to add anger to the already unpalatable cocktail of suspicion and scepticism with which the sector is viewed by many. The challenge is to replace this with trust. Biocontrol and IPM practitioners, themselves no strangers to criticism, have criticized the current top-down, technology-driven approach of the biotechnology sector. Biotechnology has much to offer, but it needs to stop seeing itself as a world apart from other technically less-advanced approaches. It should learn from current demand-led farmer-based IPM approaches: it should be asking farmers what they want, and finding out how biotechnology can contribute to an integrated and sustainable agriculture – then refocusing its considerable energies appropriately.

[1] Panos Alert Pack (July 1998)
The Panos Institute, 9 White Lion Street, London N1 9PD, UK
E-mail: markc@panoslondon.org.uk
Fax: +44 171 278 0345
Internet: http://www.oneworld.org/panos/

[2] RAFI (1998): The Terminator Technology (Communique, March/April, 6 pp.); And Now, the Verminator (News Release, 24 August); Help Stop the Terminator (Action Alert, October).
Rural Advancement Foundation International – International Office, 110 Osborne St., Suite 202, Winnipeg MB R3L 1Y5, Canada
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[3] Written with input, gratefully acknowledged, from Dr David E. Culley, Glass Garden Research, NW 745 Darrow St., Pullman, WA 99163, USA
E-mail: dculley@pullman.com
The explanation of 'Terminator' is based on descriptions by Culley on the Plant-TC listserver. Archives can be accessed at:
http://www.agro.agri.umn.edu/plant-tc/listserv/1998

[4] Panos Environment and Development Briefing No. 30. Greed or need? Genetically modified crops. (September 1998). [address as [1]]

[5] Poole, N. (pers. comm., 1998)

[6] Krattiger, A. (1998) ISAAA: Our strategy in Africa. Introduction by the Executive Director.
International Service for the Acquisition of Agri-biotech Applications, 260 Emerson hall, Cornell University, Ithaca, NY 14853, USA
E-mail: isaaa@cornell.edu
Internet: http://www.isaaa.cornell.edu/

[7] Krattiger, A. (pers. comm., 1998)

[8] Crouch, M. (1998) How the Terminator terminates: an explanation for the non-scientist of a remarkable patent for killing second generation seeds of crop plants.
Indiana University, Bloomington, Indiana, USA.
E-mail: crouch@indiana.edu
An occasional paper of The Edmonds Institute, 20319-92nd Avenue, West Edmonds, WA 98020, USA. The paper is on the Internet at:
http://www.bio.indiana.edu/people/terminator.html

[9] Waage, J. K. (1997) What does biotechnology bring to integrated pest management? *Biotechnology and Development Monitor* **32**, 19-21.

[10] Herren, H. R. (1998) The wishes of the rich versus the needs of the poor: which biotechnologies are appropriate for sustainable agricultural production in the tropics? Paper given at the Overseas Development Institute, London, 30 September 1998.

[11] Kimani, M. (1998) *In:* Proceedings of a Panos public debate: 'Will genetically modified crops feed the world or increase poverty in developing countries?' London, 16 October 1998. [address as [1]]

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Training News

In this section we welcome all your experiences in working directly with the end-users of arthropod and microbial biocontrol agents or in educational activities on natural enemies aimed at students, farmers, extension staff or policymakers.

A Californian Model

California produces 55% of US fruits, nuts and vegetables on a mere 3% of US farmland. As a state, it has the highest agricultural income in the USA. While at first sight Californian farming may have little in common with developing world smallholder cultivation, both are fertile ground for farmer participatory research. California accounts for some 22% of US agricultural pesticide use. There is strong pressure to reduce this, from consumers and farmers as well as the 'green' lobby. Restrictions are likely only to increase, for example with the planned phasing out of methyl bromide production and use, and the looming possibility of tighter regulations on organophosphate use.

