# *MITIGATING THE THREAT OF CACTOBLASTIS CACTORUM TO INTERNATIONAL AGRICULTURE AND ECOLOGICAL SYSTEMS AND BIODIVERSITY*

## SUMMARY REPORT


**Summary**

*Cactoblastis cactorum* has become a serious threat to the high diversity of Opuntia (cactus pear) species throughout the world, both native and cultivated. These plants have a valuable role in subsistence and commercial agriculture, in maintaining the ecological balance of unique ecosystems, and in soil conservation and combating desertification. Increasing areas in opuntia cultivation and reliance on food and income from products means that invasion by *C. cactorum* has the potential to impact large regions and thousands of subsistence farmers in Central and South America, the Mediterranean, North Africa and in other countries. The magnitude of impact on biodiversity and ecosystems, timing and scale of the likely response needed, requires immediate action.

In line with the TC strategy, the thematic plan outlines a programmatic strategy for tackling the threat, as well as highlighting the necessary partnerships with the international community, regional organizations and institutions, national counterparts and the private sector to expand the knowledge base and capabilities for achieving programme objectives.


### PROBLEM CONTEXT

Despite the successful biocontrol of invasive *Opuntia* species by the South American cactus-feeding moth *Cactoblastis cactorum* (Berg) (Lepidoptera; Pyralidae), the moth has now become a serious threat to the high diversity of *Opuntia* species throughout the world, both native and cultivated. It is now present in the Southeastern, USA; and areas of Cuba and other Caribbean islands. If the cactus moth further invades the Southwestern United States (Texas, Arizona, New Mexico, Nevada, California) and Mexico the effects will be devastating. The imminent spread of *C. cactorum* from Florida or Cuba to southern United States and Mexico requires preventive measures. In addition, C. *cactorum* poses a threat to other countries where opuntias thrive.

#### Value of Cactus

Cactus species (*Opuntia* spp.) are important plants for maintaining ecological balance, especially in arid and semi-arid regions where few plants can be grown. They are a major component of the semi-desert regions of the Caribbean and the Americas and increasingly in other semi-arid regions of the world.

The Southwestern USA and Mexico are considered the most important centre of biodiversity for *Opuntia.* Cacti in the genera *Nopalea*, *Consolea*, and *Opuntia* (hereafter Opuntia or Platyopuntia) comprising 114 of the 200 species world wide.

**Agricultural uses:**

a) The establishment of sustainable systems of production based on *Opuntia* spp. contribute to the food security of populations in agriculturally marginalized areas and to the improvement of the soil.

b) Since they grow in severely degraded land, opuntia use is important as fodder in areas where few crops can grow. They also have high palatability, digestibility, and moisture content, reducing the need to supply water to animals.

c) The tender cladodes of certain species are used as a vegetable representing a huge industry, being consumed in fresh and processed form mainly in Mexico and the United States of America. Emerging markets in Peru and Africa and increasing Mexican exports to Europe and Asia, shows an expanded demand in non-traditional markets.

d) Opuntia spp. are cultivated in many areas of the world (North and South African, the Americas, and Middle Eastern) for pricky pear fruit production and commercialisation. The potential market for this product is extensive but little exploited. Cultivation of *Opuntia* spp. requires extensive labour, which is an important souce of employment (particularly for women) in developing countries.

e) The cochineal insect (*Dactylopius coccus*) produces Carminic acid, which is a natural red dye accepted by health authorities worldwide. Cochineal constitutes a significant alternative to forage or fruit production because of its profitability and intensive use of labour.

f) The industrialization and commercialisation of opuntia products is expanding into concentrated foods, juices, liquors, semi-processed and processed vegetables, food supplements and the cosmetic industry.

g) Research has demonstrated promising results on the use of opuntia products for gastritis; for diabetes due to the reduction of glucose in blood and insuline; for hypercholesterolemia by reducing total cholesterol, LDL cholesterol and triglycerids serum levels; enlarged prostate treatment; and for obesity.

