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Consideration of the draft risk management evaluation on endosulfan

Supporting document for the draft risk management evaluation on endosulfan

Note by the Secretariat

The annex to the present note contains a supporting document for the draft risk management evaluation on endosulfan prepared by the intersessional working group established at the fifth meeting of the Persistent Organic Pollutants Review Committee. The draft risk management evaluation is set out in document UNEP/POPS/POPRC.6/9. The annex is presented as prepared by the working group and has not been formally edited by the Secretariat.

* UNEP/POPS/POPRC.6/1/Rev.1.

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Annex

Stockholm Convention on Persistent Organic Pollutants
POPs Review Committee (POPRC)

ENDOSULFAN

SUPPORTING DOCUMENT FOR THE DRAFT RISK MANAGEMENT EVALUATION

Draft prepared by the ad hoc working group on endosulfan
under the POPs Review Committee
of the Stockholm Convention

July 2009

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Executive Summary

At its fifth meeting the POPRC reviewed and adopted a revised draft risk profile on endosulfan. The POPRC decided that endosulfan is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and environmental effects such that global action is warranted. A risk management evaluation should be prepared. Parties and observers were invited to submit the information specified in Annex F for endosulfan before 8 January 2010.

The current production of endosulfan worldwide is estimated to range between 18,000 and 20,000 tonnes per year. Production takes place in India, China, Israel, Brazil and South Korea. Endosulfan is used in varying amounts in Argentina, Australia, Brazil, Canada, China, India, the USA and some other countries. Its use as a plant protection product in agriculture is the most relevant emission source for endosulfan.

Currently applied control measures cover the whole spectrum of possible control measures. In countries where endosulfan is still applied, use is restricted to specific authorised uses and specific use conditions and restrictions are usually established in order to control health and environmental risks in the country concerned. The ban of endosulfan in more than 60 countries demonstrates that economically viable alternatives are likely available in many different geographical situations and in developed and developing countries. There seem to be no or only small stocks of obsolete endosulfan containing pesticides in most countries. However, countries that still manufacture endosulfan may have considerable stocks to manage and there may be a need to clean-up contaminated sites. The destruction of endosulfan does not pose a technical problem. In some countries access to appropriate destruction facilities is limited but these countries seem to have no or low stockpiles.

Alternatives to endosulfan include not only alternative substances that can be used without major changes in the process design, but also innovative changes such as agricultural processes or other practices that do not require the use of endosulfan or chemical substitutes. In total information on almost 100 chemical alternatives (including plant extracts) and a considerable number of biological control measures and semio-chemicals have been identified for a very wide range of applications and geographical situations. Alternatives exist for a wide range of crop-pest complexes and it may be that for each specific crop-pest complex an appropriate combination of chemical, biological and cultural control action may be taken.

Considering the whole spectrum of chemical and non-chemical alternatives it can be assumed that endosulfan can in most cases be substituted by equally or more efficient alternatives. However, some information indicates that it may be difficult to substitute endosulfan for some specific crop-pest complexes in some countries or in general due to specific properties of endosulfan such as appropriateness for insecticide resistance management and its broad spectrum of targeted pests.

According to the results of a screening risk assessment alternatives are generally considered safer than endosulfan. However,for some of the alternatives a clear conclusion whether they are more or less toxic to bees than endosulfan is not possible on the basis of the present information. Non-chemical alternatives generally have no or lower risk.

Several countries expect increased costs for agricultural production and price increases for agricultural products. Some information on costs of chemical alternatives indicates that these are significantly higher. However, examples concerning production of cotton and other crops where the use of endosulfan was banned indicate that alternatives are economically comparable or can even lead to reduced costs for farmers and increased incomes. It can be estimated that a ban of endosulfan could cause one time costs to governments to implement the ban and facilitate access to alternatives, annual costs for agriculture and corresponding impacts on society (up to 40 million USD) and one time costs for waste management (range from approximately 0.10 to 0.23 million USD). These costs have to be considered in contrast to high, non-monetarised long term benefits for environment and health and positive cost impacts such as savings for farmers.

An analysis of possible control measures demonstrates that the most complete control measure would be the prohibition of all production and uses of endosulfan, i.e. listing it in Annex A of the Stockholm Convention. Available information indicates that alternatives are technically feasible, efficient and safer and that they could be available for all current applications of endosulfan. However, as noted above substitution may be difficult and/or costly for some specific crop pest complexes. Exemptions may be required for several years for some crop-pest complexes to permit the development of feasible and efficient alternatives. A harmonised ban on production and use would contribute to balanced agricultural markets.

In accordance with paragraph 9 of Article 8 of the Convention the Committee recommends to the Conference of the Parties to consider listing technical endosulfan (CAS 115-29-7) and its related isomers (CAS 959-98-8 and 33213-65-9) and endosulfan sulfate (CAS 1031-07-8) in Annex A of the Convention.

Introduction

At the fourth meeting of the POPRC in October 2008 the European Community and its Member States being parties to the Stockholm Convention have proposed endosulfan to be listed in Annex A, B or C of the Convention (UNEP/POPS/POPRC.4/14).

At its 5th meeting in October 2009 the POPRC reviewed and adopted a revised draft risk profile on endosulfan [UNEP/POPS/POPRC.5/10/Add.2]. The POPRC decided, taking into account that a lack of full scientific certainty should not prevent a proposal from proceeding, that endosulfan is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and environmental effects such that global action is warranted. The Committee decided to develop for endosulfan a risk management evaluation document that includes an analysis of possible control measures for consideration at its next meeting and final recommendation to the COP for its listing in the Annexes of the Convention.[1]

Parties and observers have been invited to submit to the Secretariat information specified in Annex F information by 8 January 2010.[2] The submitted information is considered in this document. The information submitted is compiled in a supporting document (see [RME Endosulfan 2010, Supporting document-2]).

Chemical identity of Endosulfan

Chemical Identity

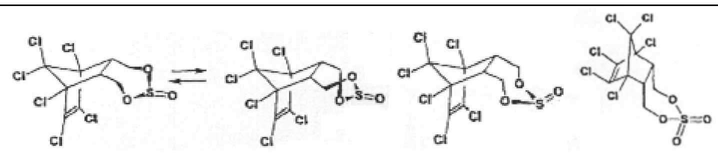
Names and registry numbers

Common name	Endosulfan	
IUPAC Chem. Abstracts	6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin-3-oxide 6,9-methano-2,4,3-benzodioxathiepin-6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9-hexahydro-3-oxide	
CAS registry numbers	alpha (α) endosulfan	959-98-8
	beta (β) endosulfan	33213-65-9
	technical endosulfan *	115-29-7
	endosulfan sulfate: * stereochemically unspecified	1031-07-8
Trade name	Thiodan®, Thionex, Endosan, Farmoz, Endosulfan, Callisulfan	

* Technical endosulfan is a 2:1 to 7:3 mixture of α- and β-isomer.

Technical grade endosulfan is a diastereomeric mixture of two biologically active isomers (α- and β-) in approximately 2:1 to 7:3 ratio, along with impurities and degradation products. The technical product must contain at least 94% endosulfan in accord with specifications of the Food and Agricultural Organization of the United Nations (FAO Specification 89/TC/S) with content of the α-isomer in the range of 64-67% and the β-isomer of 29-32%. The α-isomer is asymmetric and exists in two twist chair forms while the β-form is symmetric. The β-isomer is easily converted to α-endosulfan, but not vice versa (UNEP/POPS/POPRC.5.3).

Structures

Molecular formula	$C_9H_6Cl_6O_3S$	$C_9H_6Cl_6O_4S$
Molecular mass	406.96 g·mol^{-1}	422.96 g·mol^{-1}
Structural formulas of the isomers and the main transformation product		
	α-endosulfan	β-endosulfan endosulfan sulphate

[1] http://chm.pops.int/tabid/588/Default.aspx

[2] http://chm.pops.int/tabid/655//Default.aspx

Production and uses

Production, trade, stockpiles

Endosulfan is synthesized via the following steps: Diels-Alder addition of hexachloro-cyclopentadiene and cis-butene-1,4-diol in xylene. Reaction of this cis-diol with thionyl chloride forms the final product.

Endosulfan was developed in the early 1950s. Global production of endosulfan was estimated to be 10,000 tonnes annually in 1984. Current production is judged to be significantly higher than in 1984 and is estimated to range between 18,000 to 20,000 tonnes per year [India 2010 Annexure I]. India is regarded as being the world's largest producer (9,900 tonnes per year (Government of India 2001-2007)) and exporter (4,104 tonnes in 2007-08 to 31 countries (Government of India)) (according to [UNEP/POPS/POPRC.5/10/Add.2]). Current production in India ranges between 9,500 tonnes (according to [India 2010 Annexure I]) and 10,500 tonnes in the states Gujarat, Kerala and Maharashtra (according to [India 2010]). India, accounts for 50% -60% of global production of endosulfan [India 2010 Annexure-I]. In China, the output of endosulfan was 4,602 tonnes for 2006, 5,003 tons for 2007, and 5,177 tons for 2008 [China 2010]. Production in Germany stopped at 2007 (approximately 4,000 tonnes per year) [3] but export could continue until the end of 2010 [UNEP/POPS/POPRC.5/10/Add.2]. Other producers with unknown production quantities are located in Israel, Brazil and South Korea [UNEP/POPS/POPRC.5/10/Add.2]

To conclude, current annual production amounts to 18,000 to 20,000 tonnes worldwide. Roughly 10,000 tonnes are produced in India, 5,000 tonnes in China and 3,000 to 5,000 tonnes in Israel, Brazil and South Korea.

Historic production in Europe amounted to 10,000 to 50,000 tonnes per year [Germany 2010]. Endosulfan production stopped in the Czech Republic, Germany, the Netherland and in Italy in 2006/2007. It has never been produced in Croatia, Cyprus, Estonia, Ireland, Norway, Slovenia, Sweden and Ukraine [UNECE 2010 CR, CY, DE, EE, HR, IE, NL, NOR, IT, SE, SI].

Endosulfan has never been produced in Canada; in the USA production stopped in the 1980ies [UNECE 2010, CA, USA].

Prior to its ban in Colombia endosulfan was produced until 2001 (production quantities from 1994 to 2001 were: 1994: 198.5 t; 1995: 268.8 t; 1996: 216 t; 1997: 181.9 t; 1998: 382.6 t; 1999: 279.0 thousand litres; 2000 and 2001: 505.4 thousand litres) [Colombia 2010].

Uses

Endosulfan is an insecticide used to control chewing, sucking and boring insects, including aphids, thrips, beetles, foliar feeding caterpillars, mites, borers, cutworms, bollworms, bugs, white flies, leafhoppers, snails in rice paddies, and tsetse flies.

Endosulfan is used on a very wide range of crops. Major crops to which it is applied include soy, cotton, rice, and tea. Other crops include vegetables, fruits, nuts, berries, grapes, cereals, pulses, corn, oilseeds, potatoes, coffee, mushrooms, olives, hops, sorghum, tobacco, and cacao. It is used on ornamentals and forest trees, and has been used in the past as an industrial and domestic wood preservative, and for controlling earthworms in turf.

In 2006 the US EPA registered the use of endosulfan as a veterinary insecticide to control ectoparasites on beef and lactating cattle. It was used as an ear tag in cattle and occupied less than 25% of the US market share of cattle ear tags [KMG Bernuth 2009]. However that use has now been disallowed, along with all other endosulfan uses in the USA.[4]

The production and use of endosulfan is now banned in at least 60 countries[5] with former uses replaced by products and methods considered less hazardous. More detailed information on current uses as informed by countries is provided in an informal document to the endosulfan risk profile (see UNEP/POPS/POPRC.5/INF/9).

[3] A huge majority of this volume is exported for use in tropical and subtropical regions such as Latin America, Caribbean and southeast Asia [UNECE 2007].

[4] Comment from PAN & IPEN on the 2nd draft risk management evaluation

[5] Austria, Bahrain, Belgium, Belize, Benin, Bulgaria, Burkina Faso, Cambodia, Cape Verde, Chad, Colombia, Cote d'Ivoire, Croatia, Cyprus, Czech Republic, Denmark, Egypt, Estonia, Finland, France, Gambia, Germany, Greece, Guinea Bissau, Hungary, Indonesia, Ireland, Italy, Jordan, Kuwait, Latvia, Lithuania, Liechtenstein, Luxembourg, Malaysia, Mali, Malta, Mauritania, Mauritius, Morocco, Netherlands, New Zealand, Niger, Nigeria, Norway, Oman, Poland, Portugal, Qatar, Romania, Saudi Arabia, Senegal, Singapore, Slovakia, Slovenia, Spain, Sri Lanka, St Lucia, Sweden, Switzerland, Syria, the United Arab Emirates, United Kingdom, United States of America.

In Morocco, the Pesticides Committee decided at its last meeting that pesticide preparations containing endosulfan will be withdrawn from the Moroccan market. The deadline is December 31, 2010. See http://www.onssa.gov.ma/onssa/fr/doc_pdf/PV_CPUA_GLOBAL_22_AVRIL_2010.pdf

In USA, the Environmental Protection Agency has withdrawn approval for all uses of endosulfan.

Countries using varying amounts of endosulfan include Australia, Argentina, Brazil, Cameroon, Canada, Chile, Costa Rica, Ghana, Guatemala, India, Israel, Japan, Kenya, Madagascar, Mexico, Mozambique, China, Paraguay, Pakistan, Sierra Leone, South Africa, South Korea, Sudan, Tanzania, Uganda, Venezuela, Zambia, Zimbabwe, USA.

According, to the International Stewardship Centre (ISC) the total average annual use quantity of endosulfan is estimated at approximately 15,000 metric tonnes of active ingredient with Brazil, India, China, Argentina, the USA, Pakistan, Australia and Mexico representing the major markets. According to ISC, the use in Latin America and Asia has been growing consistently [ISC 2010]. Endosulfan is one of the largest used insecticides in India. Out of an estimated annual production of 9,500 tonnes, 4,500 to 5,000 tonnes are consumed domestically [India 2010 Annexure-I].

In detail, a total annual use of 15,400 tonnes is indicated for Argentina (1,500 t), Brazil (4,400 t), India (5,000 t), China (4,100 t) and the USA (400 t), not including use quantities in Pakistan, Australia, Mexico and the African countries Mozambique, Zambia, Ethiopia, Uganda, Sudan, Nigeria, Guinee and Ghana ([ISC 2010], for details see Annex V). Considering also the use in those countries where use quantities are not available, the actual world wide use amount correlates approximately with the estimated production amount of 18,000 to 20,000 tonnes per year. This indicates annual use quantities up to 4,820 tonnes in countries where information on specific amounts is not available.

Table 1. Overview on possible cost impacts

Type of cost impact	Quantification
Implementation costs for governments and authorities	One time administrative costs could range from 0.82 to 4.53 million USD. Realistic estimate: below 1.65 million USD Non-quantified costs for the registration of suitable alternatives
Cost impacts on industry	In countries where endosulfan is already banned and where endosulfan is not produced the cost impacts on industry are nil or negligible. Annual losses for manufacturers occur in countries where endosulfan is still produced 112.7 to 125.2 million USD (India: 61.98 million USD; China 15.03 million USD; Israel, Brazil and South Korea: 35.68 to 48.21 million USD). Globally the losses will be more or less outweighed by sales of chemical and non-chemical alternatives.
Cost impacts on agriculture	Negative annual cost impact due to increased plant protection costs in a range between 0 and 40 million USD (for Brazil: 0 to 13.87 mio USD, for India: 0 to 9.63 mio USD, for China: 0 to 7.89 mio USD, for Argentina: 0 to 2.89 mio USD, for the USA: 0 to 2.78 mio USD and for the rest of the world: 0 to 9.28 mio USD) if endosulfan will be replaced by chemical alternatives in contrast to Non-quantified positive annual cost impacts if endosulfan will be replaced by non-chemical alternatives
Cost impacts on society	Possible price increases of agricultural products up to 40 million USD One time costs for the management of stockpiles range from 101,700 to 226,000 USD. These costs would particularly incur in India (55,935 to 11,870 USD), China (13,560 to 27,120 USD), Israel, Brazil and South Korea (32,205 to 87,010 USD).
Cost impacts on environment and health	Significant, non-monetarised long term benefits for environment and health

Several countries/observers have provided specific information on current uses (see [RME Endosulfan 2010, Supporting document-2] and [UNECE 2010]).

Data provided by companies owning registries of formulations based on endosulfan indicate that the amounts (tonnes of active ingredient) commercialised/used in Brazil from 2000 to 2006 were: 2000: 5,346.6; 2001: 4,058.0; 2002: 2,454.8; 2003: 4,179.1; 2004: 7,294.1; 2005: 6,664.9; 2006: 6,010.1 [Brazil 2010]. Brazil estimates its own current uses to amount to approximately 40% of the world production [Brazil 2010]. Assuming 18,000 tonnes world production this would correspond to 7,200 tonnes annual use in Brazil.

Endosulfan is not produced or manufactured in Australia but technical active ingredient is imported (from e.g. Israel or Germany) and formulated into four registered Australian products. National sales quantities of endosulfan (tonnes of active ingredient sold in the Australian market per year) from 2004 to 2008 were: 2004: 125.2, 2005: 119.4, 2006: 116.4, 2007: 74.1, 2008 (to mid-December): 89.9 tonnes. A small amount of endosulfan is formulated in Australia and exported to New Zealand [Australia 2010]. The latter information contradicts to the current ban of endosulfan in New Zealand.

In China endosulfan has been registered for use in wheat, cotton, fruit, tea tree and tobacco. More importantly, it has been applied for pest prevention and control in cotton planting and a further study is being carried out on its application in tea planting area [China 2010].

In Costa Rica endosulfan is restricted to liquid or microencapsulated formulations with concentrations less than or equal to 35% of active ingredients for agricultural use. Application on rice is prohibited [Costa Rica 2010].

There is no local production of endosulfan in Madagascar. Total imports from 2000 to 2009 amounted to 62,935 liters (active substance and in commercial products) with a maximum of 23,900 liters in 2001. Endosulfan is used in Toilara, Mahajanga (cotton) and Hauts Plateaux (vegetables) [Madagascar 2010].

In the EU the use of endosulfan is currently banned. However, by way of derogation under special circumstances a Member State may authorise for a period not exceeding 120 days the placing of endosulfan on the market for a limited and controlled use. In Italy in 2009 a derogation for use of endosulfan as insecticide for hazelnut (harmful organism – Curculio nucum) was granted ([Italy 2009] [ISC 2010]). In Romania in 2009 a derogation for use as rodenticide for rape, orchards, stalky cereals crops (harmful organisms – Microtus arvalis) was granted for a quantity of 16.6 tonnes active ingredient [Romania 2010]. According to the UNECE survey 2010, use in the EU stopped in 2007 or before (Cyprus, Czech Republic (2001), Belgium (2006), Finland (2001), Germany (1991), Ireleand (2002), Italy, Netherlands (1990), Spain, Sweden (1995)) or has never been used (Estonia) [UNECE 2010 CY, CR, FI, FR, DE, IE, IT, NL, ES, SE, EE]. In Monaco the substance is not used [Monaco 2010]. Use in Switzerland stopped in 2009, in Croatia in 2007, in Norway in 1999, in Ukraine in 1996 [UNECE 2010 SUI, HR, NOR, UA] [Croatia 2010]. In Slovenia endosulfan has been used in plant protection products and in antifouling products in amounts of 3.9 t/year in 2005 and 0.02 t/year in 2008, respectively. Use as plant protection product stopped in 2005 (until 2007: period of grace for the disposal) and as antifouling product in 2009/2010[6] [UNECE 2010 SI]. In Switzerland use in 2008 amounted to 9.46 tonnes [UNECE 2010 SUI]. In Finland use in 2001 amounted to about 0.1 tonnes [UNECE 2010 FI].

Currently registered pest control uses in Canada include greenhouse and terrestrial food and ornamental crops, and outdoor bait stations of food processing plants. In Canada, annual sales of endosulfan on an active ingredient basis are about 22 tonnes [UNECE 2010 CA]. In the USA in 2006 to 2008 annual use was in average 180 tonnes (imported from Israel). Due to current use there exist non quantified stocks [UNECE 2010 USA]. According to this information the current annual use in North America can therefore be estimated around 200 tonnes. According to ISC current use in the USA amounts to 400 tonnes per year [ISC 2010].

Imports of endosulfan to Central American countries in tonnes of active ingredient from 2000 to 2004 were: 2000: 160.7; 2001: 174.1; 2002: 184.1; 2003: 115.4; 2004: 295.3. Primary use was in Guatemala with 169.6 tonnes in 2004 [PAN & IPEN 2010 Ref 8].

Prior to its ban in Colombia endosulfan was sold until 2002 (sales quantities from 1994 to 2002: 1994: 213.8 t; 1995: 222.9 t; 1996: no data; 1997: 220.6 t; 1998: 282.4 t; 1999: 407.9 t; 2000 and 2001: 533.0 thousand litres; 2002: 10.3 thousand litres) [Colombia 2010].

Conclusions of the Review Committee regarding Annex E information

At its fifth meeting the POPRC reviewed and adopted a revised draft risk profile on endosulfan prepared in accordance with Annex E by which it agrees that the POP characteristics of the chemical warrant global action.

Having completed the risk profile for endosulfan, the POPRC took the following decision on endosulfan as adopted in decision POPRC-5/5(UNEP/POPS/POPRC.5/10):

a) Adopted the risk profile for endosulfan contained in document UNEP/POPS/POPRC.5/10/Add.2;

b) Invited the ad hoc working group on endosulfan which prepared the risk profile to explore any further information on adverse human health effects and, if appropriate, to revise the risk profile for consideration by the Committee at its sixth meeting;

c) Considered that, although the information on adverse human health effects is not fully conclusive, there is evidence suggesting the relevance of some effects on humans;

d) Decided, in accordance with paragraph 7 (a) of Article 8 of the Convention, and taking into account that a lack of full scientific certainty should not prevent a proposal from proceeding, that endosulfan is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and environmental effects such that global action is warranted;

e) Decided furthermore, in accordance with paragraph 7 (a) of Article 8 of the Convention and paragraph 29 of decision SC-1/7 of the Conference of the Parties to the Stockholm Convention, to establish an ad hoc working group to prepare a risk management evaluation that includes an analysis of possible control measures for endosulfan in accordance with Annex F to the Convention;

f) Invited in accordance with paragraph 7 (a) of Article 8 of the Convention, Parties and observers to submit to the Secretariat the information specified in Annex F for endosulfan before 8 January 2010.

[6] Data from Phytosanitary Administration of the Republic of Slovenia and Chemicals Office of the Republic of Slovenia.

Data sources

Overview of data submitted by Parties and observers

The Risk Management evaluation is primarily based on information that has been provided by parties to the Convention and observers. Responses regarding the information specified in Annex F of the Stockholm Convention (risk management) have been provided by the following countries and observers:

a) Countries: Australia, Brazil, Bulgaria, Burundi, Canada, China, Colombia, Costa Rica, Croatia, Germany, India, Japan, Lithuania, Madagascar, Malaysia, Mexico, Monaco, Norway, Poland, Romania, Sri Lanka, Switzerland, Togo, Ukraine, USA,

b) Observers: PAN & IPEN[7], ISC[8]

The Annex F information provided by these Parties and observers is presented in a supporting document "Compilation of information on endosulfan provided according to Annex F" [RME Endosulfan 2010, Supporting document-2].

In addition to the information relevant for the risk management evaluation, five parties or observers provided additional Annex E information relevant for the risk profile with respect to adverse human health effects:

c) Countries: Australia and Norway,

d) Observers: Croplife, ISC, MAI[9]

A questionnaire related to production, use and alternatives of endosulfan was sent to the Parties to the UNECE LRTAP Convention and to a group of stakeholders from industry. Relevant results from the survey are used in the present report (reference: [UNECE 2010]).

Other information sources are listed under "References".

Information on national and international management reports

National risk management plans are or will be established on the basis of re-evaluations of risks from endosulfan in Australia, Brazil, Canada and the USA (see chapters 1.5 and 2.1).

Status of Endosulfan under International Conventions

Endosulfan is subject to a number of agreements, regulations and action plans:

a) In March 2007 the Chemical Review Committee (CRC) of the Rotterdam Convention on the Prior Informed Consent Procedure (PIC) for Certain Hazardous Chemicals and Pesticides in International Trade decided to forward to the conference of the parties of the Convention (COP) a recommendation for inclusion of endosulfan in Annex III. Annex III is the list of chemicals that are subject to the PIC procedure. Listing in Annex III is based on two notifications from different regions of regulatory action banning or severely restricting the use for health or environmental reasons that were found to meet the criteria listed in Annex II of the Convention. The COP in 2008 was not able to reach consensus on inclusion of endosulfan due to the opposition of some Parties [UNEP/FAO/RC/COP.4/24], and decided to further consider the draft decision at the next COP. Meanwhile, the CRC has been evaluating further notifications of endosulfan, and has agreed to forward to the next COP a recommendation to list endosulfan in Annex III based on notifications of final regulatory action by the European Union and 8 of the 9 West African countries that take joint regulatory action through the Sahelian Pesticides Committee (Burkina Faso, Cape Verde, Gambia, Guinea Bissau, Mali, Mauritania, Niger and Senegal) [UNEP/FAO/RC/CRC.6/7].

b) Endosulfan has been proposed and is currently considered as a candidate for inclusion in the Annex I to the Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Persistent Organic Pollutants of the United Nations Economic Commission for Europe (UNECE LRTAP Convention).

c) Endosulfan is recognised as one of the twenty-one high-priority compounds identified by UNEP-GEF (United Nations Environment Programme – Global Environment Facility) during the Regional Evaluation of Persistent Toxic Substances (STP), 2002. These reports have taken into account the magnitude of usage, environmental levels and effects for human beings and for the environment of this compound.

d) The Sahelian Pesticides Committee (CSP) has banned all formulations containing endosulfan. The CSP is the structure for the approval of pesticides for CILSS Member States (Burkina Faso, Cape Verde, Chad, Gambia, Guinea

7 Pesticides Action Network International (PAN) and International POPs Elimination Network (IPEN)

8 International Stewardship Centre, Inc.

9 Makteshim Agan Industries (MAI)

Bissau, Mali, Mauritania, Niger and Senegal). The deadline set for termination of the use of existing stocks of endosulfan was 31/12/2008.

e) The UNECE has included endosulfan in Annex II of the Draft Protocol on Pollutant Release and Transfer Registers to the AARHUS Convention on access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters.

f) The Helsinki Commission, or HELCOM, works to protect the marine environment of the Baltic Sea from all sources of pollution through intergovernmental co-operation between Denmark, Estonia, the European Community, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden. The contracting parties have agreed that by 2010 in the whole Baltic Sea catchment area of the Contracting States to ban the use, production and marketing of endosulfan [Lithuania 2010].

g) The OSPAR Commission has included endosulfan in the List of Chemicals for Priority Action (update 2002)

h) In the Third North Sea Conference (Hague Declaration, 8th March 1990), endosulfan was agreed on the list of priority substances.

Any national or regional control actions taken

Specific national or regional control actions for endosulfan have been provided under Annex F (g) by several parties.

Africa

Burundi reports on regulations concerning imports and storage of endosulfan [Burundi 2010].

The nine CILSS country members of the Economic Community of West African States (ECOWAS) have already phased out endosulfan [Togo 2010].

Asia

China will carry out activities for environmental risk assessment of endosulfan in some regions [China 2010].

Endosulfan is designated as an agricultural chemical causing water pollution under Order for Enforcement of the Agricultural Chemicals Regulation Law of Japan. Local governments can restrict use of the agricultural chemicals causing water pollution. Japan will prohibit production, import, distribution and use of endosulfan [Japan 2010].

Australia

In the course of a review of endosulfan which was completed in 2005[10] a number of measures and restrictions were implemented that have been put in place in order to reduce environmental and health impacts and trade risks. These measures include withholding periods and livestock feeding restraints; mandatory buffer zones for spraying; removal of specific uses (beans, sweet corn and peas); specific label instructions; mandatory neighbour notification; record keeping requirements; restricted availability to persons with appropriate training [Australia 2010]. However, these measures were not designed to prevent long-range transport of endosulfan to the Arctic or Antarctic regions.[11]

Europe

In the 27 EU Member States the use of endosulfan as plant protection product is banned. The authorisation of endosulfan as active substance in plant protection products has been withdrawn (Commission Decision 2005/864/EC of 2 December 2005, concerning the non-inclusion of endosulfan in Annex I to Council Directive 91/414/EEC).

North America

National actions in Canada are described in the re-evaluation by Health Canada's Pest Management Regulatory Agency (see chapter 1.3.2). Label changes which will affect the allowed use, will be implemented by the 2012 growing season ([Canada 2010], [UNECE 2010 CA]. The re-evaluation of the health and environmental risks of existing older chemicals which could be possible alternatives to endosulfan is targeted for completion in 2010 [Canada 2010].

USA EPA's Reregistration Eligibility Decision (RED) was in 2002. In 2010 US EPA decided to withdraw approval for all uses of endosulfan.[4]

[10] http://www.apvma.gov.au/products/review/completed/endosulfan.php

[11] Comment by PAN and IPEN on the 2nd draft risk management evaluation.

South and Central America

Brazil reports on labelling requirements for endosulfan with specific information about harmful effects on the environment (i.e. on persistency; bioaccumulation potential in fishes; toxicity for aquatic organisms, bees and other beneficial insects), equipment requirements (“Do not use punctured equipment”), application (“Do not apply this product in the presence of strong winds or during the hottest hours”), dosage, cleaning and disposal of containers, aircraft application buffer zones [Brazil 2010].

In 1997 in Colombia the import, production and placing on the market of endosulfan was severely restricted. The only exempted use for endosulfan containing products was for the coffee pest organism Hypothenemus Hampei. In 2001 the exemption was abrogated and the authorisations for plant protection products containing endosulfan were cancelled [Colombia 2010].

Since 2009 specific legal restrictions for endosulfan are in place in Costa Rica. These are sales restrictions, use restrictions, prohibition of use for the rice cultivation, respect of protected areas and worker protection [Costa Rica 2010].

The national institute of ecology of Mexico has planned for 2010 to carry out an analyses of the situation of endosulfan in order to improve the knowledge about this substance [Mexico 2010].

Summary information relevant to the risk management evaluation

Identification of possible control measures

The following control measures are possible for endosulfan:

a) Prohibition or restriction of production, use, import and export

b) Replacement of the chemical by chemical and non-chemical alternatives

c) Termination of processes which could lead to unintentional release of the chemical (such as specific use conditions and restrictions, trainings, labelling)

d) Clean-up of contaminated sites

e) Environmentally sound management of obsolete stockpiles

f) Establishment of exposure limits in workplaces

g) Establishment of maximum residue limits in water, soil, sediment or food

Currently applied control measures cover the whole spectrum of possible control measures.

The use of endosulfan is currently banned in more than 60 countries (UNEP/POPS/POPRC.5/CRP7.Rev2) and replaced by alternatives. In countries where endosulfan is still applied, use is restricted to specific authorised uses and specific use conditions and restrictions are usually established in order to control health and environmental risks in the country concerned. Clean up of contaminated sites and management of obsolete pesticides may particularly become a relevant issue in countries where endosulfan is manufactured. In many countries workplace exposure limits and maximum residue limits for different matrices are established (see UNEP/POPS/POPRC.3/INF/9). However, despite existing control measures it has to be noted that in other countries endosulfan is used under inappropriate use conditions (e.g. without personal protection equipment or appropriate training) (see e.g. [PAN & IPEN 2010 Add 1]).

Several parties and observes have reported possible control measures [Endosulfan RME Informal Document 2010].

In Australia the supply and use of endosulfan is restricted. Details of the restricted supply and use of endosulfan including limits on frequency of spraying, introduction of mandatory buffer zones during spraying to reduce off-target spray drift, and revised labels can be found on the Australian Pesticides and Veterinary Medicines Authority (APVMA) website[12]. A full review of endosulfan can be found on the APVMA website.[13] Control measures for end-users of endosulfan products are described in an APVMA brochure entitled ‘Endosulfan users’ notice which addresses control measures such as labeling requirements, controlled supply conditions, and use conditions (e.g. record keeping, withholding periods, neighbour notification, consideration of downwind surrounding, time restrictions).[14] Further details of specific state requirements, user training and certification which have been found acceptable to the APVMA for the purposes of supply and use of endosulfan can be found on the APVMA website.[15]

Brazil has established maximum residue limits of endosulfan in specific water bodies. Based on the analysis of the severe adverse effects of endosulfan to human health, ANVISA (Brazilian Sanitary Surveillance Agency) is re-evaluating this pesticide in Brazil and proposing its banishment in Public Consultation. The deadline of this consultation is next February, 4th. Before making a re-evaluation final decision on endosulfan, ANVISA will consider all comments received from the public in response to this consultation document. After that, there will be a meeting with designed members from Ministry of Agriculture and Environment in order to consider the information on the availability and viability of alternative chemical and non-chemical pest management practices for the site and pest combinations registered for it [Brazil 2010].

Bulgaria applies the EU legislation related to endosulfan as well as the international treaties to which the country is a Party. Bulgaria has described in detail the control measures applied to endosulfan [Bulgaria 2010]. Similar control measures are applied in all EU Member States. According to the Bulgarian information, the control measures comprise the following: (1) prohibition of production, use, import and export of plant protection products containing endosulfan; (2) specific prescriptions for classification and labeling; (3) reporting of release and transfer of endosulfan under the UNECE pollutant release and transfer register (4) environmentally sound management of prohibited and obsolete pesticides; (5) establishment of maximum limits in water and food. Bulgaria states that endosulfan formulations are prohibited for use in Bulgaria since 2000 and were replaced by safer plant protection products that are available on the market.