The BIOS (Biologically Integrated Orchard Systems) Program[1] in northern California promotes the adoption of integrated systems, emphasizing a collection of practices that build on naturally occurring biological processes for pest and soil fertility management. Farmers are introduced to this through a combination of extension and information sharing. The programme is co-ordinated by the Community Alliance with Family Farmers (CAFF) Foundation who encourage the participation of diverse members of the agricultural community in a format that leads to the exchange and synthesis of both practical and highly technical information. They recognized that in the transition from chemically dependent to biologically based production, participants would need a programme offering a broad range of easily accessible information, skills and services. So they established a consortium of farmers, private agricultural consultants, University of California personnel, private businesses, and USDA and other government agency staff to provide technical assistance.

The BIOS Program had its beginnings with 26 almond growers in Merced County in California's Central Valley in 1993. CAFF worked with these growers to develop and spread viable alternatives to chemically intensive practices commonly used throughout the state. Key to the programme was the farmers' desire to reduce agrochemical use without sacrificing agricultural productivity. Almonds are California's sixth most valuable crop (representing 100% of US production), and in 1993 were ranked second in overall pesticide use in the state. Yet some farmers already had well-established alternative production systems and had achieved documented success in reducing pesticide inputs while keeping insect damage low and remaining economically competitive. The goals of the BIOS program were: to demonstrate that such biologically integrated systems reduced reliance on agrochemicals and were profitable; to increase their adoption by farmers and to build farmers' confidence through technical support and information sharing; to document the changes and effectiveness of BIOS production practices; to cultivate and maintain private and public agricultural industry participation and support; and to develop and enable long-term community leadership and coordination for BIOS.

These goals were achieved by a diversity of activities. Locally based teams were established to provide programme leadership and guidance, and farmer participants were selected carefully. A customized management plan was designed for each farmer in the first year, and these were 'fine tuned' according to local results and conditions for subsequent years. The process of developing these plans was found to be an important factor in establishing successful long-term collaborative relationships. The plans included concrete suggestions for switching to biologically integrated systems and suggestions for cover crops, plants that attract beneficial insects, and other remedies. Information exchange with the management team and based on the knowledge and experience of farmers who had pioneered and developed biologically integrated systems – including a 'buddy' system – was also facilitated for individual technical assistance. Field days, workshops, problem-solving meetings and seminars and the use of diverse educational materials and formats were used to disseminate information, provide technical support and build analytical and problem-solving capacities. As well as hands-on field activities, there were oral presentations, group discussions, videos and written materials. Regular field days and workshops were held to improve skills in identifying beneficial and pest arthropods, plant diseases and cover crop species. Monitoring programmes for orchard ecology were developed, and these included advice on how to spot specific insect pests or damage as well as beneficials. The use of field monitoring in decision-making related to pest and other management operations was increased. Weekly updates of field conditions and monitoring results were also given. Emphasis was placed on keeping the programme flexible and responsive to participants needs and local agricultural conditions. Scientific community research on biologically integrated systems was encouraged, together with outreach activities to the broader agricultural community. Finally, some financial assistance was also available.

Elements emphasized in the BIOS approach were: biological and cultural control of pests; the creation of on-farm habitats for beneficial arthropods; soil building practices, including facilitating biological nitrogen fixation; and reduced reliance on agrochemicals. This was achieved by promoting cover crop mixes planted between tree rows, which enhanced the soil and improved tree vigour and also attracted beneficial insects which prey on primary nut pests. As a result growers were able to reduce both insecticide and herbicide use. These practices also reduced the need for tilling, and the rich soil produced by the cover crop residue provided a healthy habitat for earthworms. Some participating farmers were able to eliminate chemical use completely, which gave them the added benefit of premium prices for organic produce. One of the barriers to introducing cover crops had been strong peer pressure to have floors of orchards bare of vegetation – partly for aesthetic reasons but partly to make the operation of harvesting machinery easier. However, BIOS farmers found that by mowing their crop at the right time they had no problems with the machinery.