**Environmental issues**

a) The species of the *Opuntia* subgenus have developed phenological, physiological and structural adaptations favourable in arid environments where water is the main factor limiting the development of most plant species.

b) *Opuntia* spp. can develop in severely degraded soils where their rooting characteristics reduce wind and rain erosion. *Opuntia* spp. have a great capacity for adaptation and are ideal for responding to global environmental changes..

c) *Opuntia* spp. are some of the best plants for the reforestation of arid and semi-arid areas within their native range because they can survive scarce and erratic rainfall and high temperatures.

d) Many species of bird, mammal, reptile, and insect species eat, nest in, or otherwise rely on opuntia species. Further, opuntia have been identified as nurse plants, facilitating the establishment of other plant species by providing a more moderate (cooler, moister) and protected growing environment. Large-scale loss of opuntia where they are the dominant species is likely to be accompanied by shifts in species composition of both the vegetation and animal communities.

**Damage Potential**

The dramatic impact of *C. cactorum* on invasive opuntia species in Australia, South Africa and many other countries as a biological control agent, and the damage it causes to commercial cultivations of *O. ficus-indica* in countries where it has been introduced, has provided evidence of the pest status of the moth on desired opuntia. Damage to invaded plants is often exacerbated by secondary bacterial infections that can kill large plants in a single season.

It will be virtually impossible to control or even contain *C. cactorum* once it has naturalized in the wild, which may be the final blow to several endangered opuntia species. *C. cactorum* is also known to be particularly damaging to new species with which it has not previously been associated. Studies show that there are no climatic restrictions to *C. cactorum* in Mexico and that the areas with a high diversity of native species and large commercial plantations all fall within the ideal climatic parameters of the insect.

The threat of *C. cactorum* to other important regions of the world should not be ignored. Countries like Tunisia, Spain, Italy (Sicily), Algeria, Israel etc. have large cultivations of *O. ficus-indica* and the arrival of the cactus moth in these countries could be devastating. The value of cactus to combat desertification and its use on marginal lands is widely recognized and any limitation imposed on such developments may deprive people of an indispensable tool to improve rural livelihood in resource-limited countries.

**Risk for Future Spread and Damage**

*C. cactorum* was purposely introduced to many areas in the Old and New World for biological control of invasive opuntias. Subsequent to these introductions, the moth was observed to disperse to other locations.

*C. cactorum* has also been documented as a contaminant on horticultural shipments of cacti from the Dominican Republic. Additionally, individuals may have purposely or inadvertently translocated the moth to new locations. Regardless of the explanation of dispersal in specific cases, the evidence of continued spread of this species and increasing international trade in host opuntias, widespread cactus cultivation across continents, increasing exchange of germplasm to support this cultivation, and the enrichment of collection in many botanical gardens indicates that the risk of expanding *C. cactorum* distribution is extremely high.

## POTENTIAL ROLE FOR NUCLEAR TECHNIQUES

Sterile Insect Techique (SIT) progammes have been successful applied against a number of pest Diptera (including the screwworm fly, *Cochliomyia hominivorax*, tsetse flies, the Mediterranean fruit fly, *Ceratitis capitata* and various other fruit fly pests), and numerous mass rearing facilities have been constructed worldwide to support these programmes. However, compared to dipterans, lepidopterans (moths) generally are more expensive to rear and have a propensity to fly greater distances. Additionally, moths are more radio-resistant than dipterans. As a consequence, the larger dose of radiation required to completely sterilize moths reduces the competitiveness and performance of SIT in the field. Nevertheless, two SIT programmes are currently operating against moth pests, namely the pink bollworm programme in the USA, and the codling moth programme in Canada, and both of these have been very successful.