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[12] http://www.apvma.gov.au/products/review/completed/endosulfan.php

[13] http://www.apvma.gov.au/products/review/docs/endosulfan_final_summary.pdf

[14] http://www.apvma.gov.au/products/review/docs/endosulfan_user_brochure.pdf

[15] http://www.apvma.gov.au/products/restricted.php

Control measures applied in Canada concern (1) restrictions for specific uses and (2) and control of discharges or emissions for remaining uses. According to the most recent Re-evaluation of the PMRA [Canada 2010 Ref 4], specific risk mitigation measures that are now required include (i) additional protective equipment, precautions, and packaging of wettable powder (WP) formulations in water soluble bags to protect mixers, loaders and applicators; (ii) a restricted-entry interval to protect those re-entering treated sites; (iii) reduced rates and numbers of applications for some crops; (iv) removal of several crops from product labels (alfalfa, clover, sunflower, spinach, succulent beans, succulent peas); for wettable powder products, use on field tomatoes, sweet corn, dry beans and dry peas must also be removed; and (v) additional advisory label statements and buffer zones to reduce potential surface water contamination [Canada 2010] [UNECE 2010 CA].

Madagascar indicates as possible control measure (1) controls aiming at the prohibition of import and use of products containing endosulfan, or at least (2) restriction to specific uses (e.g. cotton) by trained users; (3) monitoring contamination in areas of primary use and (4) monitoring of residual concentrations in vegetable products [Madagascar 2010].

China proposes to (1) improve the production sites of endosulfan (specify the maximum residue value of endosulfan in the ambient air of production plants; effectively treat the gas emissions, wastewater, and waste residue caused by endosulran production in order to reduce its adverse impact to the surrounding environment and workers' health), to (2) use endosulfan scientifically (restrict its application scope, prevention targets, amount and times in order to effectively reduce the environmental risk) and (3) when conditions are met, to promote IPM, including physical and biological measures in order to further reduce the use of chemical pesticides and lower environmental risks [China 2010].

Costa Rica states as possible control measure the prohibition of use if alternatives to endosulfan are available [Costa Rica 2010].

In Norway, endosulfan has been banned from use since 1/1/1999. Moreover, it is prohibited to stock, sell and use endosulfan as a pesticide. Endosulfan has never been produced in Norway [Norway 2010].

The ban on import and use in the CILSS countries that have conditions very similar to the ones in Togo demonstrates that alternatives are available. Togo is already in the process of banning the use of endosulfan [Togo 2010].

In Ukraine endosulfan was not registered for production or authorised for production, storage, transportation, usage, disposal and destruction. However, it is not included in the list of pesticides banned for usage in agriculture, registration and re-registration [Ukraine 2010].

The USA is currently re-evaluating endosulfan and indicates the following as possible control measures: (1) cancel any or all uses and revoke any or all tolerances, (2) restrict application rates for any or all uses, or (3) extend restricted entry intervals to mitigate worker exposure for any or all uses [USA 2010].

According to PAN & IPEN, the most cost effective and practicable control measures are the prohibition of all production, use, import and export of endosulfan; and the replacement of all uses by non-chemical pest control practices and safer alternative chemicals. Endosulfan should be listed in Annex A, Part 1, of the Stockholm Convention, with no specific exemptions. This should be supported by the clean up of contaminated sites, such as at or near manufacturing facilities, and environmentally sound management of obsolete stockpiles and wastes [PAN & IPEN 2010].

According to ISC, control measures have been established by the Joint FAO/WHO Meeting on Pesticide Residues (JMPR), an international expert scientific group administered jointly by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO). The JMPR has been working on estimating the maximum residue levels that might occur as a result of the use of a pesticide according to good agricultural practices and estimating, where possible, acceptable daily intakes for humans of the pesticides under consideration. The JMPR has established safe residue levels for endosulfan in foods for human consumption [ISC 2010]. Several national authorities including the USA, Australia, India, Brazil, China, Canada and the EU have established safe residue levels [ISC 2010].

Efficacy and efficiency of possible control measures in meeting risk reduction goals

Technical feasibility

General technical feasibility is demonstrated for all possible control measures as they are already applied in many countries. The control measure "prohibition or restriction of production, use, import and export" has as a consequence the need to substitute endosulfan by chemical and/or non-chemical alternatives. Therefore the information provided by parties and observers and the discussion of technical feasibility concentrates on the technical feasibility of the substitution. Another relevant aspect is the feasibility of cleaning-up of contaminated sites and the management of obsolete stockpiles.

The ban of endosulfan in more than 60 countries, including both developed and developing countries, demonstrates that viable alternatives are available in many different geographical situations. However, the efficacy and efficiency of possible control measures is country-dependent. The technical feasibility of the substitution of endosulfan by alternatives is discussed in chapter 2.3.2.

The technical feasibility related to waste and disposal implications is given. There seem to be no or only small stocks of obsolete endosulfan containing pesticide products in most countries. However, the countries that still manufacture endosulfan may have considerable stocks to manage and there may be a need to clean-up contaminated sites. The destruction of endosulfan does not pose a technical problem. In some countries access to appropriate destruction facilities is limited but these countries seem to have no or low stockpiles.

Useful information was provided by parties and observers according to Annex F.

Technical feasibility of using alternatives to endosulfan

For Australia the technical feasibility of applying possible control measures to comply with risk reduction goals for endosulfan would be determined during a subsequent review of endosulfan. It is feasible to amend the legislation and cancel approvals and registrations. If a pesticide is de-registered by the APVMA, the APVMA is not obliged under its legislation to provide suitable replacements, but will evaluate and register suitable alternatives that are determined by affected industries [Australia 2010].

Bulgaria, as a country which has already banned production and use of endosulfan, explains that chemical or non-chemical alternatives which are already in use (and permitted) could be phased-in (note: where they are not already in place). Obsolete stocks of pesticides should be managed according to standards for best available techniques and best environmental practices (BAT/BEP) and inventories of installations meeting the BAT/BEP standards. Adequate facilities for final disposal or destruction of obsolete pesticide stockpiles are not available in Bulgaria. Elimination of stockpiles and clean-up of contaminated sites is not relevant as endosulfan containing pesticides were not identified during annually conducted inventories in Bulgaria.

In Canada a pre-decision consultation with stakeholders determined the interim control measures described by REV2009-09 were feasible. Further consultation on the feasibility of additional control measures for remaining uses is required.

According to Madagascar an abolishment of the substance would not cause relevant problems since there exist homologue substitution products. Costs would arise for the replacement of analytical equipment.

In Togo the technical feasibility to use the chemical alternative of Calfos has already been demonstrated through field experiments during the 2009-2010 cotton production campaign.

According to PAN & IPEN the wide commercial and current availability of alternatives for endosulfan indicates technical feasibility and the practicability of prohibition [PAN & IPEN 2010]. PAN & IPEN argue that for all known uses of endosulfan there would be safer alternative chemicals and practices already in use in developing, transition, and developed countries, such that endosulfan is no longer needed. For example alternatives to endosulfan for pest control on cotton, vegetables, rice, pulses, and tobacco are being used in India [PAN & IPEN 2010 Ref 1] and West Africa [PAN & IPEN 2010 Ref 2] on vegetables, rice and tea in Sri Lanka [Manuweera 2008] and on coffee, soy, flowers, and other crops in Latin America [PAN & IPEN 2009 Ref 9]. In China, where endosulfan is used on cotton, wheat, tea, tobacco and apples, it is used on only 25% of the acreage grown of each crop, indicating that alternatives are used on the remaining 75% of crop [Jia 2009]. At least 62 countries have prohibited endosulfan use and have already broadly implemented technically feasible alternatives.[16] Many more countries currently employ an array of endosulfan alternatives even before prohibiting production and use [PAN & IPEN 2010].

Technical feasibility related to waste and disposal implications (in particular obsolete stocks of pesticides and clean-up of contaminated sites)

According to Brazil endosulfan can be destroyed by incineration at 900°C with a flux of 300 kg per hour. India states that disposal of obsolete/date expired pesticides is a problem for all pesticides. In Bulgaria and Madagascar adequate facilities for final disposal or destruction of available obsolete pesticide stockpiles is not available. Lithuania provided general information on the approach taken to manage pesticide waste. There are no existing stockpiles containing endosulfan in Bulgaria and Sri Lanka. There is no information on existing stockpiles containing endosulfan in Lithuania, Madagascar, Togo and Ukraine. PAN & IPEN state that use of endosulfan has been declining in most countries in recent years, so stocks of obsolete product, whilst they will exist, should not be large in comparison with stockpiles of some other obsolete POPs (such as HCH). However, the countries that still manufacture endosulfan may have considerable stockpiles to manage (see Annex F 2010 submissions of the corresponding parties and observers, section (d)(i)).

Despite a ban of endosulfan in Malaysia some illegal use is assumed. Since the ban in 2005 a total of 3.857 tons has been confiscated and were disposed by a licensed toxic waste disposal operator in accordance to legal requirements. The costs for disposal of 1085 USD/tonne are borne by the government. According to Malaysia it is assumed that a global ban of endosulfan and its enforcement would reduce the possibility for illegal use and corresponding releases to the environment [Malaysia 2010].

[16] UNEP/POPS/POPRC.5/CRP.7/Rev.1.

Identification of critical uses

Possible critical uses for which there may not be an available alternative in a country at the present time can be (a) specific crop-pest combinations where a chemical and/or non-chemical alternative does not yet exist in the country or (b) situations where such an alternative is not technically feasible because of specific advantages of endosulfan or specific disadvantages of available alternatives.

According to some parties and observers it could be difficult to substitute endosulfan at the present time for specific crop-pest complexes e.g. in soybean, cotton, coffee, cane sugar and sunflower in Brazil and Argentina ([Brazil 2010], [ISC 2010]) or in general due to properties of endosulfan such as appropriateness for pollinator management, IPM systems, insecticide resistance management and its broad spectrum of targeted pests ([Brazil 2010], [China 2010], [India 2010], [ISC 2010]). Other information indicates endosulfan is not appropriate for pollinator management or IPM (see chapter 2.3.4).

Critical uses related to specific crop-pest combinations

Australia, Canada and Malaysia provided information on specific crop-pest combinations for which a chemical alternative is currently not registered. This does not mean that they are not available and the problem could be overcome in foreseeable time if alternative chemicals could be registered or non-chemical alternatives could be implemented for the relevant crop-pest combinations.

According to member companies of ISC, endosulfan is important in some major applications, i.e. in cotton, cane sugar, soybeans, sunflower, coffee in South America and hazelnuts in Europe [ISC 2010].

According to Australia, implementing control measures on endosulfan would have a negative impact on cashew nuts(production 25 tonnes/year)[17], cucurbits, guava, kiwi fruit, longans, loquats, mango, rambutans and tamarillo, as currently, endosulfan is the only chemical registered on these crops to control the fruit spotting bug (Amblypelta lutescens). Loss of endosulfan could mean loss of control and economic loss for growers until alternatives are adequately in place [Australia 2010]. There are actives registered for fruit spotting bug in other tropical fruit and nut crops that could potentially be registered for other crops after significant research. The Rural Industries Research and Development Corporation has also undertaken research into IPM for rambutans and other exotic fruit. [18] Sixteen insecticides were screened where beta-cyfluthrin was identified as an “effective alternative” to endosulfan. However, synthetic pyrethroids such as beta-cyfluthrin are recognised as being highly disruptive to beneficial insects.[19] A number of potential options for fruit spotting bug management have been identified, e.g., sex pheromones, plant attractants and biopesticides, carrying the caveat that solutions will only come from considerable research investment. Such research is occurring but unlikely to provide the needed solutions in the short-term. [20]

Canada has provided a list of alternative registered active ingredients to endosulfan for those site-pest combinations of commercial class products that are not supported by the technical registrant or for which risk concerns have been identified ([Canada 2010 Ref 2], [UNECE 2010 CA]). An evaluation of this lists shows that there is currently no alternative registered for the following 16 crop-pest combinations: pepper, tarnished plant bug, greenhouse; ornamentals, rose chafer, greenhouse; ornamentals, elm leaf beetle, greenhouse; ornamentals, black vine weevil, greenhouse; japanese jaw, black vine weevil, greenhouse; apricot, leafhoppers, terrestrial; cherry, plant bugs, terrestrial; cherry, stink bug, terrestrial; cucumber, tarnished plant bug, terrestrial; eggplant, pepper maggot, terrestrial; pumpkin, squash vine borer, terrestrial; pumpkin, tarnished plant bug, terrestrial; squash, tarnished plant bug, terrestrial; tomato, pepper magot, terrestrial; food processing plants (outdoor), sap beetle; japanese jaw, black vine weevil, outdoor ornamentals [Canada 2010 Ref 2].

According to the list of alternatives to endosulfan in Malaysia, there are currently no alternatives registered in Malaysia for three crop pest complexes (i.e. aphids on mango, banana and bok choy/mustard green) [Malaysia 2010].

According to Brazil endosulfan is currently regarded as an indispensable product of the IPM for soybean (pests: Anticarsia gemmatalis, Euschistus heros, Nezara viridula, Piezodorus guildinii), sugar cane (pest: Migdolus fryanus), cotton (pest: Anthonomus grandis) and coffee (pest: Hypothenemus hampei) due to its efficacy and competitive properties [Brazil 2010]. However, a wide range of biological control organisms are being used to replace endosulfan for coffee berry borer (Hypothenemus hampei) in coffee cultivation in Brazil and near-by countries, including the parasitic wasps Cephalonomis stephanotheris and Phymastichus coffea, the entomopathogenic fungus Beauvaria bassiana, as well as neem. Biological controls are also being used to replace endosulfan in soybean, cotton and sugar cultivation in Brazil [PAN & IPEN 2010 Ref 8].

[17] http://www.fao.org/inpho/content/documents/vlibrary/ac306e/ac306e00.htm

[18] https://rirdc.infoservices.com.au/downloads/09-154.pdf

[19] www.cottoncrc.org.au/files/46c4352a-b530-49be-8911.../file.pdf

[20] https://rirdc.infoservices.com.au/downloads/09-154.pdf (according to comment from Australia on the 2nd draft risk management evaluation document)

ISC describes the importance of endosulfan in some major applications, i.e. in cotton, cane sugar, soybeans, sunflower, coffee in South America and hazelnuts in Europe [ISC 2010].

The importance of endosulfan in cotton production according to ISC [ISC 2010]:

The cultivation of cotton is certainly more expensive than other major crops, since it requires a heavy investment in exclusive machines, logistics and in pest control. This is the case because of cotton's increased susceptibility to disease and pest, especially in the early stage of its growth.

The boll weevil (Anthonomus grandis) can cause, at any time of cultivation, losses of up to 70% of production of cotton. Of the products used in its control, endosulfan is the most important, considering that the crop protection products based on malathion and methyl parathion have lower selectivity and low efficiency. The use of pyrethroid based insecticides, which has low selectivity to natural enemies, is not recommended in cotton before the crop is 80 days old, which can result in an unacceptable mite population. While endosulfan is being used specifically against the boll weevil, due to it being a broad spectrum insecticide, it is also effective in controlling other important pests as the leaf worm (Alabama argillacea), apples caterpillar (Heliothis virescens, Helicoverpa zea), mite (Polyphagotarsonemus latus) and aphid (Aphis gossypii). As the result of this, endosulfan is vital to control the boll weevil and other secondary insects, especially in the first 80 days of the crop's growth. Consequently, if endosulfan is not available for use as part of the IPM for cotton, production will be severely impaired, as the boll weevil becomes resistant to existing products. The state government of Parana, EMBRAPA and the Foundation for Support of Agricultural Research of Mato Grosso and House of Cotton Sector project such catastrophic effects.

The importance of endosulfan for cane sugar according to ISC [ISC 2010]:

The main pest that plagues the sugar cane crop is the beetle Migdolus (Migdolus fryanus). The losses caused by this pest may restrict production to a few tons of cane per hectare. In most cases in which the control is inadequate, the loss is of the entire crop, which requires replanting the crop.

The difficulty of fighting Migdolus lies in the fact that it is not possible to be aware of where it is in its life cycle or to accurately predict its appearance in a given area. This is coupled with the fact that adults spend part of their life at great depths in the soil (2 to 5 meters), which provides this insect substantial protection to traditional measures of treatment 4. Experience indicates that the use of insecticides based on endosulfan is the best way to control the Migdolus, providing increased production of 19 metric tons per hectare.

If endosulfan is removed from the market, the only replacement products will be based on fipronil, to which insects build resistance. This concern is highlighted by Cosan:

"Endosulfan has a mode of action that differentiates it from other products such as organophosphates, carbamates, and pyrethroids. Fipronil is protected by patent, and is supplied by a single supplier and would represent an increase of 268% in cost per hectare treated. For these reasons endosulfan is an important tool in management programs resistance to insecticides, since it helps in preventing emergence of resistance to other classes of insecticides.

These data lead to the unwavering conclusion that the maintenance of the IPM of cane sugar depends on the availability of endosulfan on the market, with its unavailability will, on the other hand, result in a significant increase in the cost of production.

The importance of endosulfan for soybeans according to ISC [ISC 2010]:

The soybean crop is subject throughout its cycle by the attack of different species of insects and IPM is needed to maintain its population within acceptable levels. Among the main pest affecting soybeans are the caterpillar (Anticarsia gemmatalis), the Brown Stink Bug (Euschistusheros), Southern Green Stink Bug (Nezara viridula) and the Small Green Stink Bug (Piezodorus guildinni). They cause quantitative and qualitative losses because they suck the grain, reducing them or changing the amount of oil and protein according to Crébio Jose Avila, entomologist and researcher at Embrapa (Dourados-MS), a unit of Empresa Brasileira de Pesquisa Agropecuaria-Embrapa, under the Ministry of Agriculture, Livestock and Supply. Stink bug control on soybean is mostly accomplished by organophosphate based products (including pyrethroids and neonicotinoids) and endosulfan. It has been reported, however, that the exclusive use of organophosphates in some regions of Brazil led to the unsuccessful control of the bugs. The most likely explanation of this is the development of resistant populations, due to lack of rotation with endosulfan, which possess distinct mechanism of action and high selectivity to natural enemies and, as is common knowledge, does not generate resistance.

The need for endosulfan as part of the IPM for soybean has been highlighted by the Association of Soy Producers of Mato Grosso -- APROSOJA: "Especially with its unique mode of action, selectivity to natural enemies, endosulfan has been a key tool for Integrated Pest Management (IPM) and programs Handling Resistance. Endosulfan is the ideal product for species difficult to control such as Helicoperva armigera and whitefly cotton culture in which there is already resistance to insects to other groups of insecticides in Europe. In this context, endosulfan is of fundamental importance to maintain the IPM used in the plantation, so as to avoid the development of resistance of the pests to available organophosphates. Also it is important to provide resources to farmers to maintain the economic viability of their production.

At present, soybean uses at least 50% of the commercialized endosulfan in Argentina. It is widely used in this crop against Himenópteros, Pentatómidos (bugs) and Lepidópteros (caterpillars) attacks. It is used alone or, in some cases, mixed with other products to reach a broader spectrum. It is the product of choice because target insects do not build resistance to it, its lower cost, and its lack of adverse effects on beneficial insects. The possible alternatives are mainly pyrethroids and organophosphate used individually which suffer from a narrower spectrum of action, the insects build resistance to it, higher prices and a significant effect on beneficial insects.

The importance of endosulfan for sunflower according to ISC [ISC 2010]:

The Sunflower crop is subject throughout its growing season to attack by Rachiplusia nu, which is the most harmful pest in Sunflower due to the high insect pressure in all the sunflower areas. The effective control of this Lepidoptera pest for the protection from high foliar damage that happens in only a few days is through use of an IPM containing endosulfan.

The importance of endosulfan for coffee according to ISC [ISC 2010]:

The coffee berry borer (Hypothenemus hampei) is considered a key pest of the coffee crop in the main areas where coffee is grown in the world, attacking fruit at any stage of maturation, from green to dry. The males are smaller than females, have rudimentary hind wings (membranous), consequently they do not fly and never leave fruit from which they came. They attack young fruits resulting in losses in yield. (Rural Magazine, Ed No. 119, Jan. 2008). The only insecticides that satisfactorily control the coffee borer are those which are based on endosulfan, the products with the active ingredient chlorpyrifos fail to provide the necessary control, and increase the production costs by 64%.

This dependence of coffee production on endosulfan is well illustrated by the statement of Regional Cooperative of Coffee Growers of São Sebastião do Paraíso - Cooparaiso. This cooperative is one of the largest coffee producer cooperatives in Brazil, working directly in 72 municipalities. The producers are mostly small and mini growers and their properties have an average area of 11.92 hectares. Coffee, its main product, is responsible for 58% of their revenue. This region has a coffee area of 340 thousand hectares, which produces an average annual 5.2 million 60-kg bags of coffee. Composed of 5,500 associates, the cooperative makes the following statement: "Among the major pests in coffee is the fruit borer (Hypothenemus hampei). It causes large losses in the quality of green coffee, which results in loss of quality of the final product. Of the pesticides registered for use in the coffee crop, the only one that has efficacy in controlling this pest is the active ingredient endosulfan. Not having any other insecticide that might replace it, if its registration is cancelled, it will cause significant losses to the Brazilian coffee industry.". If the coffee berry borer can not be controlled by the farmer, the low productivity as the result of agricultural pest makes coffee growing economically unviable. It is no coincidence that more than 3,000 coffee farmers signed a petition, which was strongly against a ban on endosulfan. It should be remembered that Brazil is the world's largest producer and exporter of coffee and ranks second in the consumer market. In addition, Brazil has also started to capture the world's market of high quality roasted coffee beans and ground coffee. Even if it were economically feasible to treat the coffee berry borer with the alternatives to endosulfan, such as those with the active ingredient chlorpyrifos, the low efficiency of these products would require much larger applications of pesticides. This could lead to an increase in the exposure of the population and the environment. The simple withdrawal of a product may not result in improved toxicological efficiency. On the contrary, it could lead to the use of another product agriculturally less efficient, with greater impacts on human health and the environment.

The importance of endosulfan for hazel nuts according to ISC [ISC 2010]:

Endosulfan is a product of necessity for the protection of certain crops. In Italy, where the use of endosulfan ceased in 2005, a problem developed in the hazelnut that threatened the crop as the result of mite infestation. Italy is the second largest producer of hazelnuts in the world with approximately 100,000 tons of production annually. Although Italian hazelnuts are exported around the world, the main use outside Italy is Germany, France and Switzerland. In order to protect the hazelnut crop from certain types of mites, Italian growers successfully argued for and obtained a special exemption for endosulfan use in the EU. The hazelnut producers received the special exemption because endosulfan is the only insecticide that is both effective in controlling the mites that attack hazelnuts and is also safe for the crop.

Critical uses related to advantages of endosulfan or specific disadvantages of available alternatives

Critical uses of endosulfan exist if the use of chemical and non-chemical alternatives is not technically feasible for specific crop-pest situations. According to some countries using endosulfan the technical feasibility of substitution is currently restricted due to specific advantages of endosulfan (see chapter 2.3.4). Other information sources contradict these arguments and bring the same arguments forward as advantages of safer alternative chemicals and practices which would be available for all known uses and geographical situations (see chapter 2.2.1). The commercial availability of an alternative could be seen as an indicator of technical feasibility [UNEP/POPS/POPRC.5/10/Add.1].

According to India endosulfan cannot be replaced in all cases due to the unique properties (advantages) of endosulfan [India 2010 Annexure-I]. According to Brazil and ISC endosulfan is an indispensable product of the IPM for soybean, sugar cane, cotton, coffee and sunflower ([Brazil 2010] [ISC 2010]). According to China endosulfan is not easily cross-resistant with other pesticides and is therefore a good choice for rotation agriculture and defering pests' resistance to pesticides [China 2010].

According to PAN & IPEN there are for all known uses of endosulfan safer alternative chemicals and practices already in use in developing, transition, and developed countries [PAN & IPEN 2010].

Costs and benefits of implementing control measures

Costs and benefits depend strongly on the status of control in the individual countries and the assessed control measures. An adequate social and economic assessment should not only account for the costs of switching to an alternative, but also the benefits. There should be no bias towards impacts that are quantitatively described simply because of the quantification (as impacts that cannot be described quantitatively may be of equal or greater importance) [UNEP/POPS/POPRC.5/10/Add.1].

Possible costs related to the use endosulfan versus chemical and non-chemical alternatives include:

a) Implementation costs for governments and authorities

b) Cost impacts on industry (manufacturing and retailing of plant protection products)

c) Cost impacts on agriculture (costs for use of alternatives and costs due to altered productivity in terms of quantity or quality)

d) Cost impacts on society (consumer costs for agricultural products, costs for management of obsolete pesticides and remediation of contaminated sites, waste disposal costs)

e) Cost impacts on environment and health

Some of these costs can be difficult to monetize.

In a cost benefit analyses the UK estimates administrative costs for the UK government and authorities if endosulfan will be added to the Stockholm Convention. Costs are estimated 1,800 GBP (5 work days) for updating the UK implementation plan for the Stockholm Convention as a task for government personnel and another 1,800 GBP for redrafting and re-issuing guidance documents and notifying the staff of the regional authorities (for the UK for England and Wales, Scottish EPA, Northern Ireland). The implementation costs for the UK are estimated to range from 1800 to 7200 GBP [RPA 2008].

Assuming that within the 152 signatories similar implementation costs would be necessary the administrative cost could range from 0.82 to 4.53 million USD. The low range is based on the assumption that per signatory one update of the national implementation plan for the Stockholm Convention and one redrafting and re-issuing of guidance and notifying of regional authorities would be required. The high range is based on the assumption that per signatory one update of the national implementation plan for the Stockholm Convention and ten redraftings and re-issuing of guidance and notifying of regional authorities would be required. A realistic estimate could be that per signatory one update of the national implementation plan for the Stockholm Convention and three redraftings and re-issuing of guidance and notifying of regional authorities would be required. Assuming furthermore that the UK is a country with a comparatively high income level, it is expected that on average the implementation costs in UNEP countries will be lower than in the UK. This results in an estimation of below 1.65 million USD administrative costs for signatories if endosulfan would be added to the Stockholm Convention.

In addition to these implementation costs significant efforts may be required in some countries for making alternatives accessible. In countries where pesticide products are prohibited unless permitted, and where endosulfan continues to be used but several alternatives have been withdrawn, the process of developing alternative pest control products and conducting the necessary risk assessments to allow their registration will probably be lengthy, consultative, and unpredictable. In Canada, these activities could include consulting growers on a transition strategy, registering minor uses on pre-registered active ingredients and registering new active ingredients. This could be a costly process.[21] In the same sense Australia states that the high cost of registering alternatives and other factors must be accounted for.[22]

Cost impacts on industry for the UK if endosulfan will be added to the Stockholm Convention are considered nil or negligible due to existing restrictions on marketing and use within the EU [RPA 2008]. This allows to conclude that in countries where endosulfan is already banned and where endosulfan is not produced the cost impacts on industry are nil or negligible.

[21] Additional information provided by Canada in their comments on the second draft risk management evaluation.

[22] Comment by Australia on the second draft risk management evaluation.

The corresponding manufacturers in countries where endosulfan is still produced will have losses if they have to stop selling endosulfan containing products. The losses can be estimated based on production volume and market value.[23] The economic impact for the estimated annual world production from 18,000 to 20,000 t/y ranges from 112.7 to 125.2 million USD. The corresponding impacts for Indian endosulfan producing industry would be 62.61 million USD and for China 31.30 million USD. The impact on the endosulfan producing industry in the rest of the world (i.e. in Israel, Brazil and South Korea) would range between 18.78 and 31.30 million USD. It is expected that the corresponding losses of sales of products containing endosulfan will be more or less outweighed by sales of chemical and non-chemical alternatives.

For the evaluation of direct cost impacts on agriculture it is considered most important to identify possible alternatives (chemicals, semio-chemicals, biological control, IPM, organic farming and specific cultural practices), related costs, their efficiency compared to endosulfan, impacts on yields and output prices of agricultural products. Possible impacts on agriculture are assessed in chapter 2.3.3.

Possible cost impacts on agriculture range from 0 to 40 million USD due to increased production costs if endosulfan would be replaced only by chemical alternatives. Replacement by non-chemical alternatives is related to significant non-quantified cost benefits for agriculture (see chapter 2.3.3). Impacts on consumers depend on two factors.

(1) In those cases where growers experience significant production cost increases, the increased production costs will impact on the consumer prices up to a similar height as production costs increase (i.e. in total up to 40 million USD).

(2) In those cases where endosulfan will be replaced by conversion of growers to organic farming, consumers will have to pay significant price premiums for organic products. The conversion from conventional farming to certified organic farming due to a ban of endosulfan can be expected to be low. Therefore it is expected that the second effect can be considered neglectible.

Social impacts will occur if waste from endosulfan containing products would have to be disposed of after a ban of endosulfan. Endosulfan containing plant protection products usually contain 35 to 50 % of endosulfan by weight. Assuming an average content of 40% by weight, the amounts of waste arising from endosulfan containing products are approximately 2.5 fold the amount of the active ingredient. It can be expected that in countries where endosulfan is already phased out remaining stockpiles of endosulfan are nil or negligible. It is expected that particularly in countries where endosulfan is still manufactured considerable amounts of waste and stockpiles will have to be managed. Assuming residual stocks of 1% of the current production (i.e. 180 to 200 tonnes residual stocks active substance) containing 40% of endosulfan by weight (i.e. 450 to 500 tonnes residual stocks of waste containing endosulfan) the total worldwide disposal costs[24] would range between 101,700 and 226,000 USD. These costs would particularly incur in countries where endosulfan is currently manufactured, i.e. in India (56,500 to 113,000 USD), China (28,250 to 56,500 USD), Israel, Brazil and South Korea (16,950 to 56,500 USD). It is assumed that before a ban due to the listing of endosulfan in the Stockholm Convention becomes effective, most of the endosulfan produced will be consumed. Therefore the 1% scenario could be considered realistic. If lower or higher shares of the production would have to be disposed of, corresponding lower or higher disposal costs would incur. According to Costa Rica economic losses due to endosulfan residues in consumer products are an important cost issue to be considered because the demands on the producer are high.[25]

The conclusions of the risk profile on endosulfan and its widespread occurrence in environmental compartments and biota in remote areas and the related adverse health and environmental impacts let expect non-quantified but high environment and health costs due to the current use of endosulfan. For expample Costa Rica states that health costs of pollution of endosulfan in water supply for human consumption are a relevant cost issue.[25]

[23] A Chinese manufacturer offered technical endosulfan containing 95% endosulfan for a price of 6.59 USD (minimum order 1 tonne; personal information from Chinese manufacturer, 05.03.2010); Based on this price a current market value of 6.26 USD per kg active substance is assumed

[24] In an Analysis of the Costs and Benefits of the Addition of New Persistent Organic Pollutants to the Stockholm Convention [RPA 2008] for the UK the disposal cost for Trifluralin containing waste are estimated between 150 and 300 GBP. It is expected that the disposal cost for endosulfan is similar. For the cost impact assessment it is therefore assumed that the disposal cost for endosulfan containing waste ranges between 226 and 452 USD/tonne

[25] Comment from Costa Rica from 26 May 2010 on the second draft risk management evaluation document.

The following table shows an overview of the expected cost impacts:

Table 2. Overview on possible cost impacts

Type of cost impact	Quantification
Implementation costs for governments and authorities	• One time administrative costs could range from 0.82 to 4.53 million USD. Realistic estimate: below 1.65 million USD • Non-quantified costs for the registration of suitable alternatives
Cost impacts on industry	• In countries where endosulfan is already banned and where endosulfan is not produced the cost impacts on industry are nil or negligible. • Annual losses for manufacturers occur in countries where endosulfan is still produced 112.7 to 125.2 million USD (India: 61.98 million USD; China 15.03 million USD; Israel, Brazil and South Korea: 35.68 to 48.21 million USD). • Globally the losses will be more or less outweighed by sales of chemical and non-chemical alternatives.
Cost impacts on agriculture	• Negative annual cost impact due to increased plant protection costs in a range between 0 and 40 million USD (for Brazil: 0 to 13.87 mio USD, for India: 0 to 9.63 mio USD, for China: 0 to 7.89 mio USD, for Argentina: 0 to 2.89 mio USD, for the USA: 0 to 2.78 mio USD and for the rest of the world: 0 to 9.28 mio USD) if endosulfan will be replaced by chemical alternatives in contrast to • Non-quantified positive annual cost impacts if endosulfan will be replaced by non-chemical alternatives
Cost impacts on society	• Possible price increases of agricultural products up to 40 million USD • One time costs for the management of stockpiles range from 101,700 to 226,000 USD. These costs would particularly incur in India (55,935 to 11,870 USD), China (13,560 to 27,120 USD), Israel, Brazil and South Korea (32,205 to 87,010 USD).
Cost impacts on environment and health	• Significant, non-monetarised long term benefits for environment and health

Parties and observers have provided information that can contribute to evaluate possible costs of control measures. Several countries expect increased costs for agricultural production and price increases for agricultural products. Information on costs of chemical alternatives indicates that these are significantly higher. However, examples concerning production of cotton and other crops where the use of endosulfan was banned indicate that alternatives are economically comparable or can even lead to reduced costs for farmers and increased incomes. The efficient use of non chemical alternatives is managerially complex and will cause costs for training, pest forecast and consulting of farmers depending from the current situation in each country. Expectations for costs for the management and disposal of waste and obsolete stockpiles range from low to high. Implementation costs for governments are also possible. Endosulfan causes significant adverse effects on human health and the environment. As a consequence it can be expected that the current use of endosulfan causes significant non quantifiable environment and health costs.