At the end of the first year, the main field-level impact for the almond growers was reduced chemical inputs, particularly organophosphate insecticide use, which fell from 35% of participating farmers to nil. Pre-emergence herbicide (simazine) use fell from 24% to 6%; and applications of synthetic nitrogen fertilizer dropped by 46%. Planting of cover crops increased from 12% to 92% of the farms involved, while use of beneficial arthropods and application of *Bacillus thuringiensis* (*Bt*) increased from 60% to 80% and 41% to 65%, respectively. Crop yield and percentage insect damage (worm-reject level) were similar for BIOS and control blocks, and farmer satisfaction was high, with many planning to increase the area under BIOS management. Farmers were also asked to rate the usefulness of various activities (meetings/field days, newsletters and monitoring reports and programmes) and BIOS management team inputs, and their responses were used to modify procedures.

The programme was expanded in the following year to include almond and walnut growers in adjoining counties. Similar success was achieved in other almond projects, but more difficulties were encountered with the walnut production system. The success of the almond system was attributed to the existence of local biologically integrated systems with a history of demonstrated success, which served as a working model while the farmers acted as mentors for the project. The synthesis of information generated by scientific research and actual farming experience continued to be a cornerstone of the programme: scientific research helped identify, describe and evaluate the performance of key farming system components, while farmers' experiential knowledge allowed participants to integrate scientific information into their local production systems.

Learning From the BIOS Approach

A handbook[2] has now been published which introduces the principles driving the BIOS Program, gives an overview of on-the-ground operations, and identifies lessons learned and challenges faced in implementing a BIOS-style programme.

It identifies the key elements of its approach as: (1) identifying and working with motivated farmers who are willing to take risks and make significant changes to their management practices, (2) making a commitment to link the practical on-farm knowledge of farmers with scientific information (this should not be a top-down imparting of information from scientist to farmer, as teamwork where all participants are regarded as equal is critical), and (3) keeping the programme flexible: the handbook cites the fundamental lesson of the BIOS Program as flexibility. It is essential that a programme can adapt to the changing needs of participants, modify methods of communication and technical approaches as appropriate, and evolve over time as the needs of the participating farmers and institutions change.

The role of the various components – the management team, recruitment strategy, management plans, monitoring information, on-farm field days and workshops, individual technical support, financial support, publications, and documentation and evaluation – are described.

Some lessons learned are discussed, including the importance of building on existing farmer experience, integrating scientific and practical knowledge and recognising the equal value of each, having a commitment to team work, how effective coordination can enhance participation, maintaining programme flexibility, and gaining institutional and policy support.

One challenge faced as the programme expands is how to manage a programme of increasing complexity, and the importance of carefully selected locally based management teams is recognized. It is also argued that in the long term BIOS-style technical support and resources for farmers should be handed over to local organizations, so an important goal is to convince local groups and institutions to provide resources for biologically integrated farming practices beyond the life of the project.

Further details of the BIOS Program, and eight other case studies of the development of sustainable agricultural practices from around the world are described in the World Resources Institute publication cited below, which highlights lessons learned on how to carry out effective research and development for application of integrated pest, crop and soil management.

Sources: [1] Thrupp, L. A. (1996) New partnerships for sustainable agriculture. Washington DC; World Resources Institute, 138 pp.
Obtainable from: WRI Publications, PO Box 4852, Hampden Station, Baltimore, MD 21211, USA. US$13.45 + $3.50 p&p.
[2] Schafer, K. S. (*ed*) (1998) Learning from the BIOS approach. A guide for community-based biological farming programs, 40 pp.
Obtainable from: Community Alliance with Family Farmers, PO Box 363, Davis, CA 95617, USA
E-mail: bios@caff.org
Fax: +1 530 756 7857

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E-mail: ann@wri.org

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Macadamia IPM Training in Costa Rica

The macadamia nut industry in Costa Rica is less than 50 years old. As the area planted with macadamia has increased and the trees have aged, pest problems have also increased. The resulting yield reduction, together with insufficient knowledge regarding macadamia pest control, has forced many farmers to abandon their orchards. At Macadamia de Costa Rica (MCR), (managed by the Commonwealth Development Corporation, London, 1993-98) an IPM programme has been developed to address the escalating pest problems.