### Inherited Sterility in Moths

One approach to reduce the negative effects of radio-resistance in Lepidoptera has been the use of inherited or F1 sterility. Like SIT, F1 sterility involves the mass rearing and release of genetically altered insects to insure that when matings occur in the field, a significant proportion of matings involve a treated, released insect. However, F1 sterility takes advantage of two unique genetic phenomena in Lepidopetera. First, Lepidopteran females generally are much more sensitive to radiation than are males of the same species. This allows the dose of radiation to be adjusted so that the treated females are completely sterile and males are partially sterile. Second, when this partially sterile males mate with fertile females, the radiation-induced deleterious effects are inherited by the F1 generation. As a result, egg hatch is reduced and the resulting F1 offspring are highly sterile and predominantly male. The lower dose of radiation used in F1 sterility increases the quality and competitiveness of the released insects. In addition, because F1 sterile progeny are produced in the field, the release of partially sterile insects offers greater suppressive potential than the release of fully sterile insects and is more compatible with other non-chemical pest control mechanisms or strategies.

Field release of partially sterile insects have demonstrated the potential of using F1 sterility to control many Lepidopterans, including the cabbage lopper, *Trichoplusia ni*, the corn earworm*, Helicoverpa zea*, the gypsy moth, *Lymantria dispar* and the codling moth, *Cydia pomonella.* In addition many studies have shown that F1 sterility can be effective combined with other biological control such as pheromone mating disruption,

entomopathogens, host plant resistance and natural enemies. As a result of these studies, F1 sterility is regarded as the most favourable genetic method for most applications against Lepidoptera.

**Nuclear Component**

Sterilization is accomplished by exposing insects to a specific dose of gamma radiation emitted by radioisotopes (Cobalt 60 or Caesium 137). No other methods are available or appropriate to provide achieve sterilization. Chemosterilants carry a high risk for environmental contamination and pose serious health concerns. Linear accelerators have not shown sufficient applicability and reliability in consistently achieving the desired level of sterility.

Nuclear technology has not only a comparative advantage in sterilizing mass reared insects, but is, at present, the only technology available for this purpose. As every single insect used in SIT activities must be sterilized, irradiation is a central and indispensable part of the total process.

**Development of Inherited Sterility for *C. cactorum***

Although the cactus moth has been mass reared for use as a biological control agent in the past, use of sterility to control it is still untested in the field. Inherited (F1) sterility could be a valuable tool to predict and manage the expanding populations of *C. cactorum*.

The use of F1 sterility for control would be most appropriate for:

1) Elimination of *C. cactorum* from areas of new introductions, or from isolated and/or environmentally sensitive areas.

2) Establishment of a barrier through the release of irradiated moths along the leading edge of the *C. cactorum* geographical range.

3) Provisioning sterile *C. cactorum* to assess the host range and potential geographic distribution.

4) Provisioning sterile *C. cactorum* as hosts in the field to assess its potential natural enemy complex.

## IMPLEMENTATION STRATEGY

### Awareness Creation

A well-articulated and well-directed educational campaign needs to be immediately developed. This campaign could be strategically planned to selectively target the different sectors involved:

- Political and administrative (governmental agencies).
- Academic, research, and technical institutions.
- Industrial and commercial agricultural areas.
- Growers, farmers, and ranchers involved in the production chain.
- General public.

Development of media communications, educational, and training materials is also required.

### Regulatory measures

Well-structured frameworks of mandatory regulatory measures needs to be prepared for both national and international agreements. The regulations could include actions covering:

- Quarantine
- Phytosanitary certification
- Restrictions on plant movement
- Plant inspections
- Early detection
- Control measures
- Crop destruction

The regulatory measures must be applied by all countries involved to avoid movement of *C. cactorum*. The national authorities of plant protection need to regulate the internal transportation of cactus plants or parts thereof and provide "*C. catorum*-free" certification to avoid the movement of *C. cactorum* in any life stage.

*Cactoblastis cactorum* should be included in lists of quarantine pests in countries exporting or importing opuntia material. The quarantine of *C. cactorum* could also be at the regional, provincial, or state level where distribution of the moth is limited. Monitoring systems are required to delineate quarantine boundaries.