Australia has not estimated the potential costs (to Australia) that might be associated with reviewing and de-registering a product such as endosulfan. Loss of endosulfan could mean loss of control and economic loss for growers. Costs could include costs to government to conduct the work, as well as costs to industry, and potential social and economic impacts. Environmental and health costs are unknown at this stage [Australia 2010].

In Bulgaria approximately 300,000 to 500,000 USD per year from state budget are allocated for securing and/or final elimination of obsolete pesticide stockpiles. Endosulfan containing pesticides were not identified during annually conducted inventories. Furthermore Bulgaria states that an adequate facility for final disposal or destruction of available obsolete pesticide stockpiles is not available in Bulgaria but a hazardous waste treatment plant will be constructed in the period 2010 – 2013 at costs amounting approximately to 60,000,000 USD [Bulgaria 2010].

Madagascar expects possible price increases for the agricultural products. Cost assessments are required considering also the costs that are required to assure the analytical monitoring of residues of alternatives [Madagascar 2010].

A ban of endosulfan will certainly cost the difference between the costs of endosulfan and alternatives. This information is not yet available [Togo 2010].

The USA notes that type and magnitude of costs depend on the control measure(s) taken. Types of costs could include (1) direct costs to agricultural producers in terms of more costly alternatives and/or decrease in quantity or quality of output; (2) indirect costs to consumers of agricultural products in terms of reduced availability and high prices; (3) possible environmental and human health costs [USA 2010].The USA expects only minimal incremental costs for the management of obsolete stockpiles and clean-up of contaminated sites [USA 2010].

India concludes that cost effective alternatives are not available for all situations and that the need to use other insecticides than endosulfan will result in greater plant protection costs [India 2010 Annexure-I]. Furthermore, India expects high costs for the management and disposal of obsolete pesticide stockpiles as state of the art facilities need to be developed [India 2010].

According to ISC, taking endosulfan off the market and replacing it with other products would lead to increased costs per area and therefore to higher prices for food and other agricultural products [ISC 2010].

According to PAN & IPEN, the POPRC has concluded "endosulfan is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and environmental effects such that global action is warranted". This indicates that the elimination of endosulfan production, uses, export and import as the result of a listing in Annex A of the Stockholm Convention will benefit human health and the environment. This view is supported by the current existence of widespread global environmental and human food chain and body tissue contamination by endosulfan[26] which is likely to reduce and eventually to disappear some time after cessation of endosulfan production and use [PAN & IPEN 2010].

The considerable phase-out of endosulfan that has already occurred in at least 62 countries (most of them developing countries) indicates that alternatives to endosulfan are economically feasible. In West African cotton production the substitution of endosulfan by other pesticides is projected to reduce costs to farmers; [PAN & IPEN 2010 Ref 2] and in India replacement of endosulfan use in cotton, and other crops with non-pesticide management methods has significantly reduced costs and increased incomes for farmers ([PAN & IPEN 2010 Ref 1], [PAN & IPEN 2010 Ref 4]). In Sri Lanka, no reduction in yields of 13 vegetable crops or rice were observed in the years following the prohibition of endosulfan (together with monocrotophos and methamidophos), nor were there any sudden changes in costs of rice production coinciding with bans ([Manuweera 2008], [PAN & IPEN 2010]).

According to PAN & IPEN, any costs incurred in substituting other pesticides or practices for endosulfan should be measured against the costs to human health and the environment of ongoing use of endosulfan. Although there is no meaningful way of measuring these costs, some conclusions on costs to human health can be drawn from the remediation efforts being undertaken by the State Government of Kerala (India) for victims of endosulfan poisoning resulting from aerial spraying of cashew nut plantations, as reported in Section C (iv). For countries with current use and/or endosulfan stockpiles, prohibition of endosulfan production and use would lead to costs for waste handling and management. There may also be costs related to regulation, enforcement, and compliance activities [PAN & IPEN 2010].

Information on alternatives (products and processes)

Description of alternatives

Alternatives to endosulfan include not only alternative substances that can be used without major changes in the process design, but also innovative changes such as agricultural processes or other practices that do not require the use of endosulfan or chemical substitutes. Possible alternatives are (a) chemical alternatives, (b) semio-chemicals, (c) biological control systems, as well as agro-ecological practices such as (d) Integrated Pest Management (IPM), (e) organic farming and other (f) specific agricultural practices.

Generally, it is important that the whole range of alternatives is considered when evaluating possible alternatives. In many cases the comparison is focused on chemical alternatives and neglects non-chemical alternatives.

Endosulfan is used mainly on cotton, tea, coffee, vegetables, rice, pulses and fruit. From the information provided by parties and observers a wide range of technically feasible alternatives has been identified. The identified alternatives are listed in Annex I to the present document including the chemical, semio-chemical and biological alternatives, the corresponding crop-pest combination and a reference indicating which country or observer has provided the corresponding information (See tables 1 to 3, Annex I). In total information on approximately 100 chemical alternatives (including plant extracts) and a considerable number of biological control measures and semio-chemicals have been identified for a very wide range of applications, geographical situations and level of development.

According to PAN & IPEN there is a very wide range of available alternatives to endosulfan, including substitute chemical and biological insecticides; biological controls; and Integrated Pest Management (IPM), organic and agroecological practices. These depend at least in part on the pest/crop complex and only a few examples can be given. PAN & IPEN stress that although the endosulfan industry states that endosulfan is compatible with IPM, PAN & IPEN do not agree with this view because of the known adverse effects of endosulfan on beneficial insects (including on bees and thus impacts on pollinator management; see PAN & IPEN 2010, section (c)(ii)) and the IPM referred to by PAN & IPEN specifically does not include endosulfan [PAN & IPEN 2010].

In an assessment related to cotton production US EPA concluded that "endosulfan's current role in resistance management is minimal and that the loss of endosulfan will not result in adverse resistance management outcomes" [U.S.EPA 2009 A].

[26] UNEP-POPS-POPRC.5-ENDOSU-PANAP-20080601.pdf

In Colombia the use of endosulfan containing products is banned since 1997 for all uses except the coffee bean borer (Hypothenemus Hampei) and since 2001 also for the coffee bean borer. It can be assumed that appropriate alternatives are used since then and are economically available. Most common uses prior to the ban where the following crop-pest combinations: cotton-Heliotis virescens, cotton-Aphis sp., cotton-Bemisia sp., cotton-Alabama argillacea, coffee-Hypothenemus hampei, tomatoe-Trichplusia sp., potatoe-Aphis sp., potatoe-Macrosiphum euphorbiae, Rice-Spodoptera frugiperda, Rice-Aphis sp., Rice-Sogatodes oryzicola [Colombia 2010].

Prior to its ban in Malaysia endosulfan was used to control various pests in various plants. Alternatives recommended by the competent authority include synthetic pyrethroids, organophosphorous substances, Bacillus thuringiensis and other types of pesticides. Malaysia has provided a list of alternatives to endosulfan for several crop pest complexes [Malaysia 2010].

Japan states that there are many alternatives for agricultural use. These are already registered by the competent authority (MAFF) and are sold nationwide [Japan 2010].

Chemical alternatives

According to Annex F 2010 information almost 100 chemical alternatives (including plant extracts) to endosulfan are available for specific crop-pest combinations (see Annex I, Table 10).

According to Australia there are no alternatives to endosulfan to control the fruit spotting bug (Amblypelta lutescens) on cashew nuts, cucurbits, guava, kiwi fruit, longans, loquats, mango, rambutans and tamarillo [Australia 2010]. However there are possible non-chemical alternatives available or under development (see chapter 2.3.1.2). According to comments from PAN & IPEN there are two actives registered for fruit spotting bug in other tropical fruit and nut crops and only require extension of their registration for the crops listed. Similarly, a product made from the clay kaolin is being used by tropical fruit growers and has resulted in greatly reduced damage.[27] The Rural Industries Research and Development Corporation has also undertaken research into IPM for rambutans and other exotic fruit in order to replace endosulfan.[28]

In Brazil preliminary studies indicate the availability of specific active ingredients as replacements for endosulfan for cotton, sugar cane, coffee and soybean pests. However, this finding did not study efficiency assessment [Brazil 2010].

Alternative pesticides that were registered for similar purposes as endosulfan in Canada as of 2006 are listed in Annex F 2010, Canada, Appendix VI of REV2007-13. Some of those alternatives have since been withdrawn, e.g. use of diazinon for several vegetable and ornamental crops, or may be withdrawn within a few years, as a result of ongoing re-evaluation work. Growers are concerned that, in some situations, available alternatives are either lacking in Canada, less effective, inadequate for resistance management or are under consideration for restriction [Canada 2010].

According to China alternatives are other chemicals such as pyrethroids, organophosphorous, carbamates etc. However, the costs including environmental and health costs, efficacy, risks and accessibility of alternatives need to be evaluated [China 2010].

According to the USA, alternatives and technologies are other alternative pesticides, which are generally available and already in use in the agricultural sector. Economic impact studies have been implemented. Impact varies according to crop and region of country. Recent impact assessments for apple, cotton, curcurbits, potato, and tomato are available as well as assessments on some other crops conducted in 2002[29] (see [UNECE 2010 USA]).

According to ISC, endosulfan is important for pest control in cotton, sugar cane, soybeans, sunflower and coffee. According to ISC, the possible alternatives malathion and parathion have lower selectivity and lower efficiency than endosulfan for use on relevant cotton pests (particularly Anthonomus grandis). Pyrethroid based insecticides would provide unacceptable control as well. According to ISC, if endosulfan is removed from the market, the only alternative to control relevant pests for sugar cane (particularly Migdolus frianus) would be fipronil, to which insects would build resistance and which would lead to an increase of 268% in cost per hectare. According to ISC, the control of relevant pests on soybeans (particularly Anticarsia gemmatalis, Euschistus heros, Nezara viridula, Piezodorus guildinii) with possible alternatives (organophosphates) without combination with endosulfan would lead to unsuccessful control of pests. According to ISC a possible alternative to control the relevant pest in coffee (Hypothenemus hampei) is chlorpyrifos, which would lead to a cost increase of 64% due to unefficiency and therefore higher application amounts [ISC 2010].

PAN & IPEN provided information on chemical alternatives on cotton, tea, coffee, vegetables, rice, pulses and fruits:

[27] http://www.gnb.ca/0174/01740008-e.pdf

[28] http://www.aanro.net/VRESEARCH.html

[29] http://www.regulations.gov/search/Regs/home.html#docketDetail?R=EPA-HQ-OPP-2002-0262

Cotton

Cotton companies in West Africa have proposed spinosad, indoxacarb, malathion, flubendiamide, spirotetramat, triazophos and thiodicarb as replacements for endosulfan to control Helicoverpa armigera on cotton in the 9 Sahelian countries (Burkina Faso, Cape Verde, Chad, Gambia, Guinea Bissau, Mali, Mauritania, Niger and Senegal) that have banned endosulfan. Other alternatives being tested in Senegal include emamectin benzoate[PAN & IPEN 2010 Ref 2].

As of December 2009, endosulfan is still registered for use on cotton in the US. Historically, in the US, more endosulfan is used on cotton than any other crop [U.S.EPA 2002 A]; however only about 1% of cotton acres are treated with it each year. [U.S.EPA 2009 A] Use is mostly on Pima cotton, which is grown in Arizona and California, and its use on California cotton has plummeted in recent years, from more than 100,000 lbs/year in the early 1990s to just under 2,000 lbs/year (1 tonne) in 2007.[30] The US Environmental Protection Agency (EPA) concluded in 2009 that "there will be minimal impacts on cotton producers that are not likely to exceed 1% of net operating revenue if endosulfan is not available," and that growers would likely switch to alternatives if endosulfan was not available. US EPA noted that there are more than 33 alternative insecticides, representing 9 different chemical classes, which are labeled for use on cotton and recommended for controlling the same pests targeted by endosulfan.

Tea

PAN & IPEN have provided a list of natural and synthetic pesticides recommended by the Chinese tea industry, Zhejiang University Tea Research Institute and the Tea Research Institute of the Chinese Academy of Agricultural Sciences, as alternatives to endosulfan for pest management in tea plantations (10 pests, 3 biological control systems, 4 plant extracts and 22 chemical alternatives). Some of these pesticides are used in various combinations [PAN & IPEN 2010].

Vegetables

As of December 2009, endosulfan is still registered for use on some vegetables in the US. The US EPA noted in 2009 that alternative chemicals exist for all endosulfan uses and estimated that in case endosulfan should become unavailable, the financial impacts on farmers would be minimal. Specifically US EPA concluded that:

a) Switching to alternatives would result in "little impact" on production costs for potatoes; [U.S.EPA 2009 B]

b) Switching to alternatives would result in "generally minor" impacts on cucumber growers, and noted that "[equally] efficacious and affordable alternative exist" for the niche use in Florida against whiteflies; [U.S.EPA 2009 C]

c) For watermelons and cantaloupe producers "[t]here are alternatives to endosulfan, which according to published efficacy data, can control the pest spectrum as well as endosulfan"; [U.S.EPA 2009 D]

d) For pumpkin growers "[t]here are at least two alternatives which control the same pest spectrum as endosulfan but have slightly higher cost per acre"; [U.S.EPA 2009 E]

e) "The overall benefits of endosulfan on squash are generally minor" and "available data indicates that efficacious and affordable alternatives exist" for the niche use on squash in Florida against whiteflies; [U.S.EPA 2009 F]

f) According to the EPA "effective chemical alternatives are available, although some are more expensive" for fresh tomato producers". [U.S.EPA 2009 G].

Tomatoes are the one crop in the US on which endosulfan use appears to be increasing significantly. California and Florida are the largest producers of fresh tomatoes, each accounting for about one third US production, while California dominates the production of tomatoes for processing,[31] contributing 93% of US production [U.S.EPA 2009 G]. Negligible quantities of endosulfan are used on California's tomato crop: in 2007 only a single application of endosulfan to fresh tomatoes was reported, and only 26 applications were reported to tomatoes for processing, amounting to less than 1% of planted acres of tomatoes. In contrast, 86% of fresh tomato acres in Florida were treated with endosulfan in 2006, an increase from 43% and 44% treated in 2002 and 2004 respectively. Thus, the increase in use of endosulfan is confined to fresh tomatoes grown in Florida [U.S.EPA 2009 G]. The main pests that endosulfan is used against in Florida are whiteflies, aphids, and stink and leaffooted bugs. US EPA's analysis notes that 14, 21, and 9 alternative insecticides are recommended for use against these pests in Florida, respectively. The Agency estimated the costs of transitioning from endosulfan to each of three alternative chemicals: esfenvalerate, bifenthrin and cyfluthrin. Production costs were estimated to change by 0 to 8 USD per acre, amounting to 0–1% changes in net revenue. US EPA thus anticipated "little

[30] California Pesticide Use Reporting Database: http://pesticideinfo.org/List_CA_Chem_Use.jsp?chk=259&cok=00&sk=29121

[31] Pesticideinfo.org, "Pesticide Use in California: Endosulfan on Tomatoes" http://pesticideinfo.org/List_CA_Chem_Use.jsp?chk=259&cok=00&sk=11005,29136,11008

to no economic impact" if farmers were forced to switch to these chemicals [U.S.EPA 2009 G]. An earlier analysis by US EPA had yielded similar results: losses of 0.02 to 0.7% of the total value of production [U.S.EPA 2002 B]. However, EPA noted that the substantial use of endosulfan in Florida suggests that growers perceive significant advantages to the use of endosulfan that EPA's analysis may not have identified [U.S. EPA 2009 G]. EPA and PAN & IPEN conclude that in summary, there is no shortage of documented alternatives – both chemical and culture – to endosulfan use in tomato production. Alternatives are affordable and available now.

Other crops

In the US, 10.3% of apple acreage was treated with endosulfan in 2005–07, amounting 52,900 lbs/year. The key pests targeted by endosulfan are the aphids and stink bugs. There are from 12 to more than 40 alternative insecticides available for the control of these pests on apples. For apple growers in the Pacific Northwest, US EPA concluded that "use of alternative [chemical]s should not increase costs although there may be regulatory issues that make the alternative less desirable." For other apple growers, US EPA acknowledged that "effective chemical alternatives are available" but noted that those alternative "are somewhat more costly and managerially complex." [U.S.EPA 2009 H]

According to an assessment carried out for France it seems to be difficult to find one single substance which is appropriate to replace endosulfan. However, for the single crop pest complexes equivalent alternatives are available ([UNECE 2010 FR] and [INERIS 2006]).

Semio-chemicals

According to Annex F information several semio-chemicals (i.e., substance that carries a chemical message) can be used as an alternative to the use of endosulfan.

Currently, there is ongoing research into the possible use of semiochemicals (pheromones) of the fruit spotting bug ([Baker 1972], [Aldrich 1993][32]). There is reasonable confidence that all the major components of the male sex pheromone of the fruit spotting bug have been identified [Williams 2009]. Combinations of pheromone components will be evaluated for testing in potential lures and traps. However, this research is at a very early stage and commercial availability is unlikely within the next five years [Australia 2010].

Biological control systems

According to Annex F information a wide range of biological control alternatives (i.e., reduction of pest populations by natural enemies) to endosulfan are available.

PAN & IPEN provided information on biological control systems on several cultures:

Cotton

There are a number of biological controls for cotton pests described in two documents by PAN Germany ([PAN & IPEN 2010 Ref 6], [PAN & IPEN 2010 Ref 7]). Natural enemies for pests in cotton cultures are for example damsel bug, ground beetle, hoverfly, ladybird beetles, spider and trichogramma.

Tea

PAN & IPEN have provided a list of natural and synthetic pesticides recommended by the Chinese tea industry, Zhejiang University Tea Research Institute and the Tea Research Institute of the Chinese Academy of Agricultural Sciences, as alternatives to endosulfan for pest management in tea plantations. These include biological control of the Loopworm (Ectropis obliqua hypulina) with Bacillus thuringiensis, Buzura suppressaria nuclear polyhedrosis virus and Ectropis obliqua nuclear polyhedrosis virus and biological control of the Tussock moth (Euproctis pseudoconspersa) with Bacillus thuringiensis [PAN & IPEN 2010].

Coffee

A wide range of biological control organisms have been used to replace endosulfan in coffee cultivation. These include the parasitic wasp Cephalonomis stephanotheris and the entomopathogenic fungus Beauvaria bassiana for coffee berry borer (Hypothenemus hampei) in Bolivia. Field studies have shown that B. bassiana can eliminate up to 80% of adult coffee berry borers. In Costa Rica Beauvaria bassiana and the parasitoid wasp Phymastichus coffea effectively control Hypothenemus hampei. Beauvaria bassiana is also used in Cuba [PAN & IPEN 2010 Ref 9].

In 2005, Mexico had 123,000 producers of organic coffee, representing about 19% of the total land area grown in coffee, with this increasing to 25% in 2008. They do not use endosulfan. Coffee berry borer is the main pest. Main alternatives to

[32] http://www.ars.usda.gov/is/pr/2009/090313.htm.

endosulfan are the fungus Beauvaria bassiana; parasitic wasps Cephalonomia sephanoderis, Prorops nasuta and Phymastichus coffea [PAN & IPEN 2010 Ref 9].

Vegetables

Bacillus thuringiensis is widely used in place of endosulfan in Costa Rica and Cuba, to control lepidopteran pests on a range of vegetable crops. In Cuba, the parasitic wasp Trichogramma is used on approximately 777,000 hectares against lepidopteran pests of tomato, peppers, cucurbits and tobacco as a substitute for endosulfan. Other parasitoids Telenomus spp, Euplectrus plathyhypenae, Tetrastichus howardii Ollif and Tetrastichus spp are used variously for corn, garlic, onion, peppers, tomatoes, potato, and cucurbits as substitutes for endosulfan [PAN & IPEN 2010 Ref 9].

For cucumbers and whiteflies, US EPA noted that natural predators such as ladybird beetles (Nephasis oculatus), green lacewing larvae (Delphestus spp.), Beauvaria bassiana and parasitic wasps (Encarsia pergandiella, Eretmocerus spp.) can help to control some target pests, but would not be sufficient to replace endosulfan [U.S.EPA 2009 C].

Other crops

Bacillus thuringiensis is widely used to control lepidopteran pests in Costa Rica and Cuba, on tobacco and in forestry [PAN & IPEN 2010 Ref 9].

US EPA noted that several non-chemical approaches are available for suppressing aphids and stink bugs on apples with natural enemies such as green lacewing larvae, adult and larval lady beetles, syrphid fly larvae, and parasitic wasps. Growing flowering plants in or around orchards can help attract these natural enemies. Other apple aphids can be suppressed by these same predators as well as midge larvae, pirate bug, damsel bugs, and the predator Campylomma [U.S.EPA 2009 H]. However, non-chemical controls are a component of a pest control strategy and would not be sufficient to replace endosulfan (Comment USA 2010). In addition cultural practices can help to manage apple pests [PAN & IPEN 2010].

According to Costa Rica promising alternatives to control the coffee borer is the use of Beauveria bassiana and of Phymastichus coffea. Despite good control results a programme of production and use of Phymastichus coffea was not continued. Other possible alternatives are the parasites Prorops nasuta, Cephalomia stephanoderis, Heterospilus coffeicola and predators such as Crematogaster curvispinosus and Diadomus rubiginosus. For other crops such as cabbage, tomato and pepper the following biological control agents are used: Bacillus thuringiensis to control larvae of lepidopteran such as Diaphania nitidalis, Heliothis sp and Pieris sp. [Costa Rica 2010].

Integrated Pest Management (IPM) Systems

IPM emphasises the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms

According to established IPM principles (a) non-chemical alternatives must be preferred to chemical alternatives if they provide satisfactory pest control and (b) chemicals used shall be as target specific as possible and shall have the least side effects on human health, non-target organisms and the environment.[33] However, it should be noted that IPM systems accept critically selected plant protection products that should be available to the grower despite certain negative aspects (especially for reasons of resistance management or earmarked for exceptionally difficult cases). These products should have a short persistence and are permitted only for precisely identified indications with clearly defined restrictions [IOBC 2004]. As a consequence, in IPM systems endosulfan as a chemical alternative should be considered only as a last resort if all non-chemical alternatives fail. Furthermore, between chemical alternatives those with a narrow spectrum (low side effects) and with a short persistence should be preferred.

Preserving beneficial insects is an important element of developing an integrated pest management (IPM) system for fruit spotting bugs. This involves limiting the impact on a number of egg parasitoids [Fay 1997] and adult predators for which endosulfan is the least disruptive of currently available insecticide options. [Australia 2010].

Spain states that (potential) alternatives and technologies both currently in use in the agricultural sector are organic agricultural practices and integrated pest management. IPM measures can be financially supported (see [UNECE 2010 ES]).

PAN & IPEN provided information on IPM alternatives on several cultures:

Cotton

In the 2001-2004 period, PAN Africa conducted an Integrated Pest and Production Management (IPPM) training programme on cotton in the Vélingara county (Senegal). The programme trained 583 producers from 72 villages

[33] [IOBC 2004] and EU Directive 2009/128/EC related to sustainable use of pesticides (General principles of IPM; principles 4 and 5).

belonging to 4 rural communities. The programme was highly successful, with producers obtaining large yields without using chemical pesticides. Instead they used a variety of methods and products including solutions of neem, African dry zone mahogany, and pepper. Improved yields were obtained, with yields under IPPM ranging from 1,120 kg/ha to 2,660 kg/ha, compared to the average 1,200 kg/ha in the previous year [PAN & IPEN 2010 Ref 2].

Vegetables

Aphids, cucumber beetles, and squash bugs are key pests on pumpkins that are targeted by endosulfan. These pest organisms may only be problems for a minority of growers. US EPA noted that the use of silver mulch is an important tool for aphid control. US EPA also noted a variety of cultural practices that, as part of an IPM program, can help suppress these pests, including: crop rotation, cover crops, sticky traps, and using certified pest-free plants ([U.S.EPA 2009 E], [PAN & IPEN 2010]).

Organic farming

Organic farming is a form of agriculture that relies on cultural practices such as crop rotation, green manure, compost, biological pest control, and mechanical cultivation to maintain soil productivity and control pests. Organic farming excludes the use of synthetic pesticides.

Spain states that (potential) alternatives and technologies both currently in use in the agricultural sector are organic agricultural practices and integrated pest management [UNECE 2010 ES].

PAN & IPEN provided information on organic farming alternatives for several crop cultures:

Cotton

Global organic cotton production is booming. In Benin there was a 360% increase in the area under organic cotton cultivation between 2005 and 2008, the area having grown to 1,800 hectares. India is the world's largest organic cotton producer. Organic cotton output increased 292% during 2007-08 to 73,702 tonnes compared with the previous year. This resulted in a global organic cotton increase by 152%, to 146,000 tonnes. India contributes half of the world's organic cotton output. The state of Madhya Pradesh grows the largest quantity in India, followed by Maharashtra and Orissa. Gujarat and Andra Pradesh are also important organic cotton producers. In India Organic cotton growers, in place of endosulfan and other synthetic chemical pesticides, manage pests by varietal selection, crop rotation, intercropping with maize and pigeon peas as trap crops, use of flowering plants like marigold and sunflower to attract beneficial insects, use of the parasitic wasp Trichogramma, and use of botanical pesticides [PAN & IPEN 2010].

In Benin (where endosulfan is prohibited), non-chemical strategies used by organic cotton growers to manage pests include planting early maturing and pest resistant varieties, use of plant extracts, rotation, and trap crops. A research project is underway to develop food attractive for beneficial insects that combat Helicoverpa armigera. The project is identifying the appropriate food and the vegetable cycle stages at which to use this food as sprays [PAN & IPEN 2010].

There is a large number of biological, physical and chemical controls for cotton pests described in two documents by PAN Germany ([PAN & IPEN 2010 Ref 6], [PAN & IPEN 2010 Ref 7]). For example Helicoverpa armigera may be controlled by using castor as a border crop; using sunflower, black gram and/or cowpea as trap crops; use of light traps and bird perches, and spraying with extracts of Gliricidia sepium leaves. Non chemical alternatives in cotton production are described for specific pests (aphid, armyworm, cotton boll weevil, cotton bollworm, cotton stainer, cutworm, spider mite, stinkbug, thrips, whitefly), diseases (anthracnose, bacterial leaf blight, fusarium wilt of cotton, leaf curl virus, root knot nematode) and natural enemies (damsel bug, ground beetle, hoverfly, ladybird beetles, spider, Trichogramma).

Coffee

In Latin American Countries significant quantities of organic coffee are produced without endosulfan [PAN & IPEN 2010].

Specific agricultural practices

Specific agricultural practices mean any cultural practices to support pest management. The practices include mainly practices that are also used in IPM and organic farming. However, they can generally be applied in any form of agriculture. Such practices include for example varietal selection, use of certified pest free plants, selection of the appropriate planting time, crop rotation, use of flowering plants like marigold and sunflower to attract beneficial insects, use of beneficial insects such as the parasitic wasp Trichogramma, use of botanical pesticides, use of trap crops and attractant traps, collection of infested plant parts (e.g. coffee beans).

Replacement of conventional cotton crops by genetically modified cotton crops (which reduce the need for endosulfan) may also continue to occur [Australia 2010].

Cultural practices to control coffee pests include collection of infested coffee beans from soil and plants after harvesting and in high infected areas already before harvesting and preventive measures that avoid the distribution of beans between different cultures [Costa Rica 2010].

Cultural practices to lessen pest problems include collecting infested coffee beans before and after harvest (Costa Rica), and using attractant traps for coffee berry borer (Mexico) [PAN & IPEN 2010].

US EPA notes that there are non-chemical practices that can target many of endosulfan's current uses. For cucumbers US EPA noted that a spring planting may reduce pickleworm populations and trap crops can also help [PAN & IPEN 2010].

Aphids, cucumber beetles, and squash bugs are key pests on pumpkins that are targeted by endosulfan. US EPA noted that the use of silver mulch is an important tool for aphid control but is not a stand-alone pest control practice. US EPA also noted a variety of cultural practices that, as part of an IPM program, can help to control these pests, including: crop rotation, cover crops, sticky traps, and using certified pest-free plants [U.S.EPA 2009 E].

US EPA's analysis notes that 14, 21, and 9 alternative insecticides are recommended for use against these pests in Florida, respectively. The Agency estimated the costs of transitioning from endosulfan to each of three alternative chemicals: esfenvalerate, bifenthrin, and cyfluthrin. Production costs were estimated to change by 0 to 8 USD per acre, amounting to 0–1% changes in net revenue. US EPA thus anticipated "little to no economic impact" if farmers were forced to switch to these chemicals [U.S.EPA 2009 G]. An earlier analysis by US EPA had yielded similar results: losses of 0.02 to 0.7% of the total value of production [U.S.EPA 2002 B]. However, there are anecdotal reports of pest resistance to some synthetic pyrethroids [U.S.EPA 2009 G].

US EPA identified a number of non-chemical practices that could target the main pests that endosulfan is used against in Florida tomato production, but did not consider them technically viable replacements for endosulfan. US EPA lists specific cultural control measures for whiteflies, aphids and bugs. Among other US EPA notes that natural enemies are responsible for low whitefly populations observed in weeds and can help control whiteflies in field crops if broad spectrum insecticides are avoided ([US EPA 2009 G], [PAN & IPEN 2010]).

Pruning and fertilisation practices can help to manage apple aphids. For stink bugs, US EPA notes that the elimination of weed hosts such as mustard, milkweed, morning glory, and others from in and near orchards can "minimise" problems with this pest [U.S.EPA 2009 H].

Chemical, biological and cultural alternatives for crops in India

India is the world's largest producer and user of endosulfan.

Therefore PAN & IPEN have specifically analysed the availability of alternatives to endosulfan in India. The analysis comprises chemical, biological and cultural control practices that are recommended by Indian government institutions and other credible sources in India (such as the Agricutural University, Jabalpu, Madhya Pradesh). It is noted that not PAN & IPEN propose the alternative chemicals, but the Indian sources cited. They were included in the analysis in order to demonstrate that cost-effective endosulfan alternatives are available in India. As a result PAN & IPEN demonstrate that for all relevant Indian pest-crop complexes alternatives to endosulfan (chemical and biological) are available and recommended by Indian government and academic sources. In addition to the biological and chemical control alternatives also cultural control measures are recommended by Indian government and academic sources such as use of resistant varieties, intercropping, crop rotation, specific sowing times, specific ploughing times and techniques, specific irrigation measures, traps, etc. (Alternatives recommended in India are included in the Annex of the present document; for details see [PAN & IPEN 2010]).

Technical feasibility

Technical feasibility can be understood to consider whether an alternative (chemical, semio-chemical, biological control, IPM control or cultural control) exists or is expected to be developed in the foreseeable future (see UNEP/POPS/POPRC.5/6).

The current ban of endosulfan in more than 60 countries indicates that technically feasible alternatives exist. In addition, the previous chapter demonstrates that the use of endosulfan can be replaced by several chemical and non-chemical alternatives. These exist for a wide range of crop-pest complexes and for each specific crop-pest complex an appropriate combination of chemical, biological and cultural control action may be taken. However, for specific crop-pest complexes appropriate alternatives may not be available. Statements that alternatives do not exist for specific crop-pest complexes may be based on considerations that are focused only on chemical alternatives and may not consider non-chemical control measures appropriately. In specific cases promising research on semio-chemicals is ongoing and may be used in the foreseeable future.