The primary economic pest of macadamia in Costa Rica is the macadamia nut borer, *Ecdytolopha torticornis* (Lep., Tortricidae). It caused damage levels of around 9% (of harvested nuts) on MCR properties in 1997. In addition to the borer, there are hemipteran pests that feed on the macadamia kernel, and pests and diseases of the flowers.

MCR owns three orchards covering a total area of 560 ha. The pest management team consists of an IPM specialist, an assistant co-ordinator, eight pest scouts and a team of workers trained in pesticide application techniques. The pest scouts collect the information that drives the management system. The accuracy of their decision making determines the success of the control measures, and it is thus essential that they are well trained and motivated in their work.

At the core of the IPM programme is a weekly crop and pest monitoring system. The orchards are divided into 7.5-ha units, which are managed individually according to the weekly sampling results. Scouts use a random sampling technique to collect nuts from the tree and the ground. Hand lenses are used to scan the nut surface for the tiny transparent borer eggs. The nuts are then opened and searched for early instar borer larvae and for bug damage. Scouts use a scoring system, based on visible characteristics, to assess crop phenology. Each management unit contains a different mixture of macadamia varieties. Pest scouts have been trained to distinguish between these varieties, as the trees that they sample must be representative of the variety distribution within that unit. The information is collected on detailed monitoring sheets and analysed by the IPM co-ordinator to determine whether action thresholds for insecticide applications have been exceeded.

The macadamia nut borer is very difficult to control using insecticides because it is a cryptic pest. Nevertheless, in the absence of alternatives, the principal control method is still chemical, and in 1997 there were on average nine insecticide applications per management unit. Most applications are targeted at the eggs, which are laid singly on the outer husk of the nuts, and on the adults via residual insecticide effects.

Egg parasitism by a native *Trichogramma* species was first observed in the field in 1996. Since then, scouts have been trained to monitor for this parasitism, and it has been incorporated into the weekly sampling programme. A borer-egg/parasitoid ratio is calculated for each management unit. From this a parasitism index is obtained, which informs an insecticide spray decision. During a period of high borer infestation in 1997, 50% of sprays were cancelled as a result of a high parasitism index. In general, however, native parasitism levels are not sufficient to control the macadamia nut borer. Reasons for this could be the unstable host population levels, the insecticide application regime or the patchy distribution of alternative host plants within the orchard.

Recent studies into the biology of the native *Trichogramma* species and its compatibility with chemical control methods have yielded positive results, highlighting the potential use in an augmentative release programme. Increased levels of parasitism were also achieved following an experimental release of a commercial strain of *Trichogramma pretiosum.* It is hoped that parasitoid rearing and release programmes will be more widely used in future macadamia IPM.

The IPM specialist holds frequent training days for scouts, both in the field and in the laboratory. These days provide a platform for scouts from different farms to compare their work, to suggest possible improvements and to discuss the trends that they see in insect population levels. This is also an opportunity for the scouts to inform the IPM specialist about pest and parasitism hotspots within the orchards. This knowledge may be extremely helpful in reducing pesticide inputs, if only infestation hotspots within a management unit are targeted.

Scouts use microscopes to study the various stages of borer-egg development and to take a closer look at the live, emerged and dead borer eggs, which they have to distinguish in the field. The scouts are asked to draw what they see under the microscope and this is subsequently discussed and explained. Egg parasitism by *Trichogramma* sp. is also viewed under the microscope and the life cycle of the parasitoid is explained. Through increased understanding of the biology of the pests and beneficials, scouts gain insight into their work and better appreciate the importance of their role within the IPM programme.

The Commonwealth Development Corporation places value on sharing the results of any experimentation in pest management with other growers in the macadamia industry. During on-farm open days, the IPM programme is explained and scouts give practical demonstrations of their sampling techniques. As a result, other growers are moving away from calendar spraying and are adopting monitoring systems. Similarly, increasing numbers of growers are taking parasitism into account when making their spray decisions. Costa Rica is a country with an extremely high pesticide usage (having the highest per capita usage in Central America). Growers are aware of the risks, and there is great enthusiasm for the potential use of a biological control agent against the borer.

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Internet Round-up

By: Tony Little, Technical Support Group to the Global IPM Facility, CABI Bioscience.