**Early detection of new infestations**

Deployment of early pest detection systems is essential in locations that are under threat of invasion by *C. cactorum*. By taking early actions to monitor for this pest in areas where infestations are likely, newly established populations can be detected.

**Prevention of further spread**

Regulatory and other approaches to prevent the spread of *C. cactorum* need to be complemented with surveillance activities. The most effective method of determining the distribution of pests is to develop and deploy semiochemical-baited traps.

Like many Lepidopteran pests, the cactus moth is an excellent candidate for the development of pheromone-baited traps. In addition to female-produced volatiles, the importance of host plant volatiles in the attraction of males and females needs to be investigated.

**Control/eradication of current infestations**

Preliminary work with the SIT suggests that it will be the most economically and ecologically acceptable method for use throughout the geographical range of *Opuntia* spp. Preliminary studies on the radiation biology indicate that sterility can be induced with a dose of radiation that should allow for the release of highly competitive moths. In addition, the SIT is the only control method that could be used for eradication or the establishment of barriers to prevent the continued expansion of a *C. cactorum* population.

**Rapid response / contingency plan for new outbreaks**

Contingency plans for a rapid response to new outbreaks of *C. cactorum* are needed. An emergency response plan could be envisaged with components including quarantine methods for the impacted area and protocols for the immediate implementation of an eradication programme. An awareness campaign, destruction of infested host plants, intensive monitoring through surveys of *Opuntias* and the use of pheromone traps, and implementation of the SIT are integral to this programme.

The following are some examples of on-going actions being carried out by Member States:

- Radiation biology (SIT, F1 sterility) - USA.
- Development of survey and trapping technology - USA.

- Surveys to delimit current distribution of *C. cactorum* in the Caribbean Basin and North America - USA, Cuba.

- Pest management technologies (insecticides, mechanical, host destruction/exclusion) - USA, South Africa, Argentina.

- Host range testing - USA, South Africa.

- Risk assessments and potential impacts of *C. cactorum* on agriculture and biodiversity - Mexico, Cuba, USA.

- Host distribution and bioclimatic modeling of potential geographical range of *C. cactorum* - Mexico.

- Education and awareness activities - Mexico, USA, Cuba.

- Mass rearing and shipment - South Africa.

- Ecological and biological Research- South Africa, Australia, USA.

- Restoration of endemic Opuntia- USA.

**RECOMMENDED ACTIONS**

**The IAEA:**

1) Applying the SIT/F1 sterility as part of an area-wide integrated approach appears feasible to deal with cactus moth invasions. No other eradication tools are currently available or foreseen that can effectively stop the spread of this pest. The IAEA has the mandate and expertise in using this technology and should thus make every effort to facilitate its development and application against the cactus moth.

2) In view of the global impact and potential role of SIT, an Interregional Technical Co-operation Project is recommended for approval for the 2003-2004 programme cycle. Countries that would immediately participate in such a project would be Cuba, Mexico, South Africa and the United States and possibly Costa Rica and Nicaragua, and other interested countries in the Caribbean, Mediterranean Basin, South America, etc., would join as the project develops.

3) Apart from the Agricultural Departments, the Agency should establish contacts with the Environmental Protection Agencies of Member States to involve them as stakeholders in such an interregional project.

**Member States:**

1. Establish immediate collaboration between the affected countries through an IAEA interregional technical co-operation project.

2. Prepare the legal frameworks that would allow the enforcement of regulatory actions to prohibit the movement of opuntia plants. This is particularly significant for currently affected countries and those at immediate risk of a *C. cactorum* invasion.

3. Prevent the further spread of the pest in the case of countries such as the USA, where an invasion of *C. cactorum* has taken place and recent data indicate that the rate of spread of the pest is much faster than previously anticipated. It is recommended that the USA immediately embark on an action programme against *C. cactorum*; this should occur regardless of the need for simultaneous efforts in research and development to define detection and eradication tools.