Useful information has been provided by parties and observers in the Annex F information submitted in 2010. The following table gives an overview on relevant cost impact factors from this information:

Table - Overview on relevant cost impact factors

Cost impact factor	Pest	Crop	Note	Source
12.5 USD/ha	Helicoverpa spp., Green Vegetable Bug, Cotton Aphid	Cotton	Australia; costs to control pests with endosulfan	[Australia 2010]
18 to 40 USD/ha	Helicoverpa spp., Green Vegetable Bug, Cotton Aphid	Cotton	Australia; costs to control pests with alternatives to endosulfan	[Australia 2010]
77.26D/ha and application	Tarnished plant bug, Cyclamen mite	Strawberries	Canada; costs to control pests with endosulfan	[Canada 2010]
453,25D/ha and application	Tarnished plant bug, Cyclamen mite	Strawberries	Canada; costs to control pests with abemactin	[Canada 2010]
3.8 USD/ha	Not specified	Not specified	India; pest control with endosulfan	[India 2010]
4.0 USD/ha	Not specified	Not specified	India; pest control with imidacloprid	[India 2010]
6.0 USD/ha	Not specified	Not specified	India; pest control with neem based pesticide	[India 2010]
40.0 USD/ha	Not specified	Not specified	India; pest control with spinosad	[India 2010]
6.0 USD/ha	Not specified	Not specified	India; pest control with acetamiprid	[India 2010]
15 USD/ha	Not specified	Not specified	India; pest control with buprofezin	[India 2010]
35 USD/ha	Not specified	Not specified	India; pest control with novaluron	[India 2010]
25 USD/ha	Not specified	Not specified	India; pest control with indoxacarb	[India 2010]
30 USD/ha	Not specified	Not specified	India; pest control with flubendiamide	[India 2010]
10 USD/ha	Not specified	Not specified	India; pest control with thiometoxam	[India 2010]
20 USD/ha	Not specified	Not specified	India; pest control with emamectinbenzoate	[India 2010]
40 USD/ha	Not specified	Not specified	India; pest control with chlorantraniloprole	[India 2010]
Production costs possibly increased	Not specified	Not specified	Brazil; costs to control pests with alternatives to endosulfan	[Brazil 2010]
Possibly increased	Not specified	Not specified	Brazil; costs for agricultural output products	[Brazil 2010]
Decreased net cash return from 6.2 to 15.2% per ha	Tarnished plant bug, Cyclamen mite	Strawberries	Canada; costs due to restricted use of endosulfan; substitution with abemactin	[Canada 2010]
Decreased net revenue 0 to 1%	Primarily whitefly	Tomatoes	USA; costs to control pests without use of endosulfan	[PAN & IPEN 2010], [US EPA 2009 G]
Increased production costs from 0 to 8 USD/ha	Primarily whitefly	Tomatoes	USA; costs to control pests without use of endosulfan	[PAN & IPEN 2010], [US EPA 2009 G]
Decrased costs for farmers	Not specified	Not specified	West Africa; pest control without use of endosulfan	[PAN & IPEN 2010]
Decrased costs for farmers	Not specified	Not specified	India; pest control without use of endosulfan	[PAN & IPEN 2010]
No impact on production costs	Not specified	Rice	Sri Lanka; pest control without use of endosulfan	[PAN & IPEN 2010]
Significant net increase in farmers incomes; Significant	Not specified	Chilli, groundnut, red gram, cotton,	India, ‘Community Managed Sustainable Agriculture’ (CMSA) without synthetic	[PAN & IPEN 2010 Ref 4]

Cost impact factor	Pest	Crop	Note	Source
health and ecological effects; No significant change in yields		rice, maize, onion, beans, okra, and eggplant	pesticides	
Production costs reduced by 33%	Not specified	Chilli, groundnut, red gram, cotton, rice, maize, onion, beans, okra, and eggplant	India, CMSA without synthetic pesticides	[PAN & IPEN 2010 Ref 4]
Saving of production costs per acre 20 USD	Not specified	Rice	India, CMSA without synthetic pesticides	[PAN & IPEN 2010 Ref 4]
Saving of production costs per acre 300 USD	Not specified	Chilli	India, CMSA without synthetic pesticides	[PAN & IPEN 2010 Ref 4]
Saving of production costs per acre 100 USD	Not specified	Cotton	India, CMSA without synthetic pesticides	[PAN & IPEN 2010 Ref 4]
Saving of production costs per acre 16 USD	Not specified	Groundnut	India, CMSA without synthetic pesticides	[PAN & IPEN 2010 Ref 4]
Saving of production costs per acre 24 USD	Not specified	Red gram	India, CMSA without synthetic pesticides	[PAN & IPEN 2010 Ref 4]
Saving of production costs per acre 20 USD	Not specified	Fruits, vegetables, cereals	India, CMSA without synthetic pesticides	[PAN & IPEN 2010 Ref 4]
38.6 million USD cumulative cost savings	Not specified	Not specified	Cumulative savings of farmers practising CMSA on 5.1 % of the cropped area of the state of Andra Pradesh in India	[PAN & IPEN 2010 Ref 4]
Little impact on production costs	Colorado potato beetle, leafhopper, tuberworm	Potatoes	USA, pest control without endosulfan	[PAN & IPEN 2010], [US EPA 2009 B]
Generally minor impacts on production costs	Cucumber beetles, whiteflies, aphids	Cucumber	USA, pest control without endosulfan	[PAN & IPEN 2010], [US EPA 2009 C]
Decreased net revenue from 5.5 to 12.3%	Not specified	Cucumber	USA, impacts on farmers still using endosulfan	[PAN & IPEN 2010]
Decreased net revenue from less than 1 up 13%	Aphids, rindworms, whiteflies	Watermelons, Cantaloupe	USA, pest control without endosulfan	[US EPA 2009 D]
Slightly higher costs per acre	Aphids, cucumber beetles, squash bug	Pumpkins	USA, pest control without endosulfan	[PAN & IPEN 2010], [US EPA 2009 E]
Minor impacts	Cucumber beetles, whiteflies, aphids, pickleworm	Squash	USA, pest control without endosulfan	[PAN & IPEN 2010], [US EPA 2009 F]
Little to no economic impact	Primarily whitefly	Tomatoes	USA, pest control without endosulfan	[PAN & IPEN 2010], [US EPA 2009 G]
30 to 52 % increased gross margin	Not specified	Cotton	Organic farmin vs conventional production	[PAN & IPEN 2010]
30% higher prices of output crops	Not specified	Cotton	Revenues from sales of organic cotton vs. conventional cotton	[PAN & IPEN 2010]

Australia expresses some doubts that currently available alternatives can replace endosulfan. In Australia endosulfan is used in IPM systems which involves crop monitoring, identifying infestation hot spots and treating only the affected area. According to Australia the chemical alternatives that are already registered for the relevant uses (alternatives listed by Australia see Annex) may not be appropriate alternatives because beta-cyfluthrin and the organophosphates are disruptive to IPM systems. Of the organophosphates, azinphos-methyl, acephate and methidathion are currently subject to regulatory reviews and trichlorfon is earmarked as a review candidate. Therefore, the number of alternatives may be reduced leaving only beta-cyfluthrin. In the longer term, pheromone based traps may assist in fruit spotting bug management. However, even if these are commercially viable, various industries will still require IPM compatible control options [Australia 2010].

According to Costa Rica the substitution of endosulfan is technically feasible [Costa Rica 2010].

India has not provided information on the technical feasibility for possible control measures but describes specific advantages of endosulfan that cannot be achieved by cost effective alternatives in all situations. Specific advantages would be for example safety to natural enemies of pests, appropriateness for integrated pest management, appropriateness for pollinator management, appropriateness in case of insecticide resistance [India 2010 Annexure-I].

Japan states that the control measures (to prohibit production, import, distribution and use) are technically feasible. The POPs chemicals for agricultural uses are already prohibited to distribute and use based on the ordinance of Ministry of Agriculture, Forestry and Fisheries of Japan(MAFF) [Japan 2010].

Switzerland states the replacement of endosulfan is technically highly feasible [Switzerland 2010].

Alternatives to endosulfan are currently available in the USA. Some may not be as effective as endosulfan [USA 2010].

PAN & IPEN state that “Commercial or current availability of an alternative is an important indicator of technical feasibility” [UNEP/POPS/POPRC.5/L.1/Add.3] and that it is believed that all the alternatives described by PAN & IPEN are already in use and therefore technically feasible [PAN & IPEN 2010].

In Malaysia alternatives to endosulfan are used without major complaints from users [Malaysia 2010].

Costs, including environmental and health *costs*

For the evaluation of costs it is considered most important to identify possible alternatives (chemicals, semio-chemicals, biological control, IPM, organic farming and eventually specific cultural practices), related costs, their efficiency compared to endosulfan, impacts on yields and output prices of agricultural products as well as overarching indicators such as incomes of farmers or net cash revenues.

In some countries, the pest control costs per ha for chemical alternatives to endosulfan seem to be significantly higher than those for endosulfan. However if endosulfan is replaced by alternatives, reported overall cost impacts range from significant decreased net cash returns (up to 15% decrease; strawberries in Canada) to only minimal impacts (e.g. 0–1% changes in net revenue in US cotton production) or to significant positive impacts due to reduced production costs at comparable yields (e.g. cotton and other crops in India).

Alternatives to endosulfan will have positive economic impacts if they contribute to increased yield, higher output prices and lower production costs and vice versa. As a consequence it is possible to analyse the impacts of alternatives on the individual factors (i.e. yields, prices, and production costs) or the overarching impacts on the income (i.e. incomes of farmers, net cash return) for an assessment of possible economic impacts of the substitution of endosulfan with alternatives.

Table 3 shows expected cost impacts on agriculature if endosulfan will be replaced by chemical and non-chemical alternatives on the basis of the available information. It has to be kept in mind that replacement by chemical and non-chemical alternatives are not two opposed options but that in practice a certain (non-quantified) share of current endosulfan use would be replaced by chemical alternatives and the remaining share would be replaced by non-chemical alternatives. Correspondingly, the overall annual economic impact on agriculture would be a consequence of all chemical and non-chemical replacement strategies that would be put into practice if endosulfan would not be available anymore. The underlying information and the assumption for the assessement are explained on the following pages.

Table 3. Expected economic impacts on agriculture if endosulfan will be replaced by chemical and non-chemical alternatives

<table>
<tr><th colspan="3">Chemical alternatives</th></tr>
<tr><th>Cost impact factor</th><th>Expected impact</th><th>Expected costs if endosulfan would be replaced by chemical alternatives</th></tr>
<tr><td>Yields</td><td>Remain stable</td><td rowspan="3">Annual cost will increase between 0 and 40 million USD
Brazil: 0 to 13.87 mio USD
India: 0 to 9.63 mio USD
China: 0 to 7.89 mio USD
Argentina: 0 to 2.89 mio USD
USA: 0 to 2.78 mio USD
Rest of the world: 0 to 9.28 mio USD</td></tr>
<tr><td>Prices</td><td>Remain stable</td></tr>
<tr><td>Production costs</td><td>Plant protection cost increase by 0 to 40%</td></tr>
<tr><th colspan="3">Non-chemical alternatives</th></tr>
<tr><th>Cost impact factor</th><th>Expected impact</th><th>Expected costs if endosulfan would be replaced by non-chemical alternatives</th></tr>
<tr><td>Yields</td><td>Slight decrease to slight increase</td><td rowspan="3">Significant non-quantified annual economic benefit</td></tr>
<tr><td>Prices</td><td>In organic production significant price premiums</td></tr>
<tr><td>Production costs</td><td>Significant plant protection cost decrease</td></tr>
</table>

Costs related to chemical alternatives

Impact analysis

It can be assumed that the use of chemical alternatives will not have negative impacts on yields as alternatives are assumed to be at least equally efficient compared to endosulfan (see chapter 2.3.4).

Impact on prices

The use of chemical alternatives will not enable to achieve higher output prices for crops. Prices of output crops will remain stable.

Impact on production costs and net cash return

The critical factor in the assessment of chemical alternatives are the production costs. Production costs are particularly influenced by costs for chemical pest control. Several US EPA documents contain information on impacts on pesticide costs and the net cash return caused by using alternative pesticides instead of endosulfan ([U.S.EPA 2002 A] to [U.S.EPA 2009 H]). Values for the change in pesticide costs and associated negative impacts on net cash return in percent are summarised in Table 4 for specific crops and substances. The table shows increases in pesticide costs if more expensive alternatives up to almost 600% and corresponding impacts on net cash return up to 18.8%. However, in most cases pesticide cost increase is below 100 % and cost impacts are low to moderate.

Table 4. US EPA values for increase of pesticide costs in comparison to endosulfan and corresponding decrease in net cash return [%] for specific substances.

Crop	Substance	Increase pesticide cost [%]	Decrease net cash return [%]	Source
cotton	endosulfan	0	0	[U.S.EPA 2002 B]
tobacco	acephate	24.2	0.1	[U.S.EPA 2002 B]
tomato	lambda-cyhalothrin	17.6	0.6	[U.S.EPA 2002 B]
apple	diazinon	1.1	0.7	[U.S.EPA 2009 H]
cotton	fenpropathrin	26.7	0.8	[U.S.EPA 2002 B]
cotton	fenpropathrin	14.9	0.8	[U.S.EPA 2002 B]
cotton	lamda-cyhalothrin	21	1	[U.S.EPA 2002 B]
cucumber	bifenthrin	96	1.3	[U.S.EPA 2009 C]
cotton	malathion	24.4	1.7	[U.S.EPA 2002 B]
tobacco	imidacloprid	48.8	1.8	[U.S.EPA 2002 B]
apple	thiamethoxam	3.7	2.2	[U.S.EPA 2009 H]

Crop	Substance	Increase pesticide cost [%]	Decrease net cash return [%]	Source
pumpkin	bifenthrin	6.1	2.5	[U.S.EPA 2009 E]
squash	bifenthrin	152	2.9	[U.S.EPA 2009 F]
pumpkin	fenpropathrin	10.7	4.3	[U.S.EPA 2009 E]
cucumber	bifenthrin	96	4.8	[U.S.EPA 2009 C]
cucumber	bifenthrin	96	4.87	[U.S.EPA 2009 C]
cotton	indoxacarb	175.4	8.4	[U.S.EPA 2002 B]
cotton	tebufenozide	216.2	14.8	[U.S.EPA 2002 B]
tomato	imidacloprid	596.8	18.8	[U.S.EPA 2002 B]

The following illustration shows the correlation of changes in pesticide costs (y-axis) with changes in net cash return (x-axis) in percent based on the data shown in Table 4.

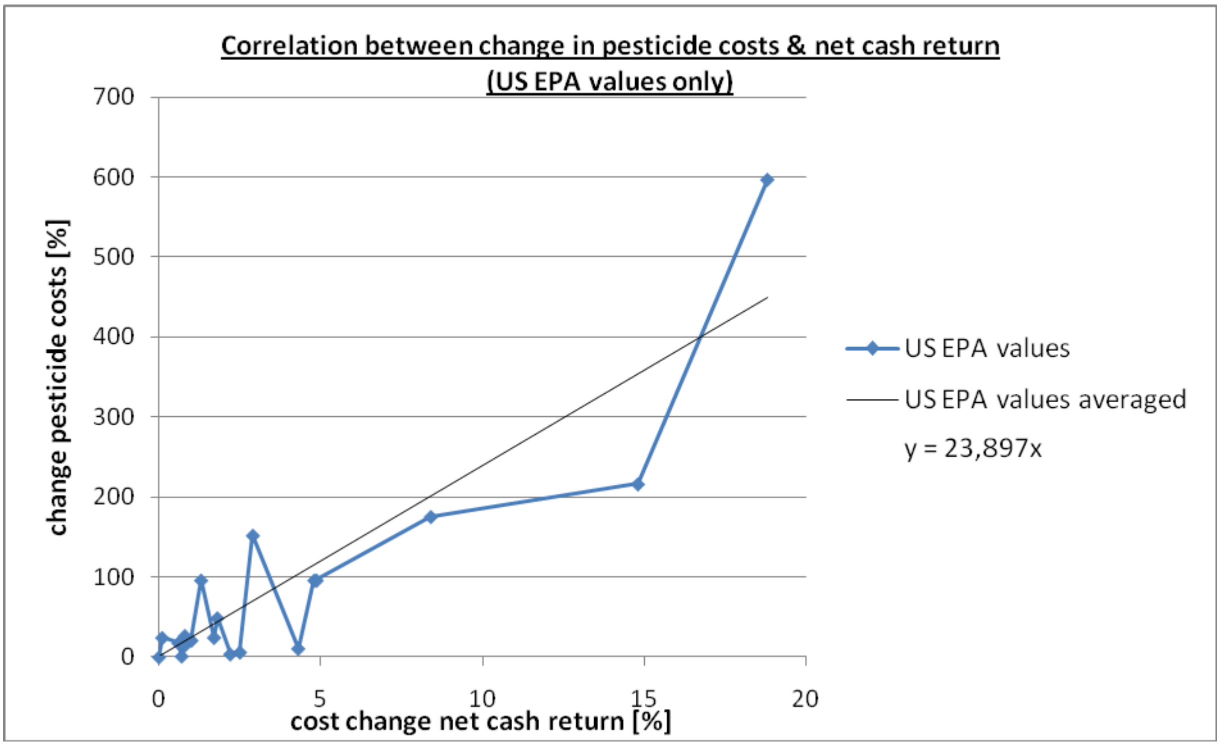

Figure 1: Correlation between change in pesticide costs and net cash return [%] (based on US EPA data)

Based on an averaged dataline (y = 23.90x) an extrapolation on the impact of changed plant protection product costs on net cash return can be made if an alternative pesticide is used instead of endosulfan. According to the correlation, a cost increase by 100% for the use of an alternative pesticide results in an average decrease of the net cash return by 4.2%.

Table 15 in Annex IV gives an overview on alternatives to endosulfan, their pest control spectrum for individual crops and the corresponding costs per application in the USA. The overview is based on US EPA data sources where specific information on costs per crop and pest specific application are available. An assessment of the information contained in Table 15 in Annex IV is summarised in Table 5.

Table 5. Overview on average cost and cost ranges for endosulfan and chemical alternatives in the USA, the availability of lower cost chemical alternatives and conclusions on possible cost impacts

Crop	Average costs endosulfan (USD/ha)	Average costs alternatives (USD/ha)	Cost range alternatives (USD/ha)	No of available alternatives	No of alternatives with lower costs	Pest spectrum covered by lower cost alternatives
Apples	46.07	51.31	7.50 – 137.00	33	16	Y
Conclusion apples: Appropriate lower cost alternatives are available; a reasonable selection of alternatives let expect that no negative cost impacts would occur. In contrast, about 50% of the alternatives are cheaper and even positive impacts are possible.						
Cantaloupe	22.50	46.25	12.50 – 140.00	10	4	Y
Conclusion cantaloupe: Appropriate lower cost alternatives are available; a reasonable selection of alternatives let expect that no relevant cost impacts would occur.						
Cotton:	19.47	27.19	7.50 – 99.50	31	16	Y
Conclusion cotton: Appropriate lower cost alternatives are available; a reasonable selection of alternatives let expect that no negative cost impacts will occur. In contrast, about 50% of the 31 chemical alternatives are cheaper and even positive impacts are possible.						
Cucumber	16.86	37.33	8.13 – 98.75	17	6	Y
Conclusion cucumber: Appropriate lower cost alternatives are available; a reasonable selection of alternatives let expect that no relevant cost impacts would occur.						
Grapes[34]	18.70	31.35	n.a.	1	0	n.a.
No conclusion possible du to insufficient information on costs for alternatives for grapes.						
Melons	17.50	57.26	12.50 – 142.50	11	4	Y
Conclusion melons: Appropriate lower cost alternatives are available; a reasonable selection of alternatives let expect that no relevant cost impacts would occur.						
Pecans[35]	15.58	26.15	18.95 – 33.35	2	0	n.a.
Conclusion pecans: Only limited data are available. These do not indicate the availability of lower cost alternatives; however a reasonable selection of (the cheaper) alternative let expect that only small cost impacts would occur (increase of pest control costs by approximately 22%[36]).						
Potatoes	20.00	38.29	7.50 – 150	19	9	Y
Conclusion potatoes: Appropriate lower cost alternatives are available; a reasonable selection of alternatives let expect that no relevant cost impacts would occur.						
Strawberries	77.26	262.58	71.90 – 453.25	2	1	Y
Conclusion strawberries: Only very limited data are available. These indicate the availability of one lower cost alternative; a reasonable selection of alternatives let expect that no relevant cost impacts would occur.						
Tobacco	20.55	43.50	25.53 – 74.41	3	0	n.a.
Conclusion tobacco: Only very limited data are available. These do not indicate the availability of lower cost alternatives; however a reasonable selection of alternatives let expect that only small cost impacts would occur (if the most expensive alternative is disregarded, pest control costs would on avarage increase by approximately 40%[37]).						
Tomatoes	20.00	104.13	19,25 – 433.75	7	1	n.a.
Conclusion tomatoes: Only one lower cost alternative available. However several alternatives have only slightly higher costs compared to endosulfan; a reasonable selection of alternatives let expect that no relevant cost impacts would occur (if the most expensive alternative is disregarded, pest control costs would on average increase by approximately 9%[38]).						

The information in Table 5 and the underlying information in Table 15 in Annex IV allow to conclude that in all cases where sufficient data on costs of alternatives is available it can be demonstrated that lower cost alternatives are usually available. The average of costs for alternatives are usually comparatively elevated compared to endosulfan because a limited number of very high cost alternatives (particularly imidacloprid, thiomethoxam, abamectin, spinosad, aldicarb, oxydemetonmethyl, azadirachtin, bifenazate, extoxazole, propargite and pyridaben) contribute to high averages of cost

[34] The US EPA cancelled (i.e., banned) the use of endosulfan on grapes under the 2002 Reregistration Eligibility Decision (RED).

[35] The US EPA cancelled (i.e., banned) the use of endosulfan on pecans under the 2002 Reregistration Eligibility Decision (RED).

[36] Increase disregarding the highest cost alternative (Tralomethrin); extrapolated decrease net cash return ~ 0.9%

[37] Average increase disregarding the highest cost alternative (Imidacloprid); extrapolated decrease net cash return ~ 1.7%

[38] Average increase disregarding the highest cost alternative (Imidacloprid); extrapolated decrease net cash return ~ 0.4%

alternatives. However, in all cases where sufficient information is available it can be demonstrated that besides these high cost alternatives there is a selection of lower cost alternatives or at least a selection of only slightly higher cost alternatives available. In practice endosulfan will be replaced by the most appropriate alternative at low costs. In some cases even cheaper alternatives may be used instead of endosulfan. In other cases the use of a high cost alternative may be necessary. As a consequence it can be expected that no or only moderate impacts on the costs for pest control (e.g. increase for tomatoes, pecans and tobacco by 9 to 40%) and corresponding low impacts on net cash return (decrease for tomatoes, pecans and tobacco by 0.4 to 1.7%) will occur. In some cases positive impacts may outweigh the negative impacts.

For India crop-pest specific information on costs for alternatives is not available. However, India provided information on average costs per hectare for 11 chemical alternatives to endosulfan [India 2010]. Table 6 shows that the average cost increases for pesticide cost are up to 950% with corresponding extrapolated impacts on net cash return up to 40%. However such increases are not realistic and if in practice endosulfan would be replaced by the three cheapest chemical alternatives indicated by India, this would on average increase the pesticide costs per hectare by approximately 40% which would be related to an average estimated decrease of the net cash returns by 1.7% where endosulfan is currently used (see Table 6, last line). Moreover this assessment considers only the data on average costs per ha for alternatives provided by India and it would be interesting to know about the Indian specific average costs per ha for the low cost alternatives that are for example available in the USA.[39] For a reasonable cost impact assessment also low cost alternatives need to be taken into account.

Table 6. Average cost increase for chemical alternatives to endosulfan based on information from [India 2010]

Chemical alternative	Average costs endosulfan (USD/ha)	Average costs alternatives (USD/ha)	Average cost increase (%)	Extrapolated impact net cash return (%)[40]
Acetamiprid	3.8	6.0	57.9	2.4
Buprofezin	3.8	15.0	294.7	12.4
Chlorantraniloprole	3.8	40.0	952.6	40.0
Emamectinbenzoate	3.8	20.0	426.3	17.9
Flubendiamide	3.8	30.0	689.5	29.0
Imidacloprid	3.8	4.0	5.3	0.2
Indoxacarb	3.8	25.0	557.9	23.4
Azadirachtin	3.8	6.0	57.9	2.4
Novaluron	3.8	35.0	821.1	34.5
Spinosad	3.8	40.0	952.6	40.0
Thiomethoxam	3.8	10.0	163.2	6.9
Average 3 cheapest			40.4	1.7

An evaluation of the US EPA data ([U.S.EPA 2002 A] to [U.S.EPA 2009 H]) shows that endosulfan quantities per application and hectare range from 0.11 to 3.01 kg with a mean value of 1.22 kg. The number of applications per year range from 1 to 4 with an average of approximately 1.9 applications per year. It can be concluded that an average annual quantity of endosulfan applied per hectare amounts to 2.32 kg.[41] An evaluation of ISC data shows that endosulfan quantities per application and hectare range from 0.10 to 1.75 kg in Argentina and from 0.40 to 1.40 kg in India with an average value of 1.05 kg and 0.79 kg, respectively [ISC 2010]. Assuming 1.9 applications per year as for the USA, the average annual quantity of endosulfan applied per hectare amounts to 2.00 kg for Argentina and 1.50 kg for India.

Table 7 shows current use quantities of endosulfan, average annual application quantities per ha and the estimated area to which endosulfan is currently applied per country/region. For Brazil and the rest of the world the same value for the average annual use quantity was used as for Argentina (i.e. 2kg/ha); for China the same value was used as for India (i.e. 1.5 kg/ha).

[39] These are for example for cotton: Bifenthrin, Cypermethrin, Deltametrin, Dicrotophos, Dimethoate, Esfenvalerate, Flonicamid, Malathion, Methamidophos, Methomyl, Naled, Parthion-methyl, Profenophos, Tralomethrin, beta-Cyfluthrin, lambda-Cyfluthrin (see Annex IV, Table 15).

[40] Extrapolation based on the assumption that a cost increase by 100% for the use of an alternative pesticide results in an average decrease of the net cash return by 4.2%.

[41] This fits more or less with mean quantities applied per ha on main uses in Colombia prior to the ban of Endosulfan (average quantity per ha 2.11 kg); source [Colombia 2010].

Table 7. Current use quantities of endosulfan, average annual application per ha and estimated area to which endosulfan is currently applied per country/region

Country/Region	Use (tonnes)	Average annual application per ha (kg)	Estimated area to which endosulfan is currently applied (million ha)
World	18,000 to 20,000	1.50 to 2.32	Up to 11.5
India	5,000	1.50	3.33
Brazil	4,400 to 7,200	2.00	2.20-3.60
China	4,100	1.50	2.73
Argentina	1,500	2.00	0.75
USA	180 to 400	2.32	0.08-0.17
Total for major known use countries	15,180 to 18,200	1.50 to 2.32	9.09 to 10.59
Rest of world	Up to 4,820	2.00	Up to 2.41

Average annual costs per ha for the use of endosulfan differ significantly from country to country. Average annual costs per ha for the use of endosulfan in the USA are approximately 40 USD (calculated on the basis of US EPA data). Corresponding costs in Australia are 23.75 USD (12.5 USD/ha and application [Australia 2010] assuming 1.9 applications per year). Corresponding costs in India are approximately 7.22 USD (3.8 USD/ha and application [India 2010] assuming 1.9 applications per year). This corresponds to average annual pesticide costs of 4.81 USD per kg endosulfan in India.[42] For the main users of endosulfan, specific information on current average costs per ha is only available for India. For a cost impact scenario average costs are calculated according to the country specific average annual use quantities of endosulfan.

Table 8. Average annual pesticides costs for the use of endosulfan in countries of majour use

Country/Region	Average annual use quantity (kg/ha)	(Average annual costs) USD/ha	Information source
India	1,5	7,22	Calculated on the basis of data provided by [India 2010]
China	1,5	7,22	Corresponding to India (estimation)
Argentina	2	9,63	Calculated from data provided by [ISC 2010]
Brazil	2	9,63	Corresponding to Argentina (estimation)
USA	2,32	40.24	Calculated from US EPA data
Rest of world	2	9,63	Corresponding to Argentina (estimation)

Concerning the pesticide cost increase due to the use of alternatives further assumptions are made for the scenario. (1) The pesticide cost increase in India is approximately ~ 40% due to the replacement by the three cheapest chemical alternatives indicated by India (see Table 6). (2) The pesticide cost increase in the USA is approximately 40% (due to the replacement by the chemical alternatives listed in Table 4 except the three most expensive alternatives). (3) The pesticide cost increase in Brazil, Argentina and China and the rest of the world is approximately 40% (due to the lack of information the increase is assumed analogue to India and the USA).

Based on these assumptions a cost impact scenario with 40% increased pesticide costs can be established (see Table 9).

[42] The annual costs of 7.22 USD per ha in India are related to an applied quantity of 1.5 kg. The costs for 1 kg is therefore 7.22 USD divided by 1.5 = 4.81 USD

Table 9. Cost impact scenario if pesticide costs would increase by 40% due to the replacement of endosulfan with chemical alternatives

Country	Use [t]	Use area [mio ha]	Average pesticide costs for endosulfan per year [USD/ha]	Pesticide cost increase for use of alternatives [%]	Increased production costs per year [mio US$]
Brazil	4400-7200	2.20-3.60	9.63	~40	8.47 to 13.87
India	5000	3.33	7.22	~40	9.63
China	4100	2.73	7.22	~40	7.89
Argentina	1500	0.75	9.63	~40	2.89
USA	180-400	0.08-0.17	40.24	~40	1.25-2.78
Total for major known use countries	15,180 to 18,200	9.09 to 10.59	7.22 to 40.24	~40%	30.13 to 37.05
Rest of world (max)	Up to 4,820	Up to 2.41	9.63	~40	Up to 9.28
Total					Up to 39.42

According to the scenario the worldwide annual agricultural production costs would increase by approximately 30 to 40 million USD if endosulfan would be replaced by chemical alternatives. The scenario would be related to an estimated decrease of the net cash return of 1.7%.[43]

However, the scenario is based on deficient information due to specific aspects it is questionable to what degree relevant economic impacts will occur. Endosulfan is mainly used on 4 crops: Soy, rice, cotton and tea. For one of these examples – cotton – comparative good data is available. As discussed above significant impacts on pesticide costs are not expected for cotton. It has been shown that appropriate alternatives are available and a reasonable selection of alternatives let expect that no substantial cost impacts will occur. Accordingly the US EPA concluded in 2009 that “there will be minimal impacts on cotton producers that are not likely to exceed 1% of net operating revenue if endosulfan is not available” [PAN & IPEN 2010]. The authors of the present document expect that also in other regions no substantial economic impacts may occur for cotton if endosulfan would be replaced by a reasonable selection of chemical alternatives.

A precise assessment for the other main uses (soy, rice, tea) is not possible on the basis of the identified information. For soy and tea no relevant information is available. For rice it has been stated that in Sri Lanka there were no sudden changes in costs of rice production coinciding with the bans of endosulfan, methamidophos and monocrotophos ([Manuweera 2008], [PAN & IPEN 2010]).

However, a wide range of alternatives has been identified for current uses of endosulfan (see chapter 2.3.1.1). In total, information on approximately 90 chemical alternatives has been identified and it can be expected that a reasonable selection of available chemical alternatives would allow the replacement of endosulfan also for all other uses without relevant negative economic impacts.

Conclusion cost impacts chemical alternatives

Considering that yields and prices remain stable and regarding the above scenario of 40% pesticide cost increase in a worst case scenario, the annual cost impacts due to the replacement of endosulfan are expected to range from 0 to 40 million USD.

Costs related to non-chemical alternatives

Non-chemical alternatives are semio-chemicals, biological control systems, as well as agro-ecological practices such as integrated pest management (IPM), organic farming and other specific agricultural practices. These non-chemical alternatives are applied in practice in IPM systems (where the use of synthetic pesticides is the last resort), organic farming systems (where the use of synthetic pesticides is prohibited) and in any other farming systems where the use of endosulfan is not allowed (e.g. in those countries where the use of endosulfan is banned).

The information available on cost impacts under such conditions is the following:

[43] The impact on net cash return is related to significant uncertainties due to rapid changes in net cash returns. For example in the USA the net cash return for soybeans increased from 2007 to 2008 from 58.26 to 110.32 USD/ha; for rice the coresponding increase was from 42.15 to 449.69 USD/ha.

Impact on yields and production costs

A three year IPM programe in Senegal, Mali and Burkina Faso started in 2001. The first results of the IPM impact assessment shows significant improvements in reducing costs, increasing the yields and quality of products on large number of sites [PAN & IPEN 2010 Ref 2].

An IPM programme on cotton in the Vélingara county (Senegal) including 583 producers were trained in the IPM methodology. The training programme was followed by pilot activities to apply IPM on the field in 2007. Producers obtained large yields without using chemical pesticides. Instead they used a variety of method and products including solutions of neem, African dry zone mahogany, and pepper. Yields ranged from 1,120 kg/ha to 2,660 kg/ha, compared to the average 1,200 kg/ha in the previous year [PAN & IPEN 2010 Ref 2].

In India replacement of endosulfan use in cotton with non-pesticide management methods has significantly reduced production costs without only minor reduction of yields and have significantly increased incomes for farmers. An economic comparison of conventional versus non-chemical pest management showed that pesticide costs decreased in a range between 80 and 90% (for cotton, chilli, red gram, groundnut, castor and rice). Production cost for cotton decreased by approximately 43%, yield decreased by 17% and the net income increased by 44% (Annex F 2010, PAN & IPEN Ref 1).

In Sri Lanka there were no sudden changes in costs of rice production coinciding with the bans of endosulfan, methamidophos and monocrotophos ([Manuweera 2008], [PAN & IPEN 2010]).

Detailed research in 2003 and 2004 in India demonstrated that organic cotton farming can be far more profitable than conventional cotton farming using endosulfan, with gross margins about 30-52% higher than the conventional production. Revenues from organic cotton sales were about 30% higher than conventional cotton [PAN & IPEN 2010]). Due to slightly higher cotton yields, a 20% price premium and lower production costs , gross margins are significantly higer in organic production. Gross margins from organic cotton fields were 43 and 30% higer compared to conventional fields in 2003 and 2004 respecitvely. Even without price premium in organic cotton, filed gross margins would have been 15% higher in 2003 and 4% higher in 2004. Even without price premium, conversion to organic farming in the long term increases the profibilty of cotton cultivation. [Eyhorn 2007].