This quarter the Internet Round up focuses on biological control of forestry pests. Starting with, what for me is close to home, a visit to the CAB Abstracts – Forestry Data Base at:

http://pest.cabweb.org/cgi-dos/webspirs

A quick search yielded 363 references in relation to biological control – a useful starting point. The Biocontrol Network website at:

http://www.biconet.com

is always a good springboard for any biocontrol information searches with links to the biocontrol reference centre:

http://www.biconet.com/reference/BICONETRC.html

which includes a Database of IPM Resources:

http://www.ipmnet.org/DIR/

Typing '*Lymantria*' into the search engine, for example, links me to Virginia Tech's entomology site and provides information and further links on biology, ecology, IPM projects and current research on the gypsy moth.

The website of the forestry advisers network (CFAN) of the Canadian International Development Agency (CIDA) at:

http://www.rcfa-cfan.org

is also an excellent resource, available in English, French and Spanish. Forestry profiles

http://www.rcfa-cfan.org/English/index.profiles.html

detail projects in Africa, Asia and the Americas, for example the biological control of aphid species on conifers in East Africa.

The CFAN site sports a useful list of links, among them FAO. FAO are in the process of adding forest pest data to their Global Plant and Pest Information System (GPPIS) at:

http://pppis.fao.org

although this is still under development, so it's a case of 'watch this space'.

Also among CFAN's links is the International Union of Forestry Research Organisations (IUFRO) at:

http://iufro.boku.ac.at/

Biological control aspects of IUFRO's activities may be found in the imaginatively named Division 7 – Forest Health:

http://iufro.boku.ac.at/iufro/iufronet/d7list.htm

However, having been rude about the naming of this division, I am at pains to point out that typing 'biological control' into the search engine available, furnished me with a useful list of references.

The European Tropical Forest research Network (ETFRN) at:

http://www.etfrn.org/etfrn/etfrn-home.html

has an on line newsletter which occasionally contains articles on biological control programmes, and a plethora of links to other related sites

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Announcements

Are you producing a newsletter, holding a meeting, running an organization or rearing a natural enemy that you want other biocontrol workers to know about? Send us the details and we will announce it in BNI.

X International Weed Symposium

The X International Symposium on Biological Control of Weeds will be held in Bozeman, Montana, USA on 4-9 July, 1999. This symposium is the next in the series of premier world meetings, held approximately every four years, of scientists interested in the biological control of weeds, and covers all aspects of the theory and practice of biological weed control. This meeting is co-sponsored by the United States Department of Agriculture/Agricultural Research Service (USDA/ARS) and Montana State University–Bozeman. The Symposium registration fee of US$450 will cover Symposium meeting facilities, published proceedings and selected activities. Accommodation and area tours are available at additional cost. Delegates from countries that have been under-represented at these symposia in the past can apply to the conference organizers to waive certain expenses.

The Symposium will run as a series of successive sessions – there will be no

concurrent sessions. Therefore, the number of oral presentations will be limited. Organizers will select papers for oral presentation, based on scientific merit, originality, and appropriateness. Submissions that are not selected may be presented as posters, which may also be published as full papers in the proceedings of the Symposium. The language of the Symposium will be English. Further information is available on the Internet at:
http://www.sidney.ars.usda.gov

Contact: Neal R. Spencer, Symposium Co-Chairman, USDA/ARS –
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11th EWRS International Symposium

Entering its 25th year, the European Weed Research Society (EWRS) is marking the occasion with an international symposium. In the series of biannual meetings, the 11th EWRS Symposium will be held on 28 June – 1 July 1999 in Basel, Switzerland. The Symposium will provide a forum for scientists to present their work on a broad range of weed science topics, such as weed biology and ecology, recent developments in biological, physical and chemical weed control and environmental aspects of weed control. The programme of the Symposium will include oral and poster presentations in successive sessions. Special aspects of biological and physical weed control will be presented in a scientific excursion during the symposium. Optional excursions to Swiss research institutions and agrochemical research facilities are offered. All contributions will be refereed and published in the proceedings which will be available at the Symposium. The official language of the Symposium will be English. The organizers will strive to keep the registration fees and costs in line with those at previous EWRS symposia, and a range of accommodation to suit all budgets is offered. Further information is available on the Internet at:
http://www.res.bbsrc.ac.uk/ewrs