4. Create awareness of the problem at higher levels in the respective Governments including environmental and plant protection agencies, through contact with these agencies, the CACTUSNET, IUCN, and GISP.

5. Create awareness of the problem among growers, biodiversity and genomic conservation organizations, and institutions that could serve as sources of support and influence through education and communication campaigns.

6. Raise the *C. cactorum* issue before the North American Plant Protection Organization (NAPPO) during its next meeting to be held in October 2002 in Oaxaca, Mexico.

7. Implement the collaborative activities that have been identified:

- Establishment of regular shipments of *C. cactorum* pupae from South Africa to the USA for basic population ecology studies and for initial pest containment purposes.

- Establishment of a regional *C. cactorum* detection network including extending the trapping network along the Gulf of Mexico, establishing a detection network in the Yucatan Peninsula and throughout the susceptible areas in Cuba.

- Group training to share the basic monitoring and control procedures available in the USA and South Africa.

- Preparation and distribution to participating countries field guidelines for establishment and operation of trapping networks and for eradication actions in case of an outbreak in free areas or for control in case of established populations.

- Organization of workshops for extension workers, and plant and environmental protection staff.

8. Focus research and development efforts on cost-effective tools for monitoring and control of the pest. Research should concentrate on:

- Development of a cost-effective trapping system including a male or female synthetic lure.
- Refinement of effective radiation dose for F1 sterility.
- Adaptation of methods to release sterile moths.
- Assessment of dispersion rates.
- Assessment of host range (number of species at risk).
- Assessment of susceptible areas and impact of indigenous natural enemies.
- Development of an artificial diet for mass rearing.
- Determination of an effective radiation dose for females used as live bait.

9. The following feasibility studies need to be conducted:

- A HACCP (Hazard Analysis and Critical Control Point) analysis to measure the potential risks of further spread, introduction and establishment of the pest. This analysis would also identify weak points in the quarantine, detection and eradication system that need strengthening to prevent the event (i.e., introduction/establishment of *C. cactorum*) from occurring.
- Analysis of the potential economical and ecological impact of the pest to assess the magnitude of the potential damage. This study would be used as part of the efforts to raise the attention of decision makers at high levels in the government and NGO's.
- Technical analysis on the feasibility of SIT application to eradicate or contain current populations in USA, Cuba and other Caribbean Islands and possible outbreaks in countries at risk.

**NGO's**:

1. Increase communication efforts with Governments, international organizations and the public to make them more aware of *C. cactorum* impacts and the need for action.

2. Become involved in survey, monitoring, prevention, research, and restoration efforts.

**FAO :**

1. Through the FAO Cactus Network, create awareness at an international level of the dangers of *C. cactorum* introduction for countries where cactus are important for economical, ecological or social reasons.

2. CACTUSNET Pest and Diseases Working Group to develop international education, training, and research programs.

## CONCLUSIONS

1. *Cactoblastis cactorum* establishment in cactus-growing areas could be devastating with irreparable ecological and economical damage as well as irreparable social effects.

**2.** An immediate containment/eradication programme of *C. cactorum* in the southeastern USA, Cuba and other Caribbean islands and particularly along the leading edge of invasion should be launched while the chances of containment and control are still possible.

**3.** The SIT approach was identified as the most promising eradication tool and a critical element of any containment and eradication programme. Sufficient knowledge is available to launch the programme.

**4.** The threat of *C. cactorum* is not fully appreciated by decision makers, particularly in the USA. An effective awareness and regulatory national and international programme should be immediately implemented.

**5.** More research and development is needed to refine and increase efficacy of the control and prevention methods.

**6.** Although the emphasis may initially focus on Mexico, Cuba, other Caribbean islands and the USA, this does not mean that the threat is less important in other countries. Any effective contingency /eradication programme developed under the proposed project will be available for application in any other country.

**7.** A collaborative effort among several countries and all available expertise on *C. cactorum* should be mobilized in this programme.