In the state of Andra Pradesh, one of India’s major producers of cotton, rice, groundnut and lentils and where endosulfan is widely used on a number of crops, more than 300,000 farmers have adopted ‘Community Managed Sustainable Agriculture’ (CMSA) on 1.36 million acres of farmland. This represents 5.1% of the cropped area in the state and this has been achieved in just over four years. Crops grown include chilli, groundnut, red gram, cotton, rice, maize, onion, beans, okra, and eggplant. Endosulfan and other synthetic chemical pesticides and fertilisers have been replaced with a combination of physical and biological measures including IPM practices, neem, pheromone traps, soil inoculation with Azospirillum and Azotobacter, vermiculture, green manure crops, and intercropping. Results reported by the World Bank show “a significant net increase in farmers’ incomes in addition to significant health and ecological benefits”, without “significantly reducing the productivity and yields”. The yields are the same for chilli and groundnut, slightly higher for red gram and slightly lower for cotton and rice, as compared with conventional farming [PAN & IPEN 2010 Ref 4]:

A survey of 141 of the CMSA farmers found the costs of cultivation to be only 33 % of the costs under conventional production. A state-wide survey found these farmers are making the following average savings on the cost of cultivation, per acre, per year: rice = USD 20; chilli = USD 300; cotton = USD 100; groundnut = USD 16; red gram = USD 24, others (fruit, vegetables, cereals) = USD 20.

Based on the savings made by individual farmers, the state-wide estimate of cumulative savings made by farmers practising CMSA is USD 38.6 million for the year 2008-09. The authors of this World Bank report stated that “there is a potential for scaling up this approach to the whole of India as CMSA is showing trends of being economically viable and ecologically friendly. The newly set up National Mission on Sustainable Agriculture in India is considering adopting CMSA as one of the key strategies at the national level” ([PAN & IPEN 2010 Ref 4], [PAN & IPEN 2010].

Impact on prices

If endosulfan is replaced and conventional farming systems are converted to organic farming systems significant price premiums for agricultural products can be obtained. Price premiums on organic cotton in an Indian example in 2003 and 2004 were 20% [Eyhorn 2007]. Also in India, price premiums for organically produced agriculture products ranged from 10 to 100%.[44] Price premium for organic farming on the world market is 35 to 100% [IJF 2005]. Price premiums for organic products in the USA amount to 20% [USDA 2005]. Farmer price premiums for organic farming products in the EU range from 20 to 257% [FIBL 2005].

Non-quantified price premiums are also possible for certified integrated farming systems.[45]

[44] http://www.fao.org/docrep/article/agrippa/658_en-06.htm

[45] See for example http://www.pan-uk.org/pestnews/Issue/Pn32/pn32p9.htm

Conclusion cost impacts non-chemical alternative

It can be expected that non-chemical alternatives will significantly change production costs at slightly decreased, stable or slightly increased yields. Moreover non-chemical alternatives enable in specific cases (particularly in organic farming systems) to obtain higher product prices due to price premiums payed for organic products. The use of non-chemical alternatives let therefore expect significant, non-quantified economic benefits.

Useful further information has been provided by parties and observers in the Annex F information submitted in 2010:

Australia reports that for use in cotton, endosulfan costs about 12.5 USD/ha to control Helicoverpa spp., Green Vegetable Bug and Cotton Aphid. Chemical alternatives are more expensive and range between 18 and 40 USD/ha. Environmental and health costs are unknown at this stage [Australia 2010]. Non chemical alternatives are not considered.

Brazil notes that regarding environmental hazard, most formulations based on endosulfan are considered class 1 – highly dangerous. The possible alternatives range between classes 2 (very dangerous) and 3 (dangerous), whereas the combination (Thiametoxam + Lambda cyhalotrin) was also considered class 1, highly dangerous [Brazil 2010].

Brazil states if endosulfan will not be available for use, will be need to use other products and is possible that these products will cost more per area of farmland, and is possible which will increase the prices of food and other agricultural products, too [Brazil 2010]. Non chemical alternatives are not considered.

In Canada modern re-assessments of the human health and environmental risks of several possible alternative chemicals are underway or scheduled. Canada has provided an analysis of benefit costs of restricting endosulfan use on strawberries. In the analysis the use of endosulfan is restricted in two scenarios to one or two applications of endosulfan (i.e. to 1 or 2 kg endosulfan/ha). A scenario with a complete ban of endosulfan was not considered. The restriction according to the two scenarios resulted in estimated decreased net cash returns ranging from 6.2 to 15.2 % per hectare (For details see [Canada 2010], [UNECE 2010 CA]). Non chemical alternatives are not considered.

India has provided information on costs for chemical alternatives to endosulfan. According to this information the costs for using endosulfan as a broad spectrum insecticide is 3.8 USD/ha/spray. The corresponding costs for using specific alternatives ranges from 4 to 40 USD/ha/spray. Furthermore, India states that replacement of endosulfan by other chemicals becomes expensive considering the unique pest control properties of endosulfan [India 2010]. Non chemical alternatives are not considered.

The USA states that the type and magnitude of costs depend on pests, production systems, and availability of alternatives and that types of costs could include (1) direct costs to agricultural producers in terms of more costly alternatives and/or decrease in quantity or quality of output and (2) indirect costs to consumers of agricultural products in terms of reduced availability and high prices. Concerning possible environmental or health costs the USA states that in some situations, multiple alternative insecticides may be needed to replace endosulfan.

According to PAN & IPEN, implementing substitutes for endosulfan has been found to result in either very small increases in costs (e.g. 0–1% changes in net revenue in US tomato production, [U.S.EPA 2009 G]) no additional costs, projected reductions in costs, or increases in income for farmers. The U.S EPA, however, has not found cases where increases in farm income would be expected.[46]

In addition to the answers by parties and observers related to alternatives and costs in Annex F, section B(iii), several pieces of information have been provided in other context that could be relevant for the socio-economic evaluation of alternatives:

Endosulfan is a broad spectrum insecticide and acaricide, IPM tool, multi crop product, excellent crop tolerance (non phytotoxic), harmless to natural enemy of crop pests, resistant management tools (IRM) due to its unique mode of action and cost effective (USD-3.8/ha/spray) plant protection chemical. Considering these properties of endosulfan, there is no cost effective alternatives of endosulfan in India. Other alternatives of endosulfan are narrow spectrum. Cost per hectare per spray of those alternatives are as follows: imidacloprid (USD-4.0), neem base pesticide (USD-6.0), spinosad (USD-40)), acetamiprid (USD-6.0), buprofezin (USD-15.0), novaluron (USD-35) indoxacarb (USD-25.0), flubendiamide (USD-30.0), thiomethoxam(USD-10.0), emamectinbenzoate(USD-20.0) chlorantraniloprole (USD 40) [India 2010].

The US Environmental Protection Agency (EPA) concluded in 2009 that “there will be minimal impacts on cotton producers that are not likely to exceed 1% of net operating revenue if endosulfan is not available” [PAN & IPEN 2010].

The US EPA noted, in 2009, that alternative chemicals exist for most endosulfan uses, and estimated that should endosulfan become unavailable, the financial impacts on farmers would generally be small. Specifically US EPA concluded that [PAN & IPEN 2010].

a) Switching to alternatives would result in “little impact” on production costs for potatoes; [U.S.EPA 2009 B]

b) Switching to alternatives would result in “generally minor” impacts on cucumber growers, and noted that

[46] Comment from US EPA on second draft of the risk management evaluation.

"[equally] efficacious and affordable alternative exist" for the niche use in Florida against whiteflies; [U.S.EPA 2009 C]

c) For watermelons and cantaloupe producers "[t]here are alternatives to endosulfan, which according to published efficacy data, can control the pest spectrum as well as endosulfan"; [U.S.EPA 2009 D]

d) For pumpkin growers "[t]here are at least two alternatives which control the same pest spectrum as endosulfan but have slightly higher cost per acre"; [U.S.EPA 2009 E]

e) "The overall benefits of endosulfan on squash are generally minor" and "available data indicates that efficacious and affordable alternatives exist" for the niche use on squash in Florida against whiteflies; [U.S.EPA 2009 F]

f) According to the EPA "effective chemical alternatives are available, although some are more expensive" for fresh tomato producers". [U.S.EPA 2009 G].

Production costs (of tomatoes) were estimated to change by 0 to 8 USD per acre, amounting to 0–1% changes in net revenue. US EPA thus anticipated "little to no economic impact" if farmers were forced to switch to these chemicals. However, the extensive use of endosulfan may indicate a value of endosulfan to producers that could not be quantified [U.S.EPA 2009 G]. An earlier analysis by US EPA had yielded similar results: losses of 0.02 to 0.7% of the total value of production ([U.S.EPA 2002 B], [PAN & IPEN 2010].

US EPA notes that there are non-chemical practices that may target many of endosulfan's current uses. For cucumbers US EPA noted that a spring planting should reduce pickleworm populations and trap crops can also help [PAN & IPEN 2010].

US EPA identified a number of non-chemical pracitces for the main pests that endosulfan is used against in Florida tomato production, though they did not consider them to be viable stand-alone alternatives to endosulfan.

According to an impact assessment carried out for France, endosulfan could be replaced without additional production costs and without additional environmental impact due to the availability of appropriate chemicals at no or only low additional cost ([UNECE 2010 FR] and [INERIS 2006]).

Malaysia has provided a comparison of costs for recommended alternatives to endosulfan and concludes that there are some negative cost implications related to the use of alternatives [Malaysia 2010].

Efficacy

Efficacy is how well the alternative performs in a particular functionality including any potential limitations (UNEP/POPS/POPRC.5/6). In pest control, efficacy can therefore be considered as how well the alternative performs in a particular crop-pest complex including any potential limitations. However, not only limitations but also benefits should be considered in the evaluation.

An important question is whether alternatives are equally efficient compared to endosulfan. A review of scientific literature related to the efficiency of 46 identified chemical alternatives to endosulfan has shown that out of 78 scientific papers the alternative was in 152 cases more efficient, in 18 cases equally efficient and in 68 cases less efficient than endosulfan. In 4 cases a conclusion was not possible. In 9 cases development of resistance was reported (pest: Helicoverpa armigera). In 7 cases the pest developed stronger resistance against the alternatives (cypermethrin, chlorpyriphos, profenophos, methomyl, carbaryl, thiodicarb) than against endosulfan. In 1 case the pest developed slightly stronger resistance against endosulfan than against the alternative (quinalphos). In 1 case (spinosad) a conclusion was not possible. The results of the literature review are documented in Annex II to the present document. An overview of the results is provided in Annex II, Table 13.

Against this background it can be expected that in most cases chemical alternatives will be more efficient than endosulfan. Considering the whole spectrum of chemical and non-chemical alternatives it can be assumed that endosulfan can in most cases be substituted by equally or more efficient alternatives. In specific cases development of resistance may become a problem. However, in the case of Helicoverpa armigera there seems to be at least one more efficient alternative chemical substance concerning resistance (quinalphos), as well as a number of non-chemical methods of control. Generally it seems noteworthy that local producers may have important knowledge about their production systems that may not be available to analysts in other locations.

Furthermore, many examples under different geographical conditions and for different crops demonstrate the efficacy of the alternatives to endosulfan because yields are maintained or increased also after the widespread use of alternatives.

However, according to some countries/observers the efficacy of alternatives is limited due to specific advantages of endosulfan. Advantages that are particularly brought forward as arguments for endosulfan are (a) safety to natural enemies of pests, appropriateness (b) for integrated pest management, (c) for pollinator management, (d) for insecticide resistance management. Furthermore it is stated that (e) for critical uses alternatives would not be available and (f) endosulfan may have to be replaced by several alternatives instead of one. Other information sources contradict these arguments and bring the same arguments forward as advantages of safer alternative chemicals and practices which would be available for all known uses and geographical situations.

Benefits and limitations related to the efficacy of alternatives could therefore be:

a) Safety to natural enemies of pests

b) Safety to pollinators and appropriateness for pollinator management (in particular bee toxicity)

c) Appropriateness for use in IPM systems

d) Insecticide resistance management

e) Appropriateness for critical uses

f) Need for several chemical alternatives instead of one substance

Safety to natural enemies of pests; Appropriateness for pollinator management

According to information provided according to Annex F (from Australia, Brazil, India and ISC) endosulfan is safe to beneficial insects of agro-ecosystems and has relatively low toxicity to bees. According to PAN & IPEN endosulfan is toxic to bees. Accordingly endosulfan products in Canada and the USA are labeled correspondingly. According to PAN & IPEN endosulfan is also toxic to several other beneficial insects.

It can be assumed that in general a thorough selection of target specific pest control actions (including non-chemical alternatives) adjusted to the individual situation will have less negative impacts on beneficial organisms than the use of the broad spectrum endosulfan.

Appropriateness for use in IPM systems

In IPM systems chemicals used shall be as target specific as possible and shall have the least side effects on human health, non-target organisms and the environment. However IPM systems include critically selected plant protection products that should be available to the grower despite certain negative aspects (especially for reasons of resistance management or earmarked for exceptionally difficult cases). These products should have a short persistence and are permitted only for precisely identified indications with clearly defined restrictions [IOBC 2004]. As a consequence, in IPM systems endosulfan as a chemical alternative should be considered only as a last resort if all non-chemical alternatives fail. Furthermore, between chemical alternatives those with a narrow spectrum (which let expect the lowest side effects) and with a short persistence should be preferred.[47] In order to evaluate the appropriateness for IPM systems, the side effects of alternatives to beneficial organisms and their persistence have to be identified and assessed.

According to information provided according to Annex F (e.g. from Brazil, India and ISC) endosulfan is particular appropriate for IPM because endosulfan is a broad spectrum insecticide, less toxic to several useful insect parasites, predators and pollinators. The importance of endosulfan as part of an IPM is the lack of resistance on the part of pests to it. According to PAN & IPEN endosulfan is toxic to several other beneficial insects and is therefore incompatible for IPM systems.

The information provided is therefore contradictory. However, considering that in IPM systems chemical alternatives should (1) be as target specific as possible, (2) have a narrow spectrum and should (3) not be persistent, it can be concluded that endosulfan (not target specific, broad spectrum, persistant) is comparatively inappropriate for use in IPM systems.

Appropriateness for insecticide resistance management

According to Annex F information (e.g. Australia, Brazil, China, India, ISC) endosulfan is particularly appropriate for insecticide resistance management. Due to its particular pest spectrum and mode of action endosulfan would allow it to provide effective control of a range of important chewing and sucking pests without generating resistance. Loss of endosulfan would reduce the number of different chemical modes of action available and could result in quicker resistance build up in pests.

According to PAN & IPEN a significant number of pests are now resistant to endosulfan. For cotton the US EPA concluded, that the current role of endosulfan in resistance management is minimal.

The information provided indicates that the value of endosulfan in insecticide resistance mangagment is dependent on the specific situation. The results of a review of scientific literature indicate that development of resistance may become relevant in specific cases. However specific additional information identified so far on the development of resistance concerns one specific pest (Helicoverpa armigera) where at least one more efficient alternative chemical substance

[47] Endosulfan is persistent and should therefore be considered less appropriate for IPM systems.

concerning resistance (quinalphos) seems to be available. This allows concluding that the occurrence of resistance may also be managed with available (chemical) alternatives.

Critical uses

Several countries report on critical uses (see chapter 2.2.2). However, the current ban of endosulfan in more than 60 countries is a strong indication that economically viable alternatives are available. The use of endosulfan can be replaced by a huge number of chemical, biological and cultural alternatives. These are available for a wide range of crop-pest complexes and it appears that for each specific crop-pest complex an appropriate combination of chemical, biological and cultural control action can be taken. Statements that alternatives are not available for specific crop-pest complexes may be based on considerations that are focused on chemical alternatives (sometimes on those that are already registered within a specific country) and do not consider non-chemical control measures appropriately. In specific cases promising research on semio-chemicals is ongoing and may be used in the foreseeable future.

India describes specific advantages of endosulfan that cannot be achieved by cost effective chemical alternatives in all situations. Specific advantages would be for example safety of endosulfan to natural enemies of pests, appropriateness for integrated pest management, appropriateness for pollinator management, appropriateness in case of insecticide resistance [India 2010 Annexure-I]. Non-chemical alternatives were not considered.

ISC describes the importance of endosulfan in some major applications, i.e. in cotton, cane sugar, coffee and hazelnuts ([ISC 2010], see chapter 2.2.2]).

Need for several chemical alternatives instead of one substance

Several countries report on critical uses (see chapter 2.2.2). However, the current ban of endosulfan in more than 60 countries is a strong indication that economically viable alternatives are available. The use of endosulfan can be replaced by a huge number of chemical, biological and cultural alternatives. These are available for a wide range of crop-pest complexes and it appears that for each specific crop-pest complex an appropriate combination of chemical, biological and cultural control action can be taken. Statements that alternatives are not available for specific crop-pest complexes may be based on considerations that are focused on chemical alternatives (sometimes on those that are already registered within a specific country) and do not consider non-chemical control measures appropriately. In specific cases promising research on semio-chemicals is ongoing and may be used in the foreseeable future.

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ISC describes the importance of endosulfan in some major applications, i.e. in cotton, cane sugar, coffee and hazelnuts ([ISC 2010], see chapter 2.2.2]).

Bacillus thuringiensis is widely used in place of endosulfan in Costa Rica and Cuba, to control lepidopteran pests on a range of vegetable crops, tobacco and in forestry [PAN & IPEN 2009 Ref 9]. The Community Managed Sustainable Agriculture practiced in 5.1% of the cropped area of Andra Pradesh, India, is achieving “a significant net increase in farmers’ incomes in addition to significant health and ecological benefits”, without “significantly reducing the productivity and yields”. The yields are the same for chilli and groundnut, slightly higher for red gram and slightly lower for cotton and rice, as compared with conventional farming. Here, it is not only endosulfan that has been replaced by alternatives but also all other synthetic chemical pesticides ([PAN & IPEN 2010 Ref 4], [PAN & IPEN 2010]).

According to ISC endosulfan provides excellent efficacy due to its characteristic of being a broad spectrum insecticide, its excellent efficacy and selectivity to natural enemies, the lack of resistance of insects to it and its lack of adverse impact on pollinating insects including the honey bee. In addition to these characteristics it is a product of choice because of its lower cost of treatment than products being sold for the same purposes. All of these factors work together to provide: an economic food supply to the population and economic benefit to the grower and the countries in which it is used [ISC 2010].

According to ISC, endosulfan as a broad spectrum insecticide brings the benefit of a reduction in the number of pesticides and applications necessary to combat target pests resulting in an overall lessening of the amount of pesticides released into the environment [ISC 2010].

According to ISC the efficacy of endosulfan has remained constant and the target insects have not built a tolerance for it, consequently it is valued as an important tool for use in resistance management. One of the most important aspects of endosulfan in agriculture is that it serves as an alternative to other pesticides which suffer from the development of resistance by the target insects. Newer products such as neonicitinoids and pyrethroids need to be sprayed more frequently and are becoming less effective and showing more insect resistance. It is common knowledge that products in the same chemical group can not be used in isolation against a particular pest for an extended period because insects will develop resistance to the products. Continued application of these pesticides requires increased doses due to the gradual reduction in efficacy each season, until it is completely ineffective. Insects do not build a resistance to endosulfan [ISC 2010].

According to ISC endosulfan is appropriate for IPM systems due to the following reasoning: In order to avoid the development of resistance and maintain the effectiveness of the pesticides, the farmer must vary the type pesticide used. This is an integral part of a system known as Integrated Pest Management (IPM). This provides a more efficient control of agricultural pests, which results in improved economy for the producer and consumer and protection of the environment. It is essential that the products constituting the IPM for a given application prevent the development of resistance, have high efficiency and low cost in order to maintain profitability for the grower and reasonable prices for the consumer. The importance of endosulfan as part of an IPM is the lack of resistance on the part of pests to it. From 1914 until 2008 there have been more than eight thousand cases of resistance to insecticides in the world, none of which includes endosulfan. Endosulfan is an indispensable product of the IPM for soybean, sugar cane, cotton and coffee and sunflower [ISC 2010]. According to ISC, in the 2002 RED, the USEPA states “Resistance, which has been observed in other crops, hinders control with another pyrethroid application, the usual method of treatment, and would require use of potentially harsher alternatives.” Should endosulfan not be available for use, the need to use increased volumes as insects’ resistance builds to the replacement products will result in exposing the environment to a greater chemical burden.

According to ISC, endosulfan is not harmful to the indispensible beneficial insects including honey bees, bumble bees and beetles. The United States Environmental Protection Agency (EPA) states in its Re-registration Eligibility Decision (RED) document of 2002 that “Endosulfan is an important resistance management tool and is an important element of integrated pest management programs in some areas especially considering its relatively low impacts on bees.” This is in contrast to many of the other pesticides used to combat the same target pests including neonicotinoides, pyrethroids, and organic phosphates, which are toxic to honeybees [ISC 2010].

Risk

Alternatives should be safer than the currently used endosulfan. For an evaluation of the safety of alternatives, a risk profile for the chemicals under consideration should be developed. As this might be difficult if there is a lack of information on hazard properties or exposure data, a simple analysis of risk should be performed, taking into consideration the weight of available evidence. It should first be confirmed that the alternatives do not have POPs properties and thus should not meet the screening criteria of Annex D of the Stockholm Convention (persistence, bioaccumulation, potential for long-range transport, and adverse effects).. Pollinator management is a relevant issue if endosulfan will be replaced by alternatives. Therefore, as additional information with particular relevance for the risk of alternatives for endosulfan, information on the safety of the alternatives for pollinators (i.e. particularly for bees) is relevant. As a consequence bee toxicity should be considered when assessing the safety of alternatives to endosulfan.

Furthermore, the alternative should not possess hazardous properties such as mutagenicity, carcinogenicity, reproductive and developmental toxicity, endocrine disruption, immune suppression, neurotoxicity. Consideration should also be given to the exposure situation under actual conditions of use by workers, farmers and consumers. For further guidance see "General guidance on considerations related to alternatives and substitutes for listed persistent organic pollutants and candidate chemicals" [UNEP/POPS/POPRC.5/10/Add.1].

Given the multitude of available alternatives a comprehensive assessment of possible risks related to alternatives is difficult. Risks are possible as a result of the exposure to hazardous alternatives. For a screening assessment of the possible risks related to the identified chemical alternatives, available information on a set of hazard indicators (i.e. on the POP properties and the hazardous properties as mentioned above) has been compiled. On the basis of the compilation it is possible to evaluate the possible risks related to the identified alternatives and to indicate priorities for more and less appropriate alternatives (concerning their possible risks to environment and health) and to identify alternatives for which information on hazard indicators is lacking. The results of a screening assessment of the alternatives can be found in Annex III to the present document.

On the basis of the results of this screening risk assessment it can be expected that if endosulfan would not be available for plant protection it would be replaceable by safer chemical alternatives. A clear conclusion whether chemical alternatives to endosulfan are more or less toxic to bees is not possible on the basis of the present information (45 of the alternatives are toxic to bees, 28 are not toxic to bees, for 13 no information on bee toxicity has been identified). However, the range of toxicity to bees among possible chemical alternatives indicates that in many situations it may be possible to replace endosulfan by chemical alternatives with no or lower bee toxicity. It has to be noted that the screening assessment only concerns chemical alternatives. Non-chemical alternatives are generally related to no or lower risks compared to endosulfan.

Concerning risks of alternatives several parties stated that for the alternatives registered within a country risk assessments were conducted and risks are known within the country of use [Australia 2010] [India 2010] [Switzerland 2010] [USA 2010].

According to Australia it was furthermore stated that implementing control measures could further reduce the risk of endosulfan residues in beef when cattle consume stock feed or pastures. However, the results of random monitoring by the National Residue Survey (NRS) indicate the level of risk involved is already low [Australia 2010].

According to China, as endosulfan is effective in pest prevention and control in cotton planting and rational use of the substance poses no safety risk to humans, its application risk is acceptable [China 2010].

According to Malaysia, generally the alternatives are less toxic to humans and less persistent in the environment [Malaysia 2010].

According to PAN & IPEN, considerable adverse human effects have been caused by exposure to endosulfan. Numerous intentional and unintentional deaths have occurred from ingestion of endosulfan, and poisonings have been reported in many countries. Endosulfan is globally regarded as one of the main causes of poisoning. Many of the deaths from endosulfan have resulted from occupational exposure. Elimination of endosulfan production and use would positively impact human health by reducing and eliminating the contribution of endosulfan to these types of health impacts (for details and specific references see [PAN & IPEN 2010]).

According to ISC, endosulfan has been used for more than 50 years as a pesticide with minimal impact on the health of workers, the public or the environment. Many studies have been conducted such that the hazard characteristics of endosulfan are well documented. Many of these studies may be found on the POPs website. The risk of using endosulfan has been well studied and acceptable tolerances (Minimum Residue Levels) have been established by national regulatory authorities as well as the World Health Organization. On the other hand the consequences of using the newer products have not been fully determined. The risk of the use of endosulfan has been evaluated by the governments with registration processes and its application specific registration prescribes risk mitigation steps which make the use of endosulfan in these countries acceptable from a human health and environmental standpoint [ISC 2010].

Availability

Availability is the extent to which an alternative is on the market or simply ready for immediate use (UNEP/POPS/POPRC.5/6). It is vital to consider the availability of all (chemical and non-chemical) alternatives.

Parties and observers stated that registered products are generally available on the market in both developed and developing countries. India stated that (chemical) alternatives are expensive ([Australia 2010] [Brazil 2010] [Bulgaria 2010] [India 2010] [Malaysia 2010] [Switzerland 2010] [Togo 2010] [USA 2010]).

PAN & IPEN state that the alternatives are on the market and ready for immediate use in many countries, including developing and transition countries [PAN & IPEN 2010].

Accessibility

Accessibility refers to whether an alternative can be used considering geographic, legal or other limitations (UNEP/POPS/POPRC.5/6). It is vital to consider the accessibility of all (chemical and non-chemical) alternatives.

Accessibility to chemical alternatives may be limited because the alternatives are currently not registered. This does not mean that they are not available and the problem could be overcome in foreseeable time if alternatives could be registered for the relevant crop-pest combinations. However, the situation of registering minor uses for pesticides is complex as there could be significantly more chemicals registered for many uses only if expensive data packages were developed for those combinations. The time required to do this could be significant.

The accessibility of both registered and permitted alternatives is governed by the conditions of use specified on the label of each product. Although alternatives may be available, it takes some time for new products to be registered/approved, especially for new chemistry products and for use on minor crops [Australia 2010].

In countries where pesticide products are prohibited unless permitted, and where endosulfan continues to be used but several alternatives have been withdrawn, the process of developing alternative pest control products and conducting the necessary risk assessments to allow their registration will probably be lengthy, consultative, and unpredictable. In Canada, these activities could include consulting growers on a transition strategy, registering minor uses on pre-registered active ingredients and registering new active ingredients.[48]

Since 2007, China has banned the use of five highly toxic organophosphorus pesticides: methamidophos, methyl parathion, parathion, monocrotophos, and phosphamidon. As a result, these chemical alternatives are not accessible in China [China 2010].

According to India high costs limit the accessibility (to chemical) alternatives [India 2010].

Other countries and PAN & IPEN state that alternatives are accessible ([Malaysia 2010] [Switzerland 2010] [Togo 2010] [USA 2010] [PAN & IPEN 2010]).

[48] Additional information provided by Canada in their comments on the second draft risk management evaluation.

PAN & IPEN state furthermore that the alternatives are widely accessible, and especially in developing countries including Burkina Faso, Cape Verde, Chad, Gambia, Guinea Bissau, Mali, Mauritania, Niger and Senegal, Argentina, Bolivia, Brazil, Chile, China, Costa Rica, Cuba, India, Mexico, Paraguay, Sri Lanka, and Uruguay, as appropriate.

Summary of information on impacts on society of implementing possible control measures

Concerning the summary on information on impacts on society of implementing possible control measures, several parties reported information that is relevant for other issues such as risks, accessibility, efficacy and costs of alternatives. This information is considered in the corresponding chapters related to alternatives.

Health

POPRC concluded that endosulfan is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and environmental effects. Several parties and observers state that the current use of endosulfan gives rise to adverse health and environmental effects and expect that the control of endosulfan will positively impact health and the environment. Others do not expect adverse effects or are in the state of evaluating the risks.

Useful information has been provided by parties and observers in the Annex F information submitted in 2010:

Australia's Department of the Environment, Water, Heritage and the Arts is finalising a review for the APVMA of the environmental risks posed by the continuing use of endosulfan in Australia. The results of this review are not yet available [Australia 2010].

Brazil provided information on adverse effects of endosulfan and concludes that endosulfan presents unacceptable acute and chronic risks for the whole population. The adverse effects associated with endosulfan human exposure are basically genotoxicity, reproductive and embryo fetal development toxicity, neurotoxicity, immunotoxicity and also endocrine disruption [Brazil 2010].

Costa Rica has provided information on numerous studies evidencing the contamination of several water resources [Costa Rica 2010]. According to Costa Rica, the prohibition of endosulfan would stop the contamination of water resources for human consumptions and would improve the environmental health of ecosystems such as cloud forests where the substance is not applied but transported. Furthermore, the occupational health of farm workers would be improved [Costa Rica 2010].

India states that registered pesticides do not cause any health hazards [India 2010].

Madagascar states that the use of alternatives to endosulfan would lead to a risk reduction of workers health and health of neighbouring population (reduction of presence of residues in water and other vegetable products) [Madagascar 2010].

According to Malaysia, exposure to applicators has been removed completely since the effective date of the ban of endosulfan, thus, its release to the environment has been avoided except for illegal use [Malaysia 2010].

The USA expect likely positive environmental and health impacts; however, control measures could require use of multiple alternative insecticides in some cases [USA 2010].

PAN & IPEN state that considerable adverse human effects have been caused by exposure to endosulfan. According to PAN & IPEN numerous intentional and unintentional deaths have occurred due to endosulfan poisonings. Endosulfan is one of the most frequently reported causes of poisoning globally. Many of the deaths from endosulfan have resulted from occupational exposure. There were observations of similar effects in animals (including domestic animals, honeybees, frogs and birds. Elimination of endosulfan production and use would positively impact human health by reducing and eliminating the contribution of endosulfan to these types of health impacts [PAN & IPEN 2010].

Agriculture, aquaculture and forestry

Several countries where endosulfan is currently used expect increased costs for agricultural production if endosulfan will not be available for use due to reduced control of pests and/or increased plant protection costs. Possible cost impacts are not quantified. According to other opinion the use of alternatives will have beneficial cost impacts on agricultural production particularly due to higher safety for beneficial organisms, reduced costs and improved incomes for farmers.

Possible annual cost impacts on agriculture are estimated to be up to 40 million USD if endosulfan will be replaced by chemical and non-chemical alternatives. The replacement with chemical alternatives could have negative impacts amounting up to 40 million USD. The replacement with non-chemical alternatives could have significant positive economic impacts. The overall economic impact on agriculture would be a consequence of all chemical and non-chemical replacement strategies that would be put into practice if endosulfan would not be available anymore. This overall impact is not quantified.

Australia cites specific critical uses and states that loss of endosulfan could mean loss of control and economic loss for some growers [Australia 2010].

Brazil explains that for specific crops and pests the use of endosulfan is regarded as indispensible and that, if endosulfan will not be available for use, there will be need to use other products and it is possible that these products will cost more per area of farmland, which will increase the prices of food and other agricultural products [Brazil 2010].

China as an agricultural country with a large territory and a variety of pests states that if endosulfan would be banned, agricultural production will surely be affected by the shortage of pesticides available or high costs for alternatives [China 2010].

Costa Rica states that the prohibition of endosulfan for agricultural use would have positive impacts on neighbouring agriculture e.g. shrimps or fish cultivation and will lead to decreased mortalities or accumulative chronic effects in aquatic organisms [Costa Rica 2010].

According to India, if endosulfan is not available for use in India, the need to use other insecticides would result in greater plant protection costs [India 2010].

Japan expects positive effects due to the possibility of the reduction of damage in fish [Japan 2010].

According to Malaysia there is no complaint from the users although the alternatives may have higher prices [Malaysia 2010].

The USA state that there may be negative impacts on agriculture (crops and livestock). The magnitude of impacts depends on the control measure(s) taken [USA 2010].

PAN & IPEN conclude that eliminating endosulfan from agriculture and substituting safer alternatives, especially agroecological practices, would have a positive impact on agricultural production. This conclusion is related to detailed explanations concerning the efficacy of endosulfan and of alternatives concerning impacts on bees, other beneficial insects (such as Trichogramma pretiosum, Oriosus insidiosus, Aphidius colemani, Geocoris punctipes, Phytoseiulus persimilis, Chrysoperla externa, Araneus pratensis, Verticilium lecanii) and other beneficial soil organisms (such as earthworms, actinomycetes, small soil invertebrates, mites and springtails) [PAN & IPEN 2010].

Furthermore PAN & IPEN state that the role of endosulfan in resistance management is minimal and that the loss of endosulfan would not result in adverse resistance management outcomes. It is stated that a significant number of pests have developed resistance to endosulfan (in at least 28 pests affecting at least 22 crops) [PAN & IPEN 2010].

Biota (biodiversity)

Some parties and observers expect positive impacts on biodiversity if the use of endosulfan is restricted. However it is noted that multiple chemical alternative insecticides may be required in certain cases which may have some associated negative impacts on biodiversity. On the other hand it needs to be stressed that non-chemical alternatives avoid these problems.

Useful information has been provided by parties and observers in the Annex F information submitted in 2010:

Australia's Department of the Environment, Water, Heritage and the Arts is finalising a review for the APVMA of the environmental risks posed by the continuing use of endosulfan in Australia. The results of this review are not yet available [Australia 2010].

Costa Rica expects that biota in general would be less exposed to persistent organic compounds with possible positive impacts on natural populations and biodiversity [Costa Rica 2010].