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Conference Reports

Indian Biocontrol Workers' Group Meeting

The VII Biocontrol Workers' Group Meeting was conducted under the aegis of the Indian Council of Agricultural Research (ICAR), New Delhi on 25-26 August 1998 at the Project Directorate of Biological Control (PDBC), Bangalore. The inaugural function was attended by 110 invitees and delegates from ICAR institutes and agricultural universities.

Dr S. P. Singh, Project Director, PDBC welcomed the gathering and gave an account of the research highlights for the years 1997-98 of the All-India Coordinated Research Project on Biological Control of Crop Pests and Weeds. Professor G. K. Veeresh inaugurated the Group Meeting and said that biocontrol was the most suitable method for control of pests in forests, plantation crops, horticulture and field crops. The need for conservation of natural enemies and adoption of biointensive pest management with careful pest management was stressed. Biocontrol programmes are considered to be in tune with ecofriendly approaches to pest management.

The following PDBC publications were released: 'PDBC celebrates 50 years of Independence', 'Production and use of polyhedrosis viruses of *Spodoptera litura* and *Helicoverpa armigera*', '*Spodoptera litura* aur *Helicoverpa armigera* kc NPV visanuo ka utpadan aur prayog' [in Hindi] and 'Proceedings of national seminar on biological suppression of plant diseases, phytoparasitic nematodes and weeds'. 'PDBC – biocontrol resource inforbase' and 'An expert system for biological control of cotton pests in India (BIOCOT)' were also released.

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New Books

Plant-Microbe Interactions and Biological Control

According to the editors, the aim of this book* is to "...discuss promising strategies and approaches to the development of effective biological controls for plant diseases, based on plant-microbe interactions". From this and the publishers blurb, it would appear that the 19 chapters in the book deal exclusively with biological control of plant disease. However, somewhat lost within the body of the book are two comprehensive and well researched chapters addressing biocontrol of weeds using microorganisms: one, an up-to-date review covering both the classical and bioherbicide approaches; the other, an in-depth introduction to the formulations currently in use or under investigation for bioherbicide production.

The greater part of the book is, indeed, devoted to the actual and potential use of microorganisms (viruses, bacteria, fungi) for plant disease control; consisting of an ill-assorted (eclectic) mixture of highly specialized chapters (e.g. 'Control of cucumber mosaic virus using viral satellites'; 'Genetic analysis of selected antifungal metabolites produced by *Pseudomonas aureofaciens*'), and more general review-type chapters ('Biological control of *Fusarium* wilt'; 'Biological control with *Trichoderma* species'; 'Biological control strategies for *Sclerotinia* diseases'), which should appeal to a much wider audience.

The book also claims to be both a practical reference for a range of scientists, involved directly or indirectly in agriculture, and a standard text for graduate students. It succeeds only partly in this objective since many of the chapters are far too narrow and specialized for the latter readers, and probably also for most agronomists and soil/crop scientists. However, it could serve as a valuable reference source and thus would be an important addition to both university and agriculturally-inclined libraries. Certainly, the price puts it beyond the reach of many of the readers at which it is aimed.

*Boland, G. J.; Kuykendall, L. D. (*eds*) (1997) Plant-Microbe Interactions and Biological Control. New York; Marcel Dekker Inc., 442 pp. Price US$165. ISBN 0 8247 0043.

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Conservation Biological Control

In one of the classic texts on biological control, DeBach (1964: 'Biological Control of Insect Pests & Weeds') defined conservation biological control as environmental modification to protect and enhance natural enemies, and this is the central focus of this new book*. In chapter 1, we are reminded that conservation biological control is probably *the* oldest form of biological control of insects and the example is cited of the Chinese, in 900 AD, placing nests of the predaceous ant *Oecophylla smaragdina* in mandarin orange trees to reduce the abundance of foliage insect pests.