The USA expect positive impacts on biota; however, the magnitude of impact will depend on the specific control measures taken. Also, multiple alternative insecticides may be required in certain cases which may have some associated negative impacts [USA 2010].

PAN & IPEN state that endosulfan is a broad spectrum insecticide with toxic effects on all classes of biota. Its toxicity to insects is likely to lead to reduced arthropod biodiversity in areas where it is used. The elimination of endosulfan, and its replacement with less toxic products and management methods, will have a positive effect on biota and biodiversity [PAN & IPEN 2010].

Economic aspects

Several countries where endosulfan is currently used expect negative economic impacts for agricultural production if endosulfan will not be available (see chapter 2.4.2). Time and cost required to register suitable alternatives are not quantified. Positive economic impacts can be expected because of the substitution of alternatives for endosulfan includes the savings made on health and environmental costs resulting from exposure to endosulfan, and improved incomes for those no longer using endosulfan. According to the cost impact assessment one time costs for implementation (realistic estimate: below 1.65 million USD), annual costs for agriculture and corresponding impacts on society (up to 40 million USD) and one time costs for waste management (range from approximately 0.10 to 0.23 million USD) have to be considered in contrast to high, non-monetarised long term benefits for environment and health and positive cost impacts such as savings for farmers. Cost impacts on industry are expected to be in balance.

Useful information has been provided by parties and observers in the Annex F information submitted in 2010:

Australia, Brazil, China, India, Madagascar and the USA expect that the use of alternatives may negatively affect the costs of crop production (see Annex F submissions of these countries).

Australia expects the loss of control of the fruit spotting bug on crops for which no alternatives exist would cause economic loss [Australia 2010].

Brazil expects important economic impacts on the Brazilian economy. According to an industry source endosulfan provides the economy with an influx of more than one hundred million dollars per annum (Source: Sindicato Nacional da Indústria de Produtos para Defesa Agrícola – SINDAG). Brazil estimates that approximately 40% of the world production of endosulfan active ingredient is used in Brazil. Brazil does not stand alone in its dependence on the availability of endosulfan. According to Brazil, endosulfan is among the five best selling insecticides in the world. Countries with more than 70% of the food producing farm land in the world use endosulfan. Among these are India, Brazil, Argentina, China, Australia, the United States, and some African countries [Brazil 2010]. However in some of these countries endosulfan use is minimal, and endosulfan is not used on 70% of food producing farm land (comment from PAN and IPEN 2010).

Since a mature production chain of endosulfan technical, its intermediates and preparation has been formed, once the production and use of endosulfan is banned, China expects that this industry chain will be impacted with idle production facilities, thus causing adverse impacts on the whole industry [China 2004].

Costa Rica expects no economic impacts on agricultural production since economically viable alternatives exist [Costa Rica 2010].

The USA recognises the potential for negative impacts on consumers. The magnitude of any impacts will be crop-specific and depend on control measures taken [USA 2010].

PAN & IPEN expect positive impacts because cost competitive alternatives that do not exhibit POPs characteristics have already been implemented in many countries, covering all known uses of endosulfan. The economic aspects of substituting alternatives for endosulfan include the savings made on health and environmental costs resulting from exposure to endosulfan, and improved incomes for those no longer using endosulfan [PAN & IPEN 2010]. PAN & IPEN give some indications on health costs by providing detailed information on health costs resulting from the use of endosulfan such as costs of medical care for people exposed to endosulfan. However, many types of costs and benefits, including environmental benefits are difficult to quantify but the data indicate that in a global context the costs can be judged to be very high. In addition to these benefits PAN & IPEN expect improved incomes for farmers that substitute endosulfan by alternative products and practices [PAN & IPEN 2010].

Movement towards sustainable development

Elimination of endosulfan is consistent with sustainable development plans that seek to reduce emissions of toxic chemicals.

A relevant global plan is the Strategic Approach to International Chemicals Management (SAICM)[49]. SAICM makes the essential link between chemical safety, sustainable development, and poverty reduction. The Global Plan of Action of SAICM contains specific measures to support risk reduction that include prioritising safe and effective alternatives for persistent, bioaccumulative and toxic substances. The Overarching Policy Strategy of SAICM includes POPs as a class of chemicals to be prioritised for halting production and use and substitution with safer substitutes. Additionally, the FAO has agreed to facilitate the phase out of Highly Hazardous Pesticides,[50] the definition of which includes those pesticides that are deemed to be POPs.[51]

Costa Rica states that the prohibition of endosulfan would be one step towards sustainable production and that it is necessary to ban its use in order to diminish the long-term environmental effects [Costa Rica 2010].

Social costs (employment etc.)

Social impacts may occur as a consequence of positive or negative economic impacts in countries where endosulfan is currently used. For the implementation of alternatives related to particular practices such as IPM, organic farming or

[49] http://www.chem.unep.ch/saicm/

[50] New Initiative for Pesticide Risk Reduction. COAG/2007/Inf.14. FAO Committee on Agriculture, Twentieth Session, Rome, 25-28 April 2007. ftp://ftp.fao.org/docrep/fao/meeting/011/j9387e.pdf.

[51] Recommendations. First Session of the FAO/WHO Meeting on Pesticide Management and 3rd Session of the FAO Panel of Experts on Pesticide Management, 22-26 October 2007, Rome, Italy. http://www.fao.org/ag/agp/agpp/pesticid/Code/expmeeting/Raccomandations07.pdf.

specific cultural measures adequate training, pest forecasting and consulting to growers are required. This will on the one hand cause corresponding costs (e.g. for governments) but will also create corresponding employment. Specific information with respect to social costs was not received.

PAN & IPEN estimate low social costs as safer products and practices are widespread and available. Costs may be incurred for training of farmers in the adoption of the corresponding practices. PAN & IPEN list several societal benefits such as increased household incomes, food security, pesticide related health problems, improved soil ecology, reduced water contamination, improved situation for beneficial insects and birds [PAN & IPEN 2010].

China expects job losses for workers [China 2010].

Costa Rica expects lowered costs for chronic illness and intoxication and a better life expectancy [Costa Rica 2010].

Other considerations

Access to information and public education

Several parties and observers provided useful information related to access to information and public education (see Annex F 2010 submission of Australia, Brazil, Bulgaria, Canada, India, Lithuania, Madagascar, Malaysia, Poland, Switzerland, Togo, Ukraine, USA and PAN & IPEN.)

Access to information is available via the internet, plant protection product labels or integrated pest management programs. The information provided concerns for example information on registered plant protection products, recommendations for the treatment of crop-pest combinations, procedures for cleaning, storage, return, transport and fate of used pesticide containers and waste material of products unsuitable for use or obsolete, information on prohibited and obsolete pesticides, risk assessments, risk mitigation measures, waste treatment measures, training and education of farmers, information on POPs and information on alternatives to endosulfan. Information is usually provided by state agencies and/or plant protection product companies and universities or other training facilities.

Madagascar notes that information access and public training is insufficient because of very limited accompanying measures are put in place. This is particularly relevant for socially disadvantaged sub-populations such as cotton workers. Furthermore there is insufficient awareness regarding the correct use of products [Madagascar 2010].

2.5.2 Status of control and monitoring capacity

Control and monitoring of endosulfan is in place in several countries.

In Australia the supply of endosulfan products by suppliers is only permitted to authorised users. Australia has provided specific regional information on the details for compliance with the requirements for supply [Australia 2010].

Based on monitoring studies demanded from registrant companies Brazil has established buffer zones with a minimum distance of 250 meters from water zones [Brazil 2010].

Bulgaria has recently monitored surface and groundwater bodies on endosulfan and concluded that these water bodies are not contaminated with endosulfan [Bulgaria 2010].

Canada provided detailed data on the monitoring of alpha-endosulfan and beta-endosulfan data from the Niagara River and Great Lakes [Canada 2010].

Some universities and research institutes in China are capable of monitoring endosulfan [China 2010].

Costa Rica has provided information on numerous studies evidencing the contamination of several water resources including water for human consumption [Costa Rica 2010].

Lithuania reports on a state environmental monitoring programme 2005 to 2010 including monitoring of endosulfan in surface water (water, bottom sediments, biota). The monitoring concerns samples from the Baltic Sea, interim water and certain rivers. Monitoring started in 2005 [Lithuania 2010].

In Madagascar and Monaco there is no regular monitoring of endosulfan in place [Madagascar 2010] and [Monaco 2010].

In Malaysia import, export, manufacture, sale, storage and use of endosulfan is controlled by the Pesticides Act 1974. Environmental monitoring is carried out in order to monitor the presence of residue of pesticides (including endosulfan) in the environment and food crops. Based on the monitoring carried out the presence of endosulfan in residue is reducing [Malaysia 2010].

A harmonised regional monitoring programme on POPs and other persistent toxic substances is a major need for the Africa region. The UNEP/GEF capacity building for monitoring is a starting step towards this objective [Togo 2010].

Ukraine reports on maximum residue limits for endosulfan in specific matrices. Laboratories capable to perform the monitoring are available. However, endosulfan is not included in the list of chemicals for regular monitoring within the state environmental monitoring system [Ukraine 2010].

The USA supports a number of monitoring programs for various chemicals, including endosulfan [USA 2010].

Synthesis of information

Endosulfan was developed in the early 1950s. The current production of endosulfan worldwide is estimated to range between 18,000 and 20,000 tonnes per year. Production takes place in India, China, Israel, Brazil and South Korea. Endosulfan is used as a plant protection product in varying amounts in Argentina, Australia, Brazil, Canada, China, India and the USA. [52] Its use in agriculture is the most relevant emission source for endosulfan. As a result of its long-range environmental transport and its properties, endosulfan is likely to lead to significant adverse human health and environmental effects such that global action is warranted.

Currently applied control measures cover a broad spectrum of possible control measures. The use of endosulfan is currently banned in more than 60 countries. In some countries where endosulfan is still applied, use is restricted to specific authorised uses and specific use conditions and restrictions are usually established in order to control health and environmental risks in the country concerned. Clean up of contaminated sites and management of obsolete pesticides may particularly become a relevant issue in countries where endosulfan is manufactured. In many countries workplace exposure limits and maximum residue limits for different matrices are established.

The most complete control measure would be the prohibition of all production and uses of endosulfan i.e. listing it in Annex A of the Stockholm Convention. As a consequence current uses of endosulfan would have to be replaced by safer alternatives. The ban of endosulfan in more than 60 countries demonstrates that economically viable alternatives are likely available in many different geographical situations and in both developed and developing countries. Available information indicates that these alternatives may be technically feasible, efficient and safer and that they may be available for all current applications of endosulfan. However, substitution may be difficult and/or costly for some specific crop pest complexes in some countries. A harmonised ban of production and use would contribute to balanced agricultural markets. Listing of endosulfan would also mean that the provisions of Article 3 on export and import and of Article 6 on identification and sound disposal of stockpiles and waste would apply. Management of waste and stockpiles of endosulfan is already included in current strategies. Stockpiles and remediation measures and related costs are expected to be low compared to other obsolete pesticides because existing stockpiles are comparatively small. Relevant costs may be incurred in countries manufacturing endosulfan. A ban of endosulfan could cause one time costs to governments to implement the ban and facilitate access to alternatives, annual costs for agriculture and corresponding impacts on society (up to 40 million USD) and one time costs for waste management (range from approximately 0.10 to 0.23 million USD). These costs have to be considered in contrast to high, non-monetarised long term benefits for environment and health and positive cost impacts such as savings for some farmers who experience reduced costs when they replace endosulfan.

Another possible control measure would be to restrict production and use of endosulfan according to specific restrictions. This would mean that emissions of endosulfan and related adverse impacts could continue. This control measure seems less appropriate considering on the one hand the properties of endosulfan and the corresponding need for global action and on the other hand the availability of economically viable, technically feasible, efficient and safer alternatives. The restricted use of endosulfan in selected countries would contribute to the distortion of agricultural markets.

It is likely that endosulfan causes significant adverse effects on human health and the environment. It can therefore be expected that the current use of endosulfan causes significant non quantifiable environment and health costs.

[52] In the USA, the EPA has withdrawn approval for all uses of endosulfan.

Concluding statement

The POPRC of the Stockholm Convention has decided, in accordance with paragraph 7 (a) of Article 8 of the Convention, and taking into account that a lack of full scientific certainty should not prevent a proposal from proceeding, that endosulfan is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and environmental effects such that global action is warranted.

Having prepared a risk management evaluation and considered the management options, the POPRC recommends that the chemical be considered by the Conference of the Parties for listing in Annex A.

A thorough review of control measures that have already been implemented in several countries shows that risks to health and environment from exposure to endosulfan can be significantly reduced by eliminating production and use of endosulfan. Control measures are also expected to support the goal agreed at the 2002 Johannesburg World Summit on Sustainable Development of ensuring that by the year 2020, chemicals are produced and used in ways that minimise significant adverse impacts on the environment and human health.

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Annex I

Table 10. Chemical alternatives (including plant extracts) to endosulfan identified from information submitted according to Annex F 2010

Alternative plant protection product (ppp) (active substance or name or type)	Crop or crop type	Pest or pest type	Information source	Note
No alternative registered	Cashew nuts, Cucurbits, Guava, Kiwi fruit, Longans, Loquats, Mango, Rambutans, Tamarillo	Fruit spotting bug (Amblypelta lutescens)	Australia	
No alternative registered	Pepper	Tarnished plant bug	Canada	Greenhouse
No alternative registered	Ornamentals	Rose chafer	Canada	Greenhouse
No alternative registered	Ornamentals	Elm leaf beetle	Canada	Greenhouse
No alternative registered	Ornamentals	Black vine weevil	Canada	Greenhouse
No alternative registered	Japanese jaw	Black vine weevil	Canada	Greenhouse
No alternative registered	Apricot	Leafhoppers	Canada	Terrestrial
No alternative registered	Cherry	Plant bugs	Canada	Terrestrial
No alternative registered	Cherry	Stink bug	Canada	Terrestrial
No alternative registered	Cucumber	Tarnished plant bug	Canada	Terrestrial
No alternative registered	Eggplant	Pepper maggot	Canada	Terrestrial
No alternative registered	Pumpkin	Squash vine borer	Canada	Terrestrial
No alternative registered	Pumpkin	Tarnished plant bug	Canada	Terrestrial
No alternative registered	Squash	Tarnished plant bug	Canada	Terrestrial
No alternative registered	Tomato	Pepper magot	Canada	Terrestrial
No alternative registered	Food processing plants (outdoor)	Sap beetle	Canada	Structural
No alternative registered	Japanese jaw	Black vine weevil	Canada	Outdoor
Carbofuran	Potato	Leafhoppers, Colorado potato beetle, Potato flea beetle, Tarnished plant bug, Meadow spittlebug, Sunflower beetle	Canada	
Chlorpyrifos	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Aphids, Whiteflies, Spruce gall aphid, Colorado potato beetle, Potato flea beetle, Tarnished plant bug	Canada	Greenhouse
Cyhalothrin-lambda	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Greenapple aphid, Rosy apple aphid, Wolly apple aphid, Tarnished plant bug, Leafhoppers, White apple leafhopper, Codling moth, Flea beetle, Imported gabbageworm, Diamondback moth, Cabbage looper, Corn earworm	Canada	Terrestrial
Cypermethrin	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Tarnished plant bug, Leafhoppers, White apple leafhopper, Codling moth, Flea beetle, Imported gabbageworm, Diamondback moth, Cabbage looper, Corn earworm, Colorado potato Beetle, Potato flea beetle, Tuber flea beetle, Meadow spittlebug, Sunflower beetle, Plant bugs	Canada	Terrestrial
Cyromazin	Potato	Colorado potato beetle	Canada	Terrestrial
Deltamethrin	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Greenapple aphid, Rosy apple aphid, Wolly apple aphid, Leafhoppers, White apple leafhopper,	Canada	Terrestrial

Alternative plant protection product (ppp) (active substance or name or type)	Crop or crop type	Pest or pest type	Information source	Note
		Codling moth, Flea beetles, Imported cabbageworm, Diamondback moth, Gabbage looper, Corn earworm, Twig borer, Pear psylla, Aphids, Colorado potato beetle, Potato flea beetle, Tuber flea beetle, Tarnished plant bug, Sunflower beetle		
Diazimon	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Aphids, Greenapple aphid, Rosy apple aphid, Wolly apple aphid, Pearleaf blister mite, Leafhoppers, White apple leafhopper, Potato leafhopper, Rust mite, Pear psylla, Codling moth, Peachtree borer, Lesser peachtree borer, Twig borer, Black cherry aphid, Eyespotted bad moth, Green peach aphid, Mealy plum aphid, Bean aphid, Mexican bean beetle, Potato leafhopper, Black bean aphid, Green clover worm, Flea beetles, Imported cabbageworm, Diamondback moth, , Cabbage looper, Plum rust mite, Squash vine borer, Cucumber beetles, Potato flea beetle	Canada	Greenhouse
Dichlorvos	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Aphids, Whiteflies, Spruce gall aphid	Canada	Greenhouse
Dicofol	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Cyclamen mites, Rust mite, Peach silver mite	Canada	Greenhouse
Dimethoate	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Aphids, Bean aphid, Mexican bean beetle, Potato leafhopper, Black bean aphid, Rosy apple aphid, Mealy plum aphid, Leafhoppers, Strawberry aphid, Tarnished plant bug, Cyclamen mite, Whiteflies, Green peach aphid, Black cherry aphid, Peach silver mite, Plant bugs, Plum rust mite, Green apple aphid, Woolly apple aphid, Pearleaf blister mite, Rust mite, Pear psylla, Codling moth, Pepper maggot	Canada	Terrestrial
Formetanate hydrochloride	Apple	Leafhoppers, White apple leafhopper	Canada	Terrestrial
Imidacloprid	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Aphids, Whiteflies, Spruce gall aphid, Greenapple aphid, Rosy apple aphid, Leaf-hoppers, White apple leafhopper, Colorado potato beetle, Potato flea beetle	Canada	Greenhouse

Alternative plant protection product (ppp) (active substance or name or type)	Crop or crop type	Pest or pest type	Information source	Note
Insecticidal soap	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Aphids, Whiteflies, Green peach aphid, Cyclamen mites, Spruce gall aphid, Greenapple aphid, Rosy apple aphid, Wolly apple aphid, Pearleaf blister mite, Rust mite, Pear psylla, Black cherry aphid, Mealy plum aphid, Peach silver mite, Plum rust mite, Bean aphid, Black bean aphid, Corn leaf aphid, Strawberry aphid	Canada	Greenhouse
Insecticidal soap/Pyrethrin	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Green peach aphid, Aphids, Whiteflies, Greenapple aphid, Rosy apple aphid, Wolly apple aphid, Pear psylla, Black cherry aphid, Mealy plum aphid, Bean aphid, Black bean aphid, Corn leaf aphid, Strawberry aphid	Canada	Greenhouse
Kaolin clay	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Tarnished plant bug, Leafhoppers, White apple leafhopper, Potato leafhopper, Pear psylla, Codling moth Cucumber beetles	Canada	Terrestrial
Kinoprene	Ornamentals	Aphids, Whiteflies, Spruce gall aphid	Canada	Greenhouse
Lime sulphur	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Pearleaf blister mite, Rust mite, Plum rust mite, Twig borer, Black cherry aphid, Green peach aphid, Mealy plum aphid, Peach silver mite	Canada	Terrestrial
Mancozeb	Pear	Pear psylla	Canada	Terrestrial
Malathion	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Aphids, Whiteflies, Cyclamen mites, Spruce gall aphid, Meadow spittlebug, Greenapple aphid, Rosy apple aphid, Wolly apple aphid, Pearleaf blister mite, Rust mite, Pear psylla, Codling moth, Black cherry aphid, Green peach aphid, Mealy plum aphid, Bean aphid, Mexican bean beetle, Potato leafhopper, Black bean aphid, Flea beetle, Imported gabbageworm, Cabbage looper, Corn earworm, Cucumber beetle, Potato flea beetle, Grape phylloxera, Leafhoppers, Cucumber beetles, Cabbageworms, Weevils, Pepper maggot, Colorado potato beetle, Strawberry aphid	Canada	Greenhouse

Alternative plant protection product (ppp) (active substance or name or type)	**Crop or crop type**	**Pest or pest type**	**Information source**	**Note**
Methamidophos	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Aphids, Imported gabbageworm, Diamondback moth, Cabbage looper, Potato flea beetle, Leafhoppers, Tarnished plant bug	Canada	Terrestrial
Methomyl	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Greenapple aphid, Rosy apple aphid, Wolly apple aphid, Leafhoppers, White apple leafhopper, Codling moth, Imported gabbageworm, Diamondback moth, Cabbage looper, Corn leaf aphid, Corn earworm, Potato flea beetle, Tuber flea beetle, Tomato fruitworm	Canada	Terrestrial
Methoxyfenozide	Apple	Codling moth	Canada	Terrestrial
Mineral oil	Apple	Pear psylla, Aphids, Whiteflies	Canada	Terrestrial
Naled	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Aphids, Whiteflies, Spruce gall aphid, Bean aphid, Black bean aphid, Imported gabbageworm, Diamondback moth, Cabbage looper, Colorado potato Beetle, Potato flea beetle, Tuber flea beetle, Leafhoppers, Strawberry aphid, Meadow spittlebug, Hornworms, Tomato fruitworm	Canada	Greenhouse
Nicotine	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Aphids, Green peach aphid, Spruce gall aphid	Canada	Greenhouse
Oxamyl	Apple	Greenapple aphid, Rosy apple aphid, Tarnished plant bug, Leafhoppers, White apple leafhopper, Potato leafhopper, Rust mite, Aphids, Colorado potato Beetle, Potato flea beetle, Tuber flea beetle	Canada	Terrestrial
Paraffinic base mineral oil	Pear	Pear psylla, Pearleaf blister mite	Canada	
Permethrin	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Whiteflies, Tarnished plant bug, Leafhoppers, White apple leafhopper, Codling moth, Flea beetle, Imported gabbageworm, Diamondback moth, Cabbage looper, Corn earworm, Plant bugs, Pear psylla, Colorado xpotato beetle, Potato flea beetle	Canada	Greenhouse
Phosalone	Apple	Greenapple aphid, Rosy apple aphid, Wolly apple aphid, Pearleaf blister mite, Leafhoppers, White apple leafhopper, Potato leafhopper, Rust mite, Pear psylla, Codling moth, Black cherry aphid, Twig borer, Mealy plum aphid	Canada	Terrestrial

Alternative plant protection product (ppp) (active substance or name or type)	Crop or crop type	Pest or pest type	Information source	Note
Phosmet	Apple	Aphid, Greenpeach aphid, Rosy apple aphid, Wolly apple aphid, Tarnished plant bug, Codling moth, Twig borer, Plant bugs, Rust mite, Pear psylla, Colorado potato beetle, Potato flea beetle, Leafhoppers, Strawberry aphid	Canada	Terrestrial
Pirimicarb	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Aphids, Greenpeach aphid, Wolly apple aphid, Leafhoppers, White apple leafhopper, Corn leaf aphid, Strawberry aphid,	Canada	Terrestrial
Pymetrozine	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Aphids, Whiteflies, Spruce gall aphid	Canada	Greenhouse
Pyrethrin/Piperonyl butoxidef	Ornamentals	Whiteflies, Aphids	Canada	
Pyridaben	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Whiteflies, Rust mite, Pear psylla	Canada	Greenhouse
Spirodiclofen	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Rust mite, Peach silver mite	Canada	Terrestrial
Spirosad	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Eyespotted bad moth, Imported gabbageworm, Diamondback moth, Cabbage looper, Colorado potato beetle	Canada	Terrestrial
Sulphur	Cherry	Plum rust mite, Plum rust mite	Canada	
Tebufenozide	Apple	Codling moth	Canada	Terrestrial
d-trans Allethrin / Piperonyl butoxide / N-octyl bicycle-heptene dicar-boximide	Ornamentals	Aphids, Spruce gall aphid	Canada	
Trichlorfon	Usually applicable to many crops. For details see Canada Rev 2007-13 Appendix VI	Imported cabbageworm, Diamondback moth, Gabbage looper, Pepper maggot, Beet webwormx	Canada	Terrestrial
Imidacloprid	Not specified	Not specified	India	Narrow spectrum insectide
Spinosad	Not specified	Not specified	India	Narrow spectrum insectide
Acetamiprid	Not specified	Not specified	India	Narrow spectrum insectide
Buprofezin	Not specified	Not specified	India	Narrow spectrum insectide
Novaluron	Not specified	Not specified	India	Narrow spectrum insectide
Indoxacarb	Not specified	Not specified	India	Narrow spectrum insectide
Flubendiamide	Not specified	Not specified	India	Narrow spectrum insectide
Thiomethoxam	Not specified	Not specified	India	Narrow spectrum insectide
Emamectinbenzoate	Not specified	Not specified	India	Narrow spectrum insectide
Chlorantraniloprole	Not specified	Not specified	India	Narrow spectrum insectide
Dimethoate	Not specified	Not specified	Sri Lanka	

Alternative plant protection product (ppp) (active substance or name or type)	Crop or crop type	Pest or pest type	Information source	Note
Carbaryl	Not specified	Not specified	Sri Lanka	
Carbofuran	Not specified	Not specified	Sri Lanka	
Diazinon	Not specified	Not specified	Sri Lanka	
Thiacloprid	Not specified	Not specified	Switzerland	Neonicotinoid
Acetamiprid	Not specified	Not specified	Switzerland	Neonicotinoid
Abamectin	Not specified	Not specified	Switzerland	
Clofentezine	Not specified	Not specified	Switzerland	
Spinosad	Not specified	Not specified	Switzerland	
Profenophos	Cotton crops	Not specified	Togo	Product name: Calfos
Thian	Cottons crops	Not specified	Togo	Will be probably under field testing in the near future
organophosphates	Not specified	Not specified	USA	Unspecific list of ppp types
Carbamates	Not specified	Not specified	USA	Unspecific list of ppp types
synthetic pyrethroids	Not specified	Not specified	USA	Unspecific list of ppp types
Neonicotinoids	Not specified	Not specified	USA	Unspecific list of ppp types
various “organic” insecticides	Not specified	Not specified	USA	Unspecific list of ppp types
Chlorpyrifos (organophosphorous)	Wide variety of crops	Woodlouse, Caterpillars, ants, Isoca, Lizards, Aphids, Thrips and other species	IPEN Ref 8	Alternatives in Latin America; Toxicity (III, low): Fish: very high Birds: high Bees: high
Methamidophos (organophosphorous)	Extensive fruit cultivation, horticulture	Aphids, Lizard, Moths, Thrips and other species	IPEN Ref 8	Alternatives in Latin America; Toxicity (Ib, high): Fish: low Birds: high Bees: high
Cypermethrin (pyrethroid)	Extensive fruit cultivation, pepper, tomato, onion	Bugs, Caterpillars, Lizards, Polilla, tomate, Aphids, Thrips	IPEN Ref 8	Alternatives in Latin America; Toxicity (II, moderate): Fish: very high Birds: very low Bees: moderate
Lambda cyhalothrin (pyrethroid)	Fruits, tomatoes, extensive cultures	Lizards, Bugs, Caterpillars, Moths, Aphids, Thrips	IPEN Ref 8	Alternatives in Latin America; Toxicity (Ib, probably high): Fish: high Birds: low Bees: high
Alfameina (pyrethroid) (note: the specific active substance could not be identified)	Not specified	Not specified	IPEN Ref 8	Alternatives in Latin America; Toxicity (II, moderate) Fish: very high Birds: very low Bees: high
Deltametrina (pyrethroid)	Extensive fruit cultivation, horticulture	Ants, Lizards, Aphids, Thrips and other species	IPEN Ref 8	Alternatives in Latin America; Toxicity (II, moderate) Fish: high Birds: very low Bees: moderate
Permethrin (pyrethroid)	Not specified	Not specified	IPEN Ref 8	Alternatives in Latin America; Toxicity (II, moderate) Fish: very high Birds: very low Bees: high

Alternative plant protection product (ppp) (active substance or name or type)	Crop or crop type	Pest or pest type	Information source	Note
Spinosad	Cotton	Helicoverpa armigera NPV	IPEN	Alternatives in West Africa
Indoxacarb	Cotton	Helicoverpa armigera NPV	IPEN	Alternatives in West Africa
Malathion	Cotton	Helicoverpa armigera NPV	IPEN	Alternatives in West Africa
Flubendiamide	Cotton	Helicoverpa armigera NPV	IPEN	Alternatives in West Africa
Spirotetramat	Cotton	Helicoverpa armigera NPV	IPEN	Alternatives in West Africa
Triazophos	Cotton	Helicoverpa armigera NPV	IPEN	Alternatives in West Africa
Thiodicarb	Cotton	Helicoverpa armigera NPV	IPEN	Alternatives in West Africa
Enamectin benzoate	Cotton	Helicoverpa armigera NPV	IPEN	Alternatives in Senegal
Bifenthrin	Tea	Loopworm Ectropis obliqua hypulina Smaller greenleaf hopper Empoasca sp. White fly Weevil	IPEN	Alternatives in China
Deltamethrin	Tea	Loopworm Ectropis obliqua hypulina Caterpillars	IPEN	Alternatives in China
Permethrin	Tea	Loopworm Ectropis obliqua hypulina	IPEN	Alternatives in China
Cypermethrin	Tea	Loopworm Ectropis obliqua hypulina Smaller greenleaf hopper Empoasca sp. Caterpillars	IPEN	Alternatives in China
Beta-cypermethrin	Tea	Loopworm Ectropis obliqua hypulina Tussock moth Euproctis pseudoconspersa Smaller greenleaf hopper Empoasca sp.	IPEN	Alternatives in China
Lambda cyhalothrin	Tea	Loopworm Ectropis obliqua hypulina Tussock moth Euproctis pseudoconspersa Bacillus thuringiensis (Bt)	IPEN	Alternatives in China
Flucythrinate	Tea	Loopworm Ectropis obliqua hypulina Gall mites	IPEN	Alternatives in China
Diflubenzuron	Tea	Loopworm Ectropis obliqua hypulina Gracillariidae (leaf miners, stem borers)	IPEN	Alternatives in China
Malathion	Tea	Loopworm Ectropis obliqua hypulina Smaller greenleaf hopper Empoasca sp	IPEN	Alternatives in China
Dichlorvos	Tea	Loopworm Ectropis obliqua hypulina Smaller greenleaf hopper Empoasca sp.	IPEN	Alternatives in China
Phoxim	Tea	Loopworm Ectropis obliqua hypulina Smaller greenleaf hopper Empoasca sp.	IPEN	Alternatives in China
Chlorpyrifos	Tea	Loopworm Ectropis obliqua hypulina Smaller greenleaf hopper Empoasca sp.	IPEN	Alternatives in China

Alternative plant protection product (ppp) (active substance or name or type)	Crop or crop type	Pest or pest type	Information source	Note
Brofluthrinate	Tea	Smaller greenleaf hopper Empoasca sp.	IPEN	Alternatives in China
Nicotine	Tea		IPEN	Alternatives in China
Propargite	Tea	Gall mites	IPEN	Alternatives in China
Lime sulphur	Tea	Red spider mite Oligonychus coffeae	IPEN	Alternatives in China
Petroleum oil	Tea	Red spider mite Oligonychus coffeae	IPEN	Alternatives in China
Imidaclothiz	Tea	Smaller greenleaf hopper Empoasca sp.	IPEN	Alternatives in China
Imidacloprid	Tea	Smaller greenleaf hopper Empoasca sp.	IPEN	Alternatives in China
Acetamiprid	Tea	Smaller greenleaf hopper Empoasca sp p.	IPEN	Alternatives in China
Fenobucarb	Tea	Smaller greenleaf hopper Empoasca sp.	IPEN	Alternatives in China
Isoprocarb	Tea	Smaller greenleaf hopper Empoasca sp p.	IPEN	Alternatives in China
Difenthiuron	Tea	Smaller greenleaf hopper Empoasca sp	IPEN	Alternatives in China
Cypermethrin	Paddy	Leaf folder	IPEN	Alternatives in India
Lampda cyhalothrin	Paddy	Leaf folder	IPEN	Alternatives in India
Quinalphos	Paddy	Hispa/case worm/cut worm Swarming caterpillar/ surti caterpillar	IPEN	Alternatives in India
	Sorghum	Defoliators	IPEN	Alternatives in India
	Jute	Semilooper	IPEN	Alternatives in India
	Sugarcane	Top shoot borer; Internode bore	IPEN	Alternatives in India
Monocrotophos	Paddy	Hispa/case worm/cut worm Swarming caterpillar/ surti caterpillar	IPEN	Alternatives in India
	Green gram, black gram	Pod borer	IPEN	Alternatives in India
	Groundnut	Leafminer	IPEN	Alternatives in India
	Niger	Lucern caterpillar defoliator	IPEN	Alternatives in India
	Soyabean	Stemfly defoliator	IPEN	Alternatives in India
	Jute	Bihar hairy caterpillar; Indigo caterpillar	IPEN	Alternatives in India
	Mango	Mealy bug	IPEN	Alternatives in India
	Guava	Bark eating caterpillar	IPEN	Alternatives in India
Chlorpyrifos	Groundnut	Helicoverpa/Spodoptera/ other leafeating caterpillar	IPEN	Alternatives in India
	Potato	Cutworm	IPEN	
Carbaryl	Paddy	Swarming caterpillar/ surti caterpillar	IPEN	Alternatives in India
	Linseed	Defoliator	IPEN	
	Maize	Corn earworm/defoliato	IPEN	
	Sugar cane	Top shoot borer; Internode borer	IPEN	
	Bhindi	Leaf roller	IPEN	
	Curcubits	Red pumpkin	IPEN	
	Cabbage/Cauliflower	Cabbage borer Tobacco caterpillar Cabbage butterfly	IPEN	
	Pea	Pod borer	IPEN	
	Mango	Mango hopper	IPEN	
	Guava	Cater capsule borer	IPEN	
Triazophos	Cotton	Spotted bollworm; pink bollworm; Helicoverpa	IPEN	Alternatives in India
	Arhar [pigeon pea]	Pod borer	IPEN	
	Green gram, black gram	Pod borer	IPEN	
	Groundnut	Helicoverpa/Spodoptera/	IPEN	