A major review of the scattered literature on this subject was way overdue, the last most accessible general work being that of Rabb, Stinner & van den Bosch in 1976 (Conservation and augmentation of natural enemies, pp. 233-254 in 'Theory and practice of biological control' edited by Huffaker & Messenger). Nonetheless, Barbosa has successfully co-ordinated an international group of authors to provide a comprehensive coverage of a wide selection of topics from the ecological basis of the subject, and its practical application, through to the constraints on uptake and the problems of compatibility with the economics of cropping systems. There is, however, a lot of interesting science in this book and this reviewer thinks that the content of many of the well referenced chapters will be of interest to ecologists as well as biological control specialists. A whirlwind tour of some of the major sections of the book will provide a flavour of what to expect.

Chapter 1 sets the scene with the historical background to the subject. However, it moves rapidly on to highlight one of the major dilemmas with this field of applied science: how to get policy makers and farmers to adopt some of the principles which have emerged from research. As it stands, conservation biological control has a lot to offer the agricultural sectors of countries which are now challenged to reduce pesticide usage and adopt integrated pest management. However, all too frequently, the basic principles of conservation run counter to production practices. Also, conservation biological control is facing competition from other biologically based management tactics (including genetically engineered crops) which are, or maybe, less demanding for farmers to implement.

The parallel of conservation biological control with conservation biology is the subject of the next chapter, with a discussion of important concepts such as island biogeographic theory, species richness, meta populations and keystone species. Nonetheless, whilst these subjects have much to tell us about the scientific basis of conservation, the author concludes: "political forces, legal proceedings, policy decisions and economic pressures often dictate the level of success or failure in a management plan for preservation or recovery of species and their habitats". Thus, again, we are reminded that it is policy that matters in the end.

Chapters 3-6 focus on the ecological basis of conservation biological control. Chapter 3 draws attention to the fact that a limited number of pest species are dominant in agroecosystems and then goes on to discuss the implications for the structure and composition of natural enemy communities. An important practical message is here for those sceptics who think that conservation biological control is too complicated to implement: "a relatively narrow suite of pests reduces the number of natural enemies that need to be targeted for conservation and may facilitate the use of a small number of effective conservation tactics that are also cost-effective". The many ways in which plants (plant patch structure, diversity and single plants) can influence the searching behaviour and population dynamics of parasitoids and invertebrate predators are reviewed in remaining chapters of this section. Whilst many of the case studies cited are, often by necessity, reductionist in approach, the authors strongly emphasize that plant factors will not act independently and that single plant traits cannot be easily 'engineered' into a tactic for conservation biological control.

The theme of chapters 7-9 is the control or manipulation of the size and distribution of crop patches and landscape features. Chapter 7 emphasizes the need for a better understanding of the ecology of natural enemies outside of agroecosystems for their effective conservation, and chapter 8 shows how artificially sown weed strips can provide essential resources for parasitoids and invertebrate predators. After revisiting some ecological theory (particularly the diversity–stability and enemies hypotheses for pest outbreaks), chapter 9 successfully shows how habitat manipulation research may be undertaken and translated into practical guidance to farmers. This reviewer found this section particularly stimulating as the authors address the major problem of the gap between research and implementation in conservation biological control.

Chapter 10 examines the important subject of the influence of genetically engineered crops, particularly pest resistant *Bt*-expressing cultivars, on the interaction of existing biological control agents with pests. In general terms, the authors conclude that conservation biological control will benefit from the use of genetically modified cultivars because less insecticide will be used on the crops. This subject is, however, not clear cut and at best controversial [e.g. see *BNI* **19(2)**, 38N-41N]. Chapter 11 discusses the compatibility of pesticides with natural enemies. The use of pesticides is likely to continue for the foreseeable future. Thus, with increasing worldwide concerns about the environmental impact of these chemicals there is now pressure to develop protocols that realistically predict their effects on non-target beneficial organisms.