Alternative plant protection product (ppp) (active substance or name or type)	Crop or crop type	Pest or pest type	Information source	Note
		other leafeating caterpillar		
	Soyabean	Leaf roller Leaf miner	IPEN	
	Chilli	Fruit borer	IPEN	
	Tomato	Fruit borer (Helicoverpa armigera)	IPEN	
	Pea	Pod borer	IPEN	
Acephate	Arhar [pigeon pea]	Pod borer Defoliators	IPEN	Alternatives in India
	Cabbage/Cauliflower	Leaf webber (Crocidoloma binotalis)	IPEN	
Methyl oxydemeton	Arhar [pigeon pea]	Pod bug	IPEN	Alternatives in India
	Safflower	Bihar hairy caterpillar	IPEN	
Imidacloprid	Arhar [pigeon pea]	Pod bug	IPEN	Alternatives in India
Ethofenprox	Mustard	Leaf webber	IPEN	Alternatives in India (recommended by the Government of India)
Dichlorvos	Sunflower	Cutworm	IPEN	Alternatives in India (recommended by the Government of India)
Dimethoate	Safflower	Bihar hairy caterpillar	IPEN	Alternatives in India (recommended by the Government of India)
	Mesta	Jassid	IPEN	Alternatives in India (recommended by the Government of India)
Phosalone	Soyabean	Leaf roller Leaf miner Stemfly defoliator	IPEN	Alternatives in India (recommended by the Government of India)
	Jute	Semilooper	IPEN	Alternatives in India (recommended by the Government of India)
Carbofuran	Maize	Stalk borer	IPEN	Alternatives in India (recommended by the Government of India)
	Sugarcane	Top shoot borer; Internode borer	IPEN	Alternatives in India (recommended by the Government of India)
Fenvalerate	Sorghum	Defoliators a;	IPEN	Alternatives in India (recommended by the Government of India)
Spinosad	Cotton	Red cotton bug; Dusky cotton bug	IPEN	Alternatives in India (recommended by the Government of India)
Indoxacarb	Cotton	Red cotton bug; Dusky cotton bug	IPEN	Alternatives in India (recommended by the Government of India)
Dicofol	Jute	Mites	IPEN	Alternatives in India (recommended by the Government of India)
	Chilli	Fruit borer	IPEN	Alternatives in India (recommended by the Government of India)
Propargite	Jute	Mites	IPEN	Alternatives in India (recommended by the Government of India)
NKSE	Citrus	Lemon butterfly	IPEN	Alternatives in India (recommended by the Government of India)
MethomyI	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)

Alternative plant protection product (ppp) (active substance or name or type)	Crop or crop type	Pest or pest type	Information source	Note
Oxamyl	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Acephate	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Chlorpyrifos	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Dicrotophos	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Dimethoate	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Methamidophos	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Methidathion	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Methyl parathion	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Naled	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Profenofos	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Beta-cyfluthrin	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Bifenthrin	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Cyfluthrin	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Deltamethrin	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Esfenvalerate	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Fenproparhrin	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)

Alternative plant protection product (ppp) (active substance or name or type)	Crop or crop type	Pest or pest type	Information source	Note
Lambda cyhalothrin	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Tralomethrin	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Zeta cypennethrin	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Acetamiprid	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Dinotefuran	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Imidacloprid	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Thiamethoxam	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Buprofezin	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Novaluron	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Pyriproxifen	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Pymetrozine	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Indoxacarb	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Flonicamid	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Spiromesifen	Cotton	Lygus bug (Lygus hesperus) Silverleaf fly (Bemisia argentfolii)	USA	Alternatives in the USA (identified by US EPA)
Monocrotophos	Arhar (pigeon pea)	Pod fly (Melanagromyza obtuse)	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Malathion	Mustard	sawfly (Athalia lugens proxima)	IPEN	

Alternative plant protection product (ppp) (active substance or name or type)	Crop or crop type	Pest or pest type	Information source	Note
Quinalphos	Mustard	sawfly (Athalia lugens proxima)	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Methyl parathion	Mustard	sawfly (Athalia lugens proxima)	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Carbaryl	Mustard	sawfly (Athalia lugens proxima)	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Quinalphos	Sesamum	Antigastra sp/ Pod capsule borer	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Phosalone	Sesamum	Antigastra sp/ Pod capsule borer	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Malathion	Sesamum	Antigastra sp/ Pod capsule borer	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Deltamethrin	Sesamum	Antigastra sp/ Pod capsule borer	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Cypermethrin	Sesamum	Antigastra sp/ Pod capsule borer	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Quinalphos	Ragi (Eleusine coracana),	Millet shoot fly	IPEN	Alternatives in India (recommended by the Government of India)
Triazaphos	Ragi (Eleusine coracana),	Millet shoot fly	IPEN	Alternatives in India (recommended by the Government of India)
Methyl parathion	Ragi (Eleusine coracana),	Millet shoot fly	IPEN	Alternatives in India (recommended by the Government of India)
Malathion	Ragi (Eleusine coracana),	Millet shoot fly	IPEN	Alternatives in India (recommended by the Government of India)
Phosalone	Sesamum	Hawk moth (Sphinx caterpillar),	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Malathion	Sesamum	Hawk moth (Sphinx caterpillar),	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh

Alternative plant protection product (ppp) (active substance or name or type)	Crop or crop type	Pest or pest type	Information source	Note
DAS (note: the specific active substance could not be identified)	Sesamum	Hawk moth (Sphinx caterpillar),	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Neem (Azadirachtin) (plant extract)	Sunflower	Castor semilooper [Achaea janata]	IPEN	Alternatives in India (recommended by the Government of India)
Neem (Azadirachtin) (plant extract)	Mustard	leaf and pod caterpillar	IPEN	Alternatives in India (recommended by the Government of India)
Neem seed kernel suspension (plant extract)	Sunflower	Castor semilooper [Achaea janata]	IPEN	Alternatives in India (recommended by the Government of India)
Neem base pesticide (plant extract)	Not specified	Not specified	India	Narrow spectrum insectide
osthole (plant extract Cnidium monnieri)	Tea	Loopworm Ectropis obliqua hypulina	IPEN	Alternatives in China
matrine (plant extract Sophora japonica roots)	Tea	Loopworm Ectropis obliqua hypulina	IPEN	Alternatives in China
stemonine (plant extract Stemona tuberosa)	Tea	Smaller greenleaf hopper Empoasca sp	IPEN	Alternatives in China
toosendanin (plant extract Melia sp)	Tea	Smaller greenleaf hopper Empoasca sp	IPEN	Alternatives in China
Neem (plant extract)	Coffee	coffee berry borer (Hypothenemus hampei)	IPEN	Alternatives in Mexico
Neem (Azadirachtin) (plant extract)	Groundnut	Helicoverpa/Spodoptera/ other leafeating caterpillar	IPEN	Alternatives in India (recommended by the Government of India)
	Sunflower	Defoliators	IPEN	Alternatives in India (recommended by the Government of India)
	Bengal gram	Pod borer	IPEN	Alternatives in India (recommended by the Government of India)

* On permit

Table 11. Biological control alternatives to endosulfan identified from information submitted according to Annex F 2010

Alternative biological control agent	Crop or crop type	Pest or pest type	Information source	Note
parasitic wasp Cephalonomis stephanotheris	Coffee	coffee berry borer (Hypothenemus hampei)	IPEN	Alternatives in Bolivia and Mexico
parasitoid wasp Phymastichus coffea	Coffee	coffee berry borer (Hypothenemus hampei)	IPEN	Alternatives in Costa Rica and Mexico
entomopathogenic fungus Beauvaria bassiana	Coffee	coffee berry borer (Hypothenemus hampei)	IPEN	Alternatives in Bolivia, Costa Rica, Cuba and Mexico
parasitic wasp Prorops nasuta	Coffee	coffee berry borer (Hypothenemus hampei)	IPEN	Alternatives inMexico
parasitic wasp Trichogramma	Vegetables (tomato)	lepidopteran pest	IPEN	Alternatives in Cuba
parasitic wasp Trichogramma	Vegetables (peppers)	lepidopteran pest	IPEN	Alternatives in Cuba
parasitic wasp Trichogramma	Vegetables (curcubits)	lepidopteran pest	IPEN	Alternatives in Cuba
parasitic wasp Trichogramma	Vegetables (tobacco)	lepidopteran pest	IPEN	Alternatives in Cuba

Alternative biological control agent	Crop or crop type	Pest or pest type	Information source	Note
parasitic wasp Trichogramma	Vegetables (tomato)	lepidopteran pests	IPEN	Alternatives in Cuba
parasitoids Telenomus spp	Vegetables (corn, garlic, onion, peppers, tomatoes, potato, and curcubits)	Lepidopteran pest	IPEN	Alternatives in Cuba
parasitoids Euplectrus plathyhypenae,	Vegetables (corn, garlic, onion, peppers, tomatoes, potato, and curcubits)	Lepidopteran pest	IPEN	Alternatives in Cuba
parasitoids Tetrastichus howardii Ollif	Vegetables (corn, garlic, onion, peppers, tomatoes, potato, and curcubits)	Lepidopteran pest	IPEN	Alternatives in Cuba
parasitoids Tetrastichus spp	Vegetables (corn, garlic, onion, peppers, tomatoes, potato, and curcubits)	Lepidopteran pest	IPEN	Alternatives in Cuba
Bacillus thuringiensis (Bt)	Vegetables (crops)	Lepidopteran pest	IPEN	Alternatives in Cuba and Costa Rica
Bacillus thuringiensis (Bt)	Tea	Loopworm Ectropis obliqua hypulina	IPEN	Alternatives in China
Buzura suppressaria nuclear polyhedrosis virus (BsNPV)	Tea	Loopworm Ectropis obliqua hypulina	IPEN	Alternatives in China
Ectropis obliqua nuclear polyhedrosis virus (EONPV)	Tea	Loopworm Ectropis obliqua hypulina	IPEN	Alternatives in China
Parasitic wasp Epidinocarsis lopezi	Cassava	Cassava mealybug Phenacoccus manihoti	IPEN ref02	Alternatives in Westafrica
Parasitic wasp Bracon hebetor	Millet	Millet head miner Heliocheilus alpipunctella	IPEN ref02	Alternatives in Westafrica
Entomopathogenous fungi - Metarhizium flavoviride, M. anisopliae	Rice, wheat	Locusts, grasshoppers	IPEN ref02	Alternatives in Westafrica
Weevil Neohydronomus affinis		Water lettuce, Pistia stratiotes	IPEN ref02	Alternatives in Westafrica
Parasitic wasps Anagyrus mangicola and Geraronoïdea tebygi	Farinaceous cochineal	Farinaceus (fruit) cochineal Rastrococcus invadens	IPEN ref02	Alternatives in Westafrica
Parasitic wasp Encarsia haïtiensis		Whitefly Aleurodicus dispersus	IPEN ref02	Alternatives in Westafrica
2 parasites Copidosoma koehleri & Apnatels subandinus	Potato, tobacco, tomato, eggplant, pepper, jimson-weed	Potato tuberworm Phthorimaea operculella	IPEN ref02	Alternatives in Westafrica
Coleoptera Curculionidae Cyrtobagous salviniae		Aquatic fern Salvinia molesta	IPEN ref02	Alternatives in Westafrica
Parasitic wasp Trichogramma	cotton	Not specified	IPEN	Alternative in India

Alternative biological control agent	Crop or crop type	Pest or pest type	Information source	Note
Cydia pomonella granulo virus	Apple	Codling moth	Canada	Alternatives in Canada
Bacillus thuringiensis (Bt) var kurstaki	Broccoli	Imported gabbageworm, Diamondback moth, Cabbage looper	Canada	Alternatives in Canada
Bacillus thuringiensis (Bt) var kurstaki	Brussels sprouds	Imported cabbageworm, , Diamondback moth, , Cabbage looper	Canada	Alternatives in Canada
Bacillus thuringiensis (Bt) var kurstaki	Cabbage	Imported gabbageworm, Diamondback moth, Gabbage looper	Canada	Alternatives in Canada
Bacillus thuringiensis (Bt) var kurstaki	Cauliflower	Imported gabbageworm, Diamondback moth, Gabbage looper	Canada	Alternatives in Canada
Bacillus thuringiensis (Bt) var kurstaki	Celery	Imported gabbageworm, Gabbage looper	Canada	Alternatives in Canada
Bacillus thuringiensis (Bt) var kurstaki	Lettuce	Gabbageworm, Gabbage looper	Canada	Alternatives in Canada
Bacillus thuringiensis var tenebrionis	Potato	Colorado potato beetle	Canada	Alternatives in Canada
Bacillus thuringiensis (Bt) var kurstaki	Spinach	Imported gabbageworm, Gabbage looper	Canada	Alternatives in Canada
Bacillus thuringiensis var tenebrionis	Tomato	Colorado potato beetle	Canada	Alternatives in Canada
Bacillus thuringiensis (Bt) var kurstaki	Tomato	Hornworms, Tomato fruit-worm	Canada	Alternatives in Canada
Bacillus thuringiensis (Bt) var kurstaki	Turnip	Cabbage looper, Diamondback moth, imported cabbageworm	Canada	Alternatives in Canada
Ladybird beetles	Cucumber	Whiteflies	IPEN	Alternatives in USA
Green lacewing larvae	Cucumber	Whiteflies	IPEN	Alternatives in USA
Beauvaria bassiana	Cucumber	Whiteflies	IPEN	Alternatives in USA
Encarsia pergandiella	Cucumber	Whiteflies	IPEN	Alternatives in USA
Eretmocerus spp.	Cucumber	Whiteflies	IPEN	Alternatives in USA
green lacewing larvae	Apple	Woolly apple aphids	IPEN	Alternatives in USA
adult and larval lady beetles,	Apple	Woolly apple aphids	IPEN	Alternatives in USA
syrphid fly larvae,	Apple	Woolly apple aphids	IPEN	Alternatives in USA
parasitic wasps.	Apple	Woolly apple aphids	IPEN	Alternatives in USA
midge larvae,	Apple	Other apple aphids	IPEN	Alternatives in USA
pirate bug,	Apple	Other apple aphids	IPEN	Alternatives in USA
damsel bugs,	Apple	Other apple aphids	IPEN	Alternatives in USA
Campylomma	Apple	Other apple aphids	IPEN	Alternatives in USA
conserve Ormyrus sp (parasite of pod fly)	Arhar (pigeon pea)	Pod fly (Melanagromyza obtusa)	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
conserve Perilissus cingulator (parasites the grubs),	Mustard	sawfly (Athalia lugens proxima)	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
bacterium Serratia marcescens	Mustard	sawfly (Athalia lugens proxima)	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh

Alternative biological control agent	Crop or crop type	Pest or pest type	Information source	Note
Bracon hebator,	Sesamum	shoot webber	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
B. Brevicornis	Sesamum	shoot webber	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Phanerotoma handecasisella	Sesamum	shoot webber	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Cantheconidia furcellata,	Sesamum	Antigastra sp/ Pod capsule borer	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Cicindella spp	Sesamum	Antigastra sp/ Pod capsule borer	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Parasitoids Trathala flavoorbitallis	Sesamum	Antigastra sp/ Pod capsule borer	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Parasitoids Campoplex sp.	Sesamum	Antigastra sp/ Pod capsule borer	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Parasitoids Erioborus sp.	Sesamum	Antigastra sp/ Pod capsule borer	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Parasitoids Temelucha biguttula	Sesamum	Antigastra sp/ Pod capsule borer	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Parasitoids Apanteles spp.	Sesamum	Antigastra sp/ Pod capsule borer	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Parasitoids Cremastus flavoorbitalis	Sesamum	Antigastra sp/ Pod capsule borer	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
egg parasite Anastatus acherontiae	Sesamum	Hawk moth (Sphinx caterpillar)	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh

Alternative biological control agent	Crop or crop type	Pest or pest type	Information source	Note
larval parasite Sarcophaga sp.	Sesamum	Hawk moth (Sphinx caterpillar)	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
larval parasite Zygobothria ciliate walp	Sesamum	Hawk moth (Sphinx caterpillar)	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
larval parasite Apanteles acherontiae	Sesamum	Hawk moth (Sphinx caterpillar)	IPEN	Alternatives in India recommended by Agricultural University, Jabalpu, Madhya Pradesh
Bacillus thuringiensis	Mustard	leaf and pod caterpillar	IPEN	Alternatives in India (recommended by the Government of India)
Trichogramma	Sunflower	Castor semilooper [Achaea janata]	IPEN	Alternatives in India (recommended by the Government of India)
Apanteles	Sunflower	Castor semilooper [Achaea janata]	IPEN	Alternatives in India (recommended by the Government of India)
Bracon	Sunflower	Castor semilooper [Achaea janata]	IPEN	Alternatives in India (recommended by the Government of India)
Chrysopa	Sunflower	Castor semilooper [Achaea janata]	IPEN	Alternatives in India (recommended by the Government of India)
Lady bird beetles	Sunflower	Castor semilooper [Achaea janata]	IPEN	Alternatives in India (recommended by the Government of India)
Bacillus thuringiensis	Sunflower	Castor semilooper [Achaea janata]	IPEN	Alternatives in India (recommended by the Government of India)
Telenomus dingus	Ragi (Eleusine coracana)	Pink borer	IPEN	Alternatives in India (recommended by the Government of India)
Trichogramma sp.	Ragi (Eleusine coracana)	Pink borer	IPEN	Alternatives in India (recommended by the Government of India)
fungus Beauvaria bassiana	Ragi (Eleusine coracana)	Pink borer	IPEN	Alternatives in India (recommended by the Government of India)
Trichogramma chilonis	Paddy	Leaf folder, Hispa/case worm/cut worm	IPEN	
Helicoverpa armigera nuclear	Arhar [pigeon pea]	Pod borer	IPEN	Alternatives in India (recommended by

Alternative biological control agent	Crop or crop type	Pest or pest type	Information source	Note
polyhedrosis virus (NPV)				the Government of India)
Bacillus thuringiensis	Arhar [pigeon pea]	Pod borer	IPEN	Alternatives in India (recommended by the Government of India)
Helicoverpa armigera nuclear polyhedrosis virus (NPV)	Bengal gram	Pod borer	IPEN	Alternatives in India (recommended by the Government of India)
Bacillus thuringiensis	Bengal gram	Pod borer	IPEN	Alternatives in India (recommended by the Government of India)
Helicoverpa armigera nuclear polyhedrosis virus (NPV)	Green gram, black gram	Pod borer	IPEN	Alternatives in India (recommended by the Government of India)
Bacillus thuringiensis	Green gram, black gram	Pod borer	IPEN	Alternatives in India (recommended by the Government of India)
Spodoptera litura NPV	Groundnut	Defoliator (Spodoptera litura)	IPEN	Alternatives in India (recommended by the Government of India)
Helicoverpa armigera nuclear polyhedrosis virus (NPV)	Groundnut	Helicoverpa/Spodoptera/ other leafeating caterpillar	IPEN	Alternatives in India (recommended by the Government of India)
Bacillus thuringiensis	Mustard	Leaf webber	IPEN	Alternatives in India (recommended by the Government of India)
Helicoverpa armigera nuclear polyhedrosis virus (NPV)	Sunflower	Helicoverpa (head borer)	IPEN	Alternatives in India (recommended by the Government of India)
Helicoverpa armigera nuclear polyhedrosis virus (NPV)	Sorghum	Gram pod borer	IPEN	Alternatives in India (recommended by the Government of India)
Bacillus thuringiensis	Sorghum	Gram pod borer	IPEN	Alternatives in India (recommended by the Government of India)
Trichogramma Chilonis	Cotton	Spotted bollworm; pink bollworm; Helicoverpa; Red cotton bug; Dusky cotton bug	IPEN	Alternatives in India (recommended by the Government of India)
Bacillus thuringiensis	Cotton	Spotted bollworm; pink bollworm; Helicoverpa; Red cotton bug; Dusky cotton bug	IPEN	Alternatives in India (recommended by the Government of India)
Helicoverpa armigera NPV	Cotton	Spotted bollworm; pink bollworm; Helicoverpa; Red cotton bug; Dusky cotton bug	IPEN	Alternatives in India (recommended by the Government of India)

Alternative biological control agent	Crop or crop type	Pest or pest type	Information source	Note
Trichogramma japonicum	Sugarcane	Top shoot borer; Internode borer	IPEN	Alternatives in India (recommended by the Government of India)
Trichogramma chilonis	Sugarcane	Top shoot borer; Internode borer	IPEN	Alternatives in India (recommended by the Government of India)
Trichogramma Chilonis	Tomato	Fruit borer (Helicoverpa armigera)	IPEN	Alternatives in India (recommended by the Government of India)
Bacillus thuringiensis	Tomato	Fruit borer (Helicoverpa armigera)	IPEN	Alternatives in India (recommended by the Government of India)
Helicoverpa armigera NPV	Tomato	Fruit borer (Helicoverpa armigera)	IPEN	Alternatives in India (recommended by the Government of India)
Bacillus thuringiensis	Cabbage/Cauliflower	Cabbage borer	IPEN	Alternatives in India (recommended by the Government of India)
Bacillus thuringiensis	Cabbage/Cauliflower	Leaf webber (Crocidoloma binotalis)	IPEN	Alternatives in India (recommended by the Government of India)
Bacillus thuringiensis	Cabbage/Cauliflower	Cabbage butterfly	IPEN	Alternatives in India (recommended by the Government of India)
Bacillus thuringiensis	Pea	Pod borer	IPEN	Alternatives in India (recommended by the Government of India)
Helicoverpa armigera NPV	Pea	Pod borer	IPEN	Alternatives in India (recommended by the Government of India)

Table 12. Semio-chemical alternatives to endosulfan identified from information submitted according to Annex F 2010

Alternative semio-chemical	Crop or crop type	Pest or pest type	Information source	Note
pheromone	Pear	Codling moth	Canada	
pheromone	Apple	Codling moth	Canada	
pheromone	Apricot	Peachtree borer	Canada	
pheromone	Cherry	Peachtree borer	Canada	
pheromone	Peach	Peachtree borer	Canada	
pheromone	Plum	Peachtree borer	Canada	
pheromone	Groundnut	Defoliator (Spodoptera litura)	India	
pheromone	Sunflower	Helicoverpa (head borer)	India	
pheromone	Tomato	Fruit borer (Helicoverpa armigera)	India	

Annex II - Results from the literature review on the efficacy of chemical alternatives compared to endosulfan

An important question is whether alternatives are equally efficient compared to endosulfan.

A review of scientific literature related to the efficiency of 46 identified chemical alternatives to endosulfan has shown that out of 78 scientific papers the alternative was in 152 cases more efficient, in 18 cases equally efficient and in 68 cases less efficient than endosulfan.

In 4 cases a conclusion was not possible. In 9 cases development of resistance was reported (pest: *Helicoverpa armigera*). In 7 cases the pest developed stronger resistance against the alternatives (cypermethrin, chlorpiriphos, profenophos, methomyl, carbaryl, thiodicarb) than against endosulfan. In 1 case the pest developed slightly stronger resistance against endosulfan than against the alternative (quinalphos). In 1 case (spinosad) a conclusion was not possible.

Hence it can be expected that in most cases chemical alternatives will be more efficient than endosulfan. Considering the whole spectrum of chemical and non-chemical alternatives it can be assumed that endosulfan can in most cases be substituted by equally or more efficient alternatives.

In specific cases development of resistance may become a problem. However in the case of Helicoverpa armigera there seems to be at least one more efficient alternative chemical substance concerning resistance (quinalphos).

The following table gives an overview of results from the literature review on the efficacy of chemical alternatives compared to endosulfan. Below the table the abstracts of the literature sources are compiled.

Table 13. Overview of results from the literature review on the efficacy of chemical alternatives compared to endosulfan

Substance compared to Endosulfan	Treated species	Test criteria	Result	Conclusion	Source (Article No.)
monocrotophos (0.05%)	Pea pod borer, Lampides boeticus (Linn.)	reduction of pod damage	88.63% reduction in year 2000 and 93.72% in year 2001 reduction with endosulfan (0.05 %) at par with monocrotophos	equally efficient	2
dimethoate	whitefly (Bemisia tabaci Genn.)	on the basis of LC50 value detected toxicity compared to those of methyl demeton, taken as standard	15 times more toxic than methyl demeton (endosulfan 3.33 times more toxic than methyl demeton)	more efficient	3
profenophos	whitefly (Bemisia tabaci Genn.)	on the basis of LC50 value detected toxicity compared to those of methyl demeton, taken as standard	10 times more toxic than methyl demeton (endosulfan 3.33 times more toxic than methy demeton)	more efficient	3
triazophos	whitefly (Bemisia tabaci Genn.)	on the basis of LC50 value detected toxicity compared to those of methyl demeton, taken as standard	10 times more toxic than methyl demeton (endosulfan 3.33 times more toxic than methy demeton)	more efficient	3
imidacloprid	whitefly (Bemisia tabaci Genn.)	on the basis of LC50 value detected toxicity compared to those of methyl demeton, taken as standard	5 times more toxic than methyl demeton (endosulfan 3.33 times more toxic than methy demeton)	more efficient	3

Substance compared to Endosulfan	Treated species	Test criteria	Result	Conclusion	Source (Article No.)
monocrotophos	whitefly (Bemisia tabaci Genn.)	on the basis of LC50 value detected toxicity compared to those of methyl demeton, taken as standard	3.75 times more toxic than methyl demeton (endosulfan 3.33 times more toxic than methy demeton)	more efficient	3
cypermethrin	Helicoverpa armigera (Hubner)	LD50 (µg/larva)	1.399 (LD50 endosulfan = 3.359)	more efficient	4
chlorpyriphos	Helicoverpa armigera (Hubner)	LD50 (µg/larva)	0.729 (LD50 endosulfan = 3.359)	more efficient	4
quinalphos	Helicoverpa armigera (Hubner)	LD50 (µg/larva)	0.680 (LD50 endosulfan = 3.359)	more efficient	4
profenophos	Helicoverpa armigera (Hubner)	LD50 (µg/larva)	0.320 (LD50 endosulfan = 3.359)	more efficient	4
methomyl	Helicoverpa armigera (Hubner)	LD50 (µg/larva)	1.515 (LD50 endosulfan = 3.359)	more efficient	4
spinosad	Helicoverpa armigera (Hubner)	LD50 (µg/larva)	0.0641 (LD50 endosulfan = 3.359)	more efficient	4
cypermethrin	Helicoverpa armigera (Hubner)	developed resistance	279.80 folds resistance (6.09 with endosulfan)	less efficient	4
chlorpyriphos	Helicoverpa armigera (Hubner)	developed resistance	36.45 (6.09 with endosulfan)	less efficient	4
quinalphos	Helicoverpa armigera (Hubner)	developed resistance	6.01 (6.09 with endosulfan)	more efficient	4
profenophos	Helicoverpa armigera (Hubner)	developed resistance	6.27 (6.09 with endosulfan)	less efficient	4
methomyl	Helicoverpa armigera (Hubner)	developed resistance	11.65 (6.09 with endosulfan)	less efficient	4
spinosad	Helicoverpa armigera (Hubner)	developed resistance	-	no conclusion possible	4
ethofenprox	Cyrtorhinus lividipennis	LC50 (ppm)	0.006 ppm (LC50 endosulfan = 66.651 ppm)	more efficient	5
thiamethoxam	Cyrtorhinus lividipennis	persistency	causing mortality up to 28 days after application (no persistency for endosulfan available)	more efficient	5
Imidacloprid	Cyrtorhinus lividipennis	persistency	causing mortality up to 14 days after application (no persistency for endosulfan available)	more efficient	5
Bifenthrin 10 EC	pod fly, Melanagromyza obtusa Malloch	grain damage	applied concentration: 80 g a.i./ha lowest grain damage (13.2%) detected, compared to control plot (19%)	more efficient	6
flubendiamide 20 WG	gram pod borer, Helicoverpa armigera (Hubner)	pod damage (%)	9.2 (applied with 50 g a.i./ha) 18.1 (with endosulfan 35 EC applied with 700 g a.i./ha)	more efficient	6
Emamectin 5 WSG	gram pod borer, Helicoverpa armigera (Hubner)	grain yield	810 kg/ha (applied with 11 g a.i./ha) minimum (370 kg/ha) grain yield obtained in control plot	more efficient	6

Substance compared to Endosulfan	Treated species	Test criteria	Result	Conclusion	Source (Article No.)
Bifenthrin 10 EC	gram pod borer, Helicoverpa armigera (Hubner)	grain yield	800 kg/ha (applied with 80 g a.i./ha) minimum (370 kg/ha) grain yield obtained in control plot	more efficient	6
Indoxacarb 15% SC	pigeonpea pod borer Helicoverpa armigera (Hubner)	pod damage, grain yield	five dosages (25, 50, 75, 100 and 150 g ai per ha) Indoxacarb 15% SC @ 50 g ai per ha recorded lower pod damage and higher grain yield compared with check (sequential spray of monocrotophos followed by endosulfan followed by quinalphos) and untreated check	more efficient	7
Novaluron	Chickpea pod borer, Helicoverpa armigera (Hubner)	pod damage	applied concentrations: 50, 75 and 100 g a.i./ha; 4.83 % pod damage detected at 100 g a.i./ha; pod damage with endosulfan between 7.16 and 8.62 %	more efficient	8
emamectin benzoate	Chickpea pod borer, Helicoverpa armigera (Hubner)	pod damage	applied concentrations: 8, 9 and 11 g a.i./ha 5.13 % pod damage detected at 11 g a.i./ha; pod damage with endosulfan between 7.16 and 8.62 %	more efficient	8
spinosad	Chickpea pod borer, Helicoverpa armigera (Hubner)	pod damage	applied concentration: 60 g a.i./ha 6.83 % pod damage detected; pod damage with endosulfan between 7.16 and 8.62 %	more efficient	8
profenofos	Chickpea pod borer, Helicoverpa armigera (Hubner)	pod damage	applied concentration: 750 g a.i./ha pod damage between 7.16 and 8.62 %; correlation to endosulfan unknown	no conclusion possible	8
methomyl	Chickpea pod borer, Helicoverpa armigera (Hubner)	pod damage	applied concentration: 250 g a.i./ha pod damage between 7.16 and 8.62 %; correlation to endosulfan unknown	no conclusion possible	8
indoxacarb	Chickpea pod borer, Helicoverpa armigera (Hubner)	pod damage	applied concentration: 72.5 g a.i./ha pod damage between 7.16 and 8.62 %; correlation to endosulfan unknown	no conclusion possible	8
indoxacarb 15 SC	tomato fruit borer, Helicoverpa armigera	fruit damage	applied concentration: 50, 60 and 75 g ai/ha (applied concentration of endosulfan: 750 g ai/ha) detected fruit damages: 7.87%, 10.10% and 12.93 % (damage with endosulfan: 15.3 %)	more efficient	9

Substance compared to Endosulfan	Treated species	Test criteria	Result	Conclusion	Source (Article No.)
indoxacarb 15 SC	tomato fruit borer, Helicoverpa armigera	grain yield	260.78 q/ha (at 75 g ai/ha), 259.78 and 257.35 q/ha at 50 and 60 g ai/ha applied concentration of indoxacarb achievement of highest yield in test series, compared with other insecticides, inter alias endosulfan	more efficient	9
Spinosad 45 SC	pod borer, Helicoverpa armigera, Hub	reduction of larval population	applied concentration: 90 g a.i./ha 0.29 larvae/plant; more efficient than endosulfan 40 SC	more efficient	10
Spinosad 45 SC	pod borer, Helicoverpa armigera, Hub	pod damage	applied concentration: 90 g a.i./ha pod damage: 5.62 %; lowest pod damage in test series	more efficient	10
Spinosad 45 SC	pod borer, Helicoverpa armigera, Hub	grain damage	applied concentration: 90 g a.i./ha grain damage: 22.85 %; lowest grain damage in test series	more efficient	10
Spinosad 45 SC	pod borer, Helicoverpa armigera, Hub	grain yield	applied concentration: 90 g a.i./ha grain yield: 1681 kg/ha; highest yield in test series	more efficient	10
Pyridaben	blueberry bud mite (Acalitus vaccinii)	reduction of population	49 % mite reduction (97 % reduction with endosulfan)	less efficient	11
chlorpyriphos	pigeonpea pod borer	return Rs per rupee invested	obtained value (Rs.2.20) lower than those of endosulfan 35 EC (Rs. 3.71)	less efficient	12
Lime sulphur (1:30)	yellow mite (Oligonychus sacchari)	frequency of mite infestation	significant and maximal reduction in the frequency of mite infestation compared to rest of treatments, inter alias endosulfan 35 EC	more efficient	13
Lime sulphur (1:30)	yellow mite (Oligonychus sacchari)	cane yield	maximum in cane yield in test series	more efficient	13
S-kinoprene	Orius insidiosus (Hemiptera: Anthocoridae)	contact toxicity	S-kinoprene was the most innocuous in this test series compared with other insecticides (inter alias endosulfan)	less efficient	14
Dicofol 0.04 %	Sorghum mite, Oligonychus indicus Hirst	population reduction	75.60 and 75.75 % population reduction in two successive years (was statistically at par with Endosulfan 0.075%)	equally efficient	15
β-cyfluthrin	Helicoverpa armigera (Hübner)	yield	applied concentrations: 12.50, 18.75 and 25.00 g ai/ha higher yields have been achieved compared with other insecticides, inter alias endosulfan	more efficient	16
Cypermethrin	Spodoptera litura (Fab.)	LC50 (ml/lit)	5.846 ml/lit (LC50 endosulfan = 6.094 ml /lit)	more efficient	18
cypermethrin	Aulacophora foveicollis	adult mortality	highest mortality observed (together with endosulfan 0.04 %)	more efficient	19
cypermethrin	Aulacophora foveicollis	protection	treatment yielded in highest protection (togehtehr with endosulfan 0.04 %)	more efficient	19
cypemethrin 0.005 %	E. machaeralis	efficiency (no further specifications)	most effective treatment (compared with endosulfan 0.05 %)	more efficient	20