The remaining chapters of this book (12-20) are devoted to reviews of either particular types of pests (mobile insect pests, chapter 12; weeds, chapter 20) or taxonomic groups of natural enemies. The latter reviews bring the literature together on a wide range of organisms in particular farming systems – entomopathogenic nematodes, entomopathogenic fungi, ants, coccinellids, spider mites and microbial antagonists.

*Barbosa, P. (*ed*) (1998) Conservation biological control. San Diego, California, USA; Academic Press, 396 pp. Price US$69.95. ISBN 0 12 078147 6.

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Proceedings

Weed Biological Control in India

The series of 18 papers in this book* was developed from a national seminar held at the Project Directorate of Biological Control in Bangalore on 16 May 1998 as part of the celebrations to commemorate the Golden Jubilee of India's Independence [see *BNI* **19(3)**, 80N-81N]. Leading Indian scientists in their respective fields have contributed, which shows the increasing national importance given to biological control by policy makers in Indian agriculture.

Eight chapters are devoted to the biological control (or suppression) of plant diseases; four chapters deal with microbial antagonists of plant parasitic nematodes; whilst three chapters address weed biocontrol with two chapters covering entomophilic nematodes of insect pests; confusingly included within the session theme on weeds! Clearly, there is some overlap between the chapters, and hence repeat of information, as exemplified by the papers on entomophilic nematodes which share almost identical titles; one favouring biological control the other suppression. Since suppression was chosen for the title of the seminar, most authors gravitate towards this term, which may have political correctness on its side, or perhaps this is now the favoured IPM-speak.

The papers reflect the past and present research on biological control within an Indian context and, in general, they are of a high standard; informative and well researched. The editors are to be congratulated on assembling this book in such a short time and of achieving the aims of the seminar which was to focus attention on the actual and potential use of biological control within an IPM strategy.

The book is also of relevance to workers involved in biological control outside of the Indian subcontinent, particularly as an update on the research currently underway in India and as a reference source to previous work.

The chapters include: Introduction (S. P. Singh); Biological control of plant diseases: status in India (A .N. Mukhopadhyay & P. K. Mukherjee); Biological suppression of diseases of plantation crops and spices – present status and future strategies (Y. R. Sarma & M. Anandaraj); Mass production technology for fungal antagonists and field evaluation (R. Jeyarajan & K. Angappan); biological suppression of fungal pathogens of commercial crops with fungal antagonists (K. Nagarajan); Role of secondary metabolites of *Pseudomonas fluorescens* in the biocontrol of plant pathogens (K. K. Mondal &. J. P. Veram); Biological suppression of major diseases of field crops using bacterial antagonists (P. Vidhyasekaran); Biological control of major diseases of rice and other cereal crops with bacterial antagonists (S. S. Gnanamanickam & K. Krishnamurthy); Epidemiological studies in biological control of plant pathogens (A. K. Sharma, D. P. Singh & A. K. Singh); Present status of biological suppression of plant parasitic nematodes (M. Wajid Khan); Bacterial antagonists for suppression of plant parasitic nematodes, (C. V. Sivakumar); Fungal and bacterial antagonists for biological suppression of plant parasitic nematodes on horticultural crops, (P. Parvatha Reddy & M. Nagesh); Use of fungal and bacterial antagonists for the biological control of nematodes in plantation crops (J. Gulsar Banu & P. K. Koshy); Biological suppression of weeds with pathogens – present scenario (V. M. Bhan, J. P. Kauraw & Archana Chile); Biological suppression of aquatic weeds with fungal pathogens (K. R. Aneja); Biological suppression of parthenium with pathogens (P. Sreerama Kumar); Use of entomophilic nematodes for the suppression of insect pests (Wasim Ahmad); and Entomophilic nematodes for control of insect pests (S. S. Hussaini & S. P. Singh). The recommendations which emerged from the seminar are included.

*Singh, S. P.; Hussaini, S. S. (*eds*) (1998) Biological Suppression of Plant Diseases, Phytoparasitic Nematodes and Weeds, 284 pp.
Obtainable from: Project Directorate of Biological Control, P. B. No. 2491, H. A. Farm Post, Bellary Road, Hebbal, Bangalore – 560 024, Karnataka, India. Price $25.

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