Substance compared to Endosulfan	Treated species	Test criteria	Result	Conclusion	Source (Article No.)
monocrotophos 0.05 %	E. machaeralis	efficiency (no further specifications)	least effective treatment (compared with endosulfan 0.05 %)	less efficient	20
cypemethrin 0.005 %	H. puera	control (no further specifications)	most effective control (together with endosulfan 0.05 %)	more efficient	20
Spinosad 48 SC	Helicoverpa armigera	reduction of larval population	applied concentration: 150 ml/ha most effective in this test series (compared with Endosulfan 35 EC @ 1250 ml/ha and 2500 ml/ha)	more efficient	21
Indoxicarb 15 EC	Helicoverpa armigera	reduction of larval population	applied concentration: 500 ml/ha more effective than Endosulfan 35 EC @ 1250 ml/ha and 2500 ml/ha	more efficient	21
Cypermethrin 25 EC	Helicoverpa armigera	reduction of larval population	applied concentration: 200 ml/ha substance was the heapest one	less efficient	21
Indoxacarb	okra fruit borer, Earias vittella (Fab.)	population reduction	applied concentration: 75 g a.i./ha (applied concentration endosulfan: 500 g a.i./ha) 78.6% population reduction	more efficient	22
Lambda-cyhalothrin	okra fruit borer, Earias vittella (Fab.)	population reduction	applied concentration: 50 g a.i./ha (applied concentration endosulfan: 500 g a.i./ha) 71.2 % population reduction	more efficient	22
Quinalphos	Rhizoctonia solani	reduction of cowpea seedling rot in soil	quinalphos was only substance, which reduced cowpea seedling rot in soil infested with R. solani; other insecticides, inter alias endosulfan showed little or no effects	more efficient	23
carbofuran 3G	Chilo partellus (Swinhoe)	protection against borer	applied concentration: 7.5 kg/ha	no conclusion possible	24
Carbofuran	weevil Myllocerus viridanus fabricius (Coleoptera:Curculionidae)	toxicity to larvae	substance was the most toxic one	more efficient	25
carbaryl 0.2 %	tomato leafhopper	reduction of leafhopper population	treatment with substance resulted in highest reduction of population (compared with other insicticides, inter alias 0.04 % endosulfan)	more efficient	26
lambda-cyhalothrin 0.01 %	tomato leafhopper	reduction of leafhopper population	treatment with substance resulted in higher reduction of population than treatment with endosulfan 0.04 %	more efficient	26
lambda-cyhalothrin 0.01 %	tomato fruit borer	reduction of fruit borer population	substance was most effective (compared with other insecticides, inter alias endosulfan 0.04 %)	more efficient	26
lambda-cyhalothrin 0.01 %	tomato fruit borer	yield	highest yield was obtained (compared with other insecticides, intera alias endosulfan 0.04 %)	more efficient	26
carbaryl 0.2 %	tomato fruit borer	yield	higher yield was obtained than endosulfan 0.04%	more efficient	26
fenvalerate 0.0125%	tomato fruit borer	yield	higher yield was obtained than endosulfan 0.04%	more efficient	26

Substance compared to Endosulfan	Treated species	Test criteria	Result	Conclusion	Source (Article No.)
carbaryl	Brinjal Fruit and Shoot Borer, Leucinodes orbonalis	fruit damage (%)	21.6 % fruit damage (lower than after treatment with endosulfan (20.0 %))	less efficient	27
carbaryl	Brinjal Fruit and Shoot Borer, Leucinodes orbonalis	Cost - benefit ratio	resulted in minimum of cost-benefit ratio (1: 5.10)	less efficient	27
fenvalerate	Brinjal Fruit and Shoot Borer, Leucinodes orbonalis	Cost - benefit ratio	resulted in maximum of cost-benefit ratio (1: 20.44)	less efficient	27
carbaryl	Brinjal Fruit and Shoot Borer, Leucinodes orbonalis	yield (q/ha)	resulted in lowest yield (225.7 q/ha)	less efficient	27
carbaryl	Brinjal Fruit and Shoot Borer, Leucinodes orbonalis	net gain (USD)	lowest net gain (USD 587.49)	less efficient	27
cypermethrin 25 EC	gram pod borer, Helicoverpa armigera (Hubner)	reduction of pod infestation	Cypermethrin (0.009, 0.0075 and 0.006%) was most effective in this test series (compared with, inter alias endosulfan 35 EC (0.13, 0.1 and 0.07%))	more efficient	28
monocrotophos 36 WSC	gram pod borer, Helicoverpa armigera (Hubner)	reduction of pod infestation	monocrotophos (0.08, 0.06 and 0.04%) was more efficient than endosulfan 35 EC (0.13, 0.1 and 0.07%)	more efficient	28
carbaryl 50 WP	gram pod borer, Helicoverpa armigera (Hubner)	reduction of pod infestation	carbaryl (0.3, 0.2 and 0.1%) was less efficient than endosulfan 35 EC (0.13, 0.1 and 0.07%)	less efficient	28
neem oil 0.15 EC	gram pod borer, Helicoverpa armigera (Hubner)	reduction of pod infestation	neem oil (0.30, 0.20 and 0.10%) was less efficient than endosulfan 35 EC (0.13, 0.1 and 0.07%)	less efficient	28
acetamiprid	glassy-winged sharpshooter, Homalodisca coagulata (Hemiptera: Cicadellidae)	LC50 values (ng(AI)/ml)	0.017 ng (AI)/ml substance was most toxic	more efficient	29
bifenthrin	glassy-winged sharpshooter, Homalodisca coagulata (Hemiptera: Cicadellidae)	LC50 values (ng(AI)/ml)	0.686 ng/ml ng (AI)/ml substance was more toxic than endosulfan	more efficient	29
Acetamiprid	mustard aphid (Lipaphis erysimi)	population reduction	91.73 % reduction (reduction with endosulfan: 77.89 %)	more efficient	30
dimethoate	mustard aphid (Lipaphis erysimi)	population reduction	88.73 % reduction (reduction with endosulfan: 77.89 %)	more efficient	30
imidacloprid	mustard aphid (Lipaphis erysimi)	population reduction	86.02 % reduction (reduction with endosulfan: 77.89 %)	more efficient	30
Novaluron	mustard aphid (Lipaphis erysimi)	population reduction	78.73 % reduction (reduction with endosulfan: 77.89 %)	more efficient	30
abamectin	broad mite, Polyphagotarsone mus lotus	LC50 (g a.i./l)	4.9 × 10-8 (LC50 endosulfan = 1.1 × 10-3 g a.i./l)	more efficient	31

Substance compared to Endosulfan	Treated species	Test criteria	Result	Conclusion	Source (Article No.)
pyridaben	broad mite, Polyphagotarsonemus lotus	LC50 (g a.i./l)	4.1 × 10-3 (LC50 endosulfan = 1.1 × 10-3 g a.i./l)	less efficient	31
dicofol	broad mite, Polyphagotarsonemus lotus	LC50 (g a.i./l)	4.5 × 10-3 (LC50 endosulfan = 1.1 × 10-3 g a.i./l)	less efficient	31
methamidophos	Frankliniella occidentalis (Pergande)	efficacy	substance was moderately effective (endosulfan was ineffective)	more efficient	33
monocrotophos	Tobacco ground beetle, Mesomorphus villiger Blanch (Tenebrionidae: Coleoptera)	toxicity	substance was more toxic than endosulfan	more efficient	34
chlorpyrifos	Tobacco ground beetle, Mesomorphus villiger Blanch (Tenebrionidae: Coleoptera)	toxicity	substance was more toxic than endosulfan	more efficient	34
fenvalerate	Tobacco ground beetle, Mesomorphus villiger Blanch (Tenebrionidae: Coleoptera)	toxicity	substance was less toxic than endosulfan	less efficient	34
carbaryl	Tobacco ground beetle, Mesomorphus villiger Blanch (Tenebrionidae: Coleoptera)	toxicity	substance was less toxic than endosulfan	less efficient	34
chlorpyrifos	Tobacco ground beetle, Mesomorphus villiger Blanch (Tenebrionidae: Coleoptera)	toxicity	substance was less toxic than endosulfan	less efficient	34
monocrotophos	Tobacco ground beetle, Mesomorphus villiger Blanch (Tenebrionidae: Coleoptera)	net returns (Rs) / benefit: cost ratio	Rs 25 280 / 1.89:1 (endosulfan: Rs 26 270 / 1.92:1)	less efficient	34
chlorpyrifos	Tobacco ground beetle, Mesomorphus villiger Blanch (Tenebrionidae: Coleoptera)	net returns (Rs) / benefit: cost ratio	Rs 24 469 / 1.86:1 (endosulfan: Rs 26 270 / 1.92:1)	less efficient	34
fenvalerate	Tobacco ground beetle, Mesomorphus villiger Blanch (Tenebrionidae: Coleoptera)	net returns (Rs) / benefit: cost ratio	Rs 22 419 / 1,79:1 (endosulfan: Rs 26 270 / 1.92:1)	less efficient	34
carbaryl	Tobacco ground beetle, Mesomorphus villiger Blanch (Tenebrionidae: Coleoptera)	net returns (Rs) / benefit: cost ratio	Rs 21 991 / 1.78:1 (endosulfan: Rs 26 270 / 1.92:1)	less efficient	34
profenofos	Helicoverpa armigera	toxicity	substance was more toxic than endosulfan	more efficient	35

Substance compared to Endosulfan	Treated species	Test criteria	Result	Conclusion	Source (Article No.)
chlorpyrifos	Helicoverpa armigera	toxicity	substance was more toxic than endosulfan	more efficient	35
methomyl	Helicoverpa armigera	toxicity	substance was more toxic than endosulfan	more efficient	35
thiodicarb	Helicoverpa armigera	toxicity	substance was more toxic than endosulfan	more efficient	35
cypermethrin	Helicoverpa armigera	toxicity	substance was more toxic than endosulfan	more efficient	35
quinalphos	Helicoverpa armigera	toxicity	substance was more toxic than endosulfan	more efficient	35
phoxim	leaf worm, Spodoptera litura (Lepidoptera: Noctuidae)	time-oriented mortality	substance showed higher efficiency than other substances, inter alias endosulfan	more efficient	36
Emamectin benzoate	leaf worm, Spodoptera litura (Lepidoptera: Noctuidae)	time-oriented mortality and LC50	substance proved to be the most efficient insecticide in new chemistry insecticides tested (3 groups of substances have been examined: pyrethroids, organophosphate and new chemistry insecticides)	more efficient	36
abamectin	leaf worm, Spodoptera litura (Lepidoptera: Noctuidae)	time-oriented mortality and LC50	substance was least effective insicticide	less efficient	36
fipronil	boll weevil (Anthonomus grandis)	control (calculated from damage levels in the treated plots compared to the untreated)	64 % control (endosulfan 45 % control)	more efficient	37
Fipronil	Catolaccus grandis (Burks)	toxicity	more toxic to females (compared with other insecticides, inter alias endosulfan) test performed at full rate	more efficinet	38
malathion	Catolaccus grandis (Burks)	toxicity	more toxic to females (compared with other insecticides, inter alias endosulfan) test performed at full rate	more efficinet	38
spinosad	Catolaccus grandis (Burks)	toxicity	substance was least toxic	less efficient	38
malathion	Catolaccus grandis (Burks)	toxicity	more toxic to females (compared with other insecticides, inter alias endosulfan) test performed at reduced rate	more efficinet	38
acetamiprid	brown plant hopper (Nilaparvata lugens)	values of relative toxicity calculated in comparison to LC50 value of monocrotophos	substance less toxic than monocrotophos -> less efficient than endosulfan, due to higher toxicity of endosulfan than monocrotophos	less efficient	39
thiamethoxam	brown plant hopper (Nilaparvata lugens)	values of relative toxicity calculated in comparison to LC50 value of monocrotophos	substance less toxic than monocrotophos -> less efficient than endosulfan, due to higher toxicity of endosulfan than monocrotophos	less efficient	39
imidacloprid	brown plant hopper (Nilaparvata lugens)	relative toxicity derived on the basis of LC50 and LC 97.5 values	less toxic than endosulfan	less efficient	39

Substance compared to Endosulfan	Treated species	Test criteria	Result	Conclusion	Source (Article No.)
chlorpyriphos	brown plant hopper (Nilaparvata lugens)	relative toxicity derived on the basis of LC50 and LC 97.5 values	less toxic than endosulfan	less efficient	39
bifenthrin	cabbage seedpod weevil (Coleoptera: Curculionidae)	prevention of pod infestation	substance was more effective than endosulfan	more efficient	40
esfenvalerate	cabbage seedpod weevil (Coleoptera: Curculionidae)	prevention of pod infestation	substance was more effective than endosulfan	more efficient	40
bifenthrin	silverleaf whitefly, Bemisia argentifolii	reduction of population	substance was more effective than endosulfan	more efficient	41
Chlorpyrifos	greenhouse whitefly, Trialeurodes vaporariorum	LC90 value	substance is less efficient than endosulfan	less efficient	42
malathion	greenhouse whitefly, Trialeurodes vaporariorum	LC90 value	substance is less efficient than endosulfan	less efficient	42
methomyl	greenhouse whitefly, Trialeurodes vaporariorum	LC90 value	substance is less efficient than endosulfan	less efficient	42
bifenthrin	greenhouse whitefly, Trialeurodes vaporariorum	LC90 value	substance is more efficient than endosulfan	more efficient	42
enpropathrin	greenhouse whitefly, Trialeurodes vaporariorum	LC90 value	substance is more efficient than endosulfan	more efficient	42
cypermethrin	Helicoverpa armigera Hub	borer population	0.50 larvae/5 heads (0.73 larvae/5 heads with endosulfan)	more efficient	43
cypermethrin	Helicoverpa armigera Hub	seed yield (q/ha)	20.58 (21.31 with endosulfan)	less efficient	43
malathion ULV	boll weevil, Anthonomus grandis grandis (Boheman)	mortality (%) after 24 h	97.9 % (86.6 % with endosulfan)	more efficient	44
bifenthrin	boll weevil, Anthonomus grandis grandis (Boheman)	mortality (%) after 24 h	80.2 % (86.6 % with endosulfan)	less efficient	44
malathion ULV	boll weevil, Anthonomus grandis grandis (Boheman)	mortality (%) after 48 h	100 % (94.9 % with endosulfan)	more efficient	44
bifenthrin	boll weevil, Anthonomus grandis grandis (Boheman)	mortality (%) after 48 h	95 % (94.9 % with endosulfan)	more efficient	44
triazophos 0.05 %	ashew leaf miner, Acrocercops syngramma	larval mortality	treatment yielded in highest mean per cent larval mortality (compared with, inter alias endosulfan 0.03 %)	more efficient	45
cypermethrin 0.0075 %	ashew leaf miner, Acrocercops syngramma	larval mortality	equally efficient as endosulfan 0.03 %	equally efficient	45

Substance compared to Endosulfan	Treated species	Test criteria	Result	Conclusion	Source (Article No.)
dimethoate 0.03 %	ashew leaf miner, Acrocercops syngramma	larval mortality	equally efficient as endosulfan 0.03 %	equally efficient	45
acephate 0.07 %	ashew leaf miner, Acrocercops syngramma	larval mortality	less efficient as endosulfan 0.03 %	less efficient	45
quinalphos 0.04%	pod borers Catechrysops cnejus F., Maruca vitrata Gey., Helicoverpa armigera Hb. and Etiella zinckenella Tret.	cumulative damage level	6.2 % (7.5 % with endosulfan 0.07 %)	more efficient	46
profenofos 0.1 %	pod borers Catechrysops cnejus F., Maruca vitrata Gey., Helicoverpa armigera Hb. and Etiella zinckenella Tret.	cumulative damage level	6.5 % (7.5 % with endosulfan 0.07 %)	more efficient	46
dimethoate 0.03 %	pod borers Catechrysops cnejus F., Maruca vitrata Gey., Helicoverpa armigera Hb. and Etiella zinckenella Tret.	cumulative damage level	7.5 % (7.5 % with endosulfan 0.07 %)	equally efficient	46
acephate 0.075%	pod borers Catechrysops cnejus F., Maruca vitrata Gey., Helicoverpa armigera Hb. and Etiella zinckenella Tret.	cumulative damage level	7.7 % (7.5 % with endosulfan 0.07 %)	less efficient	46
lambda cyhalothrin (Karate 5 EC)	mango leafhoppers Idioscopus niveosparsus (Leth.), Idioscopus clypealis (Leth.) and Amritodus atkinsoni (Leth.)	population of mango leafhoppers/inflorescence	least leafhoppers population (0.03) leaf hopper population with endosulfan: 2.06	more efficient	47
Imidacloprid (Confidor 200 SL)	mango leafhoppers Idioscopus niveosparsus (Leth.), Idioscopus clypealis (Leth.) and Amritodus atkinsoni (Leth.)	population of mango leafhoppers/inflorescence	least leafhoppers population (0.03) leaf hopper population with endosulfan: 2.06	more efficient	47
Monocrotophos	mango leafhoppers Idioscopus niveosparsus (Leth.), Idioscopus clypealis (Leth.) and Amritodus atkinsoni (Leth.)	population of mango leafhoppers/inflorescence	least leafhoppers population (0.59) leaf hopper population with endosulfan: 2.06	more efficient	47

Substance compared to Endosulfan	Treated species	Test criteria	Result	Conclusion	Source (Article No.)
cypermethrin	mango leafhoppers Idioscopus niveosparsus (Leth.), Idioscopus clypealis (Leth.) and Amritodus atkinsoni (Leth.)	population of mango leafhoppers/inflorescence	leaf hopper population < leaf hopper populationendosulfan (2.06)	more efficient	47
acephate	mango leafhoppers Idioscopus niveosparsus (Leth.), Idioscopus clypealis (Leth.) and Amritodus atkinsoni (Leth.)	population of mango leafhoppers/inflorescence	leaf hopper population < leaf hopper populationendosulfan (2.06)	more efficient	47
difenthiuron	mango leafhoppers Idioscopus niveosparsus (Leth.), Idioscopus clypealis (Leth.) and Amritodus atkinsoni (Leth.)	population of mango leafhoppers/inflorescence	least leafhoppers population (1.45) leaf hopper population with endosulfan: 2.06	more efficient	47
Fipronil	mango leafhoppers Idioscopus niveosparsus (Leth.), Idioscopus clypealis (Leth.) and Amritodus atkinsoni (Leth.)	population of mango leafhoppers/inflorescence	least leafhoppers population (1.59) leaf hopper population with endosulfan: 2.06	more efficient	47
imidacloprid 0.01%	Macrosiphoniella sanborni Gillete	aphids/shoot	2.76 aphids/shoot more efficient than endosulfan 0.05 %	more efficient	48
acephate 0.075%	Macrosiphoniella sanborni Gillete	aphids/shoot	more efficient than endosulfan 0.05 %	more efficient	48
fipronil 0.02%	Macrosiphoniella sanborni Gillete	aphids/shoot	more efficient than endosulfan 0.05 %	more efficient	48
dimethoate 0.03%	Macrosiphoniella sanborni Gillete	aphids/shoot	more efficient than endosulfan 0.05 %	more efficient	48
chlorpyriphos 0.05%	Macrosiphoniella sanborni Gillete	aphids/shoot	more efficient than endosulfan 0.05 %	more efficient	48
quinalphos 0.05%	Macrosiphoniella sanborni Gillete	aphids/shoot	more efficient than endosulfan 0.05 %	more efficient	48
monocrotophos 0.05%	Macrosiphoniella sanborni Gillete	aphids/shoot	more efficient than endosulfan 0.05 %	more efficient	48
cypermethrin 0.01%	Macrosiphoniella sanborni Gillete	aphids/shoot	less efficient than endosulfan 0.05 %	less efficient	48
chlorpyriphos 0.05%	Liriomyza trifolii	aphids/shoot	more efficient than endosulfan 0.05 %	more efficient	48
cypermethrin 0.01%	Liriomyza trifolii	aphids/shoot	more efficient than endosulfan 0.05 %	more efficient	48
acephate 0.075%	Liriomyza trifolii	aphids/shoot	more efficient than endosulfan 0.05 %	more efficient	48
fipronil 0.02%	Liriomyza trifolii	aphids/shoot	more efficient than endosulfan 0.05 %	more efficient	48
quinalphos 0.05%	Liriomyza trifolii	aphids/shoot	more efficient than endosulfan 0.05 %	more efficient	48

Substance compared to Endosulfan	Treated species	Test criteria	Result	Conclusion	Source (Article No.)
imidacloprid 0.01%	Liriomyza trifolii	aphids/shoot	more efficient than endosulfan 0.05 %	more efficient	48
dimethoate 0.03%	Liriomyza trifolii	aphids/shoot	more efficient than endosulfan 0.05 %	more efficient	48
monocrotophos 0.05%.	Liriomyza trifolii	aphids/shoot	less efficient than endosulfan 0.05 %	less efficient	48
Acephate	aphid, jassid and whiteflies	reduction of popultaion	applied concentrations: 0.5, 1.0 and 1.5 g/l application of acephate @ 1.5 g/lit was more efficient than endosulfan 35% EC @ 2 ml/l	more efficient	49
Malathion 50% EC	aphid, jassid and whiteflies	reduction of popultaion	substance was equally efficient as endosulfan 35 % EC	equally efficient	49
Acephate	aphid, jassid and whiteflies	marketable yield	substance at .5 g/l was equall efficient as endosulfan 35 % EC @ 2 ml/l	equally efficient	49
Imidacloprid 0.05%	mango hoppers Amritodus atikinsoni Lethierry	population reduction	96.56 % (data for endosulfan not available)	more efficient	50
Acetamiprid 0.005%	mango hoppers Amritodus atikinsoni Lethierry	population reduction	94.39 % (data for endosulfan not avialbale)	more efficient	50
Thiamethoxam	parasitoid Trichogramma chilonis	LC50 (mg a.i./l)	0.0014 mg a.i./l (LC50 endosulfan = 1.8501 mg a.i./l)	more efficient	51
imidacloprid	parasitoid Trichogramma chilonis	LC50 (mg a.i./l)	0.0027 mg a.i./l (LC50 endosulfan = 1.8501 mg a.i./l)	more efficient	51
acephate	parasitoid Trichogramma chilonis	LC50 (mg a.i./l)	4.4703 mg a.i./l (LC50 endosulfan = 1.8501 mg a.i./l)	less efficient	51
Imidacloprid	Geocoris punctipes (Hemiptera: Lygaeidae)	toxicity	significantly less toxic to male G. punctipes than endosulfan	less efficient	53
tebufenozide	Geocoris punctipes (Hemiptera: Lygaeidae)	toxicity	significantly less toxic to male G. punctipes than endosulfan	less efficient	53
spinosad	Geocoris punctipes (Hemiptera: Lygaeidae)	toxicity	significantly less toxic to male G. punctipes than endosulfan	less efficient	53
Spinosad	Geocoris punctipes (Hemiptera: Lygaeidae)	toxicity	significantly less toxic to female G. punctipes than endosulfan	less efficient	53
tebufenozide	Geocoris punctipes (Hemiptera: Lygaeidae)	toxicity	significantly less toxic to female G. punctipes than endosulfan	less efficient	53
azinphos-methyl	Geocoris punctipes (Hemiptera: Lygaeidae)	toxicity	significantly less toxic to female G. punctipes than endosulfan	less efficient	53
carbaryl	Helicoverpa armigera	resistance factors (RF)	RF=11 -> moderate resistance to this substance tretamnet with endosulfan showed low resistance	less efficient	54

Substance compared to Endosulfan	Treated species	Test criteria	Result	Conclusion	Source (Article No.)
methomyl	Helicoverpa armigera	resistance factors (RF)	RF= 12-18 -> moderate resistance to this substance tretamnet with endosulfan showed low resistance	less efficient	54
thiodicarb	Helicoverpa armigera	resistance factors (RF)	RF= 12-18 -> moderate resistance to this substance tretamnet with endosulfan showed low resistance	less efficient	54
Acephate	Leptocorisa acuta (Thunberg)	mortality	applied concentration: 750 g a.i./ha 100 % mortality (mortality of endosulfan (735 g a.i./ha): > 99%)	less efficient	55
monocrotophos	Leptocorisa acuta (Thunberg)	mortality	applied concentration: 300 g a.i./ha 99 % mortality (mortality of endosulfan (735 g a.i./ha): > 99%)	more efficient	55
monocrotophos	Eysarcoris trimaculatus (Distant)	mortality	applied concentration: 300 g a.i./ha 75-100 % mortality (mortality of endosulfan (735 g a.i./ha): > 99%)	more efficient	55
Chlorpyrifos	Leptocorisa acuta (Thunberg)	mortality	applied concentrations: 250, 500 and 750 g a.i./ha almost 100 % with 500 and 750 g a.i./ha, > 98 % with 250 g a.i./ha (mortality of endosulfan (735 g a.i./ha): > 99%)	more efficient (in case of 500 g a.i./ha)	55
Chlorpyrifos	Eysarcoris trimaculatus (Distant)	mortality	applied concentrations: 250, 500 and 750 g a.i./ha almost 100 % with 500 and 750 g a.i./ha, 83 % with 250 g a.i./ha (mortality of endosulfan (735 g a.i./ha): > 99%)	more efficient (in case 500 g a.i./ha)	55
trichlorfon	Anticarsia gemmatalis Hübner	decrease on the percentage of infected larvae	did not differ from the untreated check less efficient than endosulfan	less efficient	56
diflubenzuron	Anticarsia gemmatalis Hübner	decrease on the percentage of infected larvae	caused a significant decrease on the percentage of infected larvae had similar performance as endosulfan	equally efficient	56
methamidophos	Anticarsia gemmatalis Hübner	decrease on the percentage of infected larvae	caused a significant decrease on the percentage of infected larvae had similar performance as endosulfan	equally efficient	56
monocrothophos	Anticarsia gemmatalis Hübner	decrease on the percentage of infected larvae	caused a significant decrease on the percentage of infected larvae had similar performance as endosulfan	equally efficient	56
methyl parathion	Anticarsia gemmatalis Hübner	decrease on the percentage of infected larvae	caused a significant decrease on the percentage of infected larvae had similar performance as endosulfan	equally efficient	56
thiodicarb	Anticarsia gemmatalis Hübner	decrease on the percentage of infected larvae	caused a significant decrease on the percentage of infected larvae had similar performance as endosulfan	equally efficient	56
esfenvalerate	Chrysoperla externa (Hagen)	mortality rate	caused only about 20% mortality of the first- and third-instar larvae and 38% of the second-instar larvae mortality rate with endosulfan significantly higher (71 -100 %)	less efficient	57

Substance compared to Endosulfan	Treated species	Test criteria	Result	Conclusion	Source (Article No.)
deltamethrin	Glyptapanteles militaris (Walsh)	susceptibility of cocoons and adults	was highly toxic to adults but relatively safe when applied on parasitoid cocoons (endosulfan was toxic to all the tested stages)	less efficient	58
tebufenozid	Chrysoperla externa (Hagen)	survival percentage of 2nd-instar larvae	substance was equally selective as endosulfan	equally efficient	59
esfenvalerate	Chrysoperla externa (Hagen)	survival percentage of 2nd-instar larvae	substance was equally selective as endosulfan	equally efficient	59
tebufenozide	Chrysoperla externa (Hagen)	survival percentage of 3nd-instar larvae	no harmfull effects (as with endosulfan) have been detected on larvae	equally efficient	59
esfenvalerate	Chrysoperla externa (Hagen)	survival percentage of 3nd-instar larvae	no harmfull effects (as with endosulfan) have been detected on larvae	equally efficient	59
phosalone	pecan aphid predators Chrysoperla rufilabris (Neuroptera: Chrysopidae), Hippodamia convergens, Cycloneda sanguinea (L.), Olla v-nigrum (Coleoptera: Coccinellidae), and Aphelinus perpallidus (Hymenoptera: Encyrtidae)	mortality rate	substance was least toxic (as endosulfan)	equally efficient	60
triazophos 40 EC	Megalurothrips distalis	yield (kg/ha)	applied concentration: 1.5 L/ha yield: 1392 kg/ha (yield with endosulfan 35 EC at 2.25 L/ha: 1360 kg/ha)	more efficient	61
Dicofol 18.5 EC	palmi Karny Scirtothrips dorsalis Hood	efficiency (no further specifications)	applied concentration: 2500 ml/ha more efficient than Endosulfan 35 EC @ 1000 ml/ha	more efficient	63
Monocrotopho s 36 WSC	palmi Karny Scirtothrips dorsalis Hood	efficiency (no further specifications)	applied concentration: 1000 ml/ha more efficient than Endosulfan 35 EC @ 1000 ml/ha	more effcient	63
Dimethoate 30 EC	palmi Karny Scirtothrips dorsalis Hood	efficiency (no further specifications)	applied concentration: 1700 ml/ha more efficient than Endosulfan 35 EC @ 1000 ml/ha	more effcient	63
deltamethrin 2.8 EC	bollworms on cotton	bollworm infestation / cotton yield	applied concentrations: 12.5, 25.0 and 50.0 g ai/ha deltamethrin 2.8 EC @ 12.5 g ai/ha was found to be optimum and significantly superior to endosulfan	more effcient	64
quinalphos 0.07%	shoot and fruit borer, Leucinodes orbonalis (Guen)	fruit borer damage (%)	results were on par with endosulfan 0.07%	equally efficient	65
deltamethrin 0.003%	shoot and fruit borer, Leucinodes orbonalis (Guen)	marketable yield	marketable yield was higher than that with endosulfan	more effcient	65
quinalphos 0.04%	shoot and fruit borer, Leucinodes orbonalis (Guen)	marketable yield	marketable yield was higher than that with endosulfan	more effcient	65

Substance compared to Endosulfan	Treated species	Test criteria	Result	Conclusion	Source (Article No.)
monocrotophos		cotton yield kg/ha	applied concentration: 3 w.p./ha increased yields of 938.5 and 1235.5 kg/ha in two successive seasons (increased yields with endosulfan (3 w.p./ha): 670.0 and 714.5 kg/ha in two successive seasons)	more efficient	67
Carbaryl		cotton yield kg/ha	applied concentration: 1.1 kg w.p./ha increased yields of 587.0 and 763.5 kg/ha (increased yields with endosulfan (3 w.p./ha): 670.0 and 714.5 kg/ha in two successive seasons)	more efficient	67
fenvalerate	pod borer [Helicoverpa armigera (Hb.)]	reuction of population	substance was less efficient than endosulfan	less efficient	68
cypermethrin	pod borer [Helicoverpa armigera (Hb.)]	reuction of population	substance was less efficient than endosulfan	less efficient	68
deltamethrin	pod borer [Helicoverpa armigera (Hb.)]	reuction of population	substance was less efficient than endosulfan	less efficient	68
monocrotophos	pod borer [Helicoverpa armigera (Hb.)]	reuction of population	substance was less efficient than endosulfan	less efficient	68
carbaryl	pod borer [Helicoverpa armigera (Hb.)]	reuction of population	substance was less efficient than endosulfan	less efficient	68
malathion	pod borer [Helicoverpa armigera (Hb.)]	reuction of population	substance was less efficient than endosulfan	less efficient	68
monocrotophos	podfly (Melanagromyza obtusa Malloch)	reuction of population	substance was more efficient than endosulfan	more efficient	68
cypermethrin	podfly (Melanagromyza obtusa Malloch)	reuction of population	substance was less efficient than endosulfan	less efficient	68
fenvalerate	podfly (Melanagromyza obtusa Malloch)	reuction of population	substance was less efficient than endosulfan	less efficient	68
deltamethrin	podfly (Melanagromyza obtusa Malloch)	reuction of population	substance was less efficient than endosulfan	less efficient	68
carbaryl	podfly (Melanagromyza obtusa Malloch)	reuction of population	substance was less efficient than endosulfan	less efficient	68
malathion	podfly (Melanagromyza obtusa Malloch)	reuction of population	substance was less efficient than endosulfan	less efficient	68
monocrotophos		grain yield (q/ha)	24.85 q/ha treatment resulted in maximum yield	more efficient	68
lambda-cyhahlothrin (Karate 5 EC)	fruit borer (Helicoverpa armigera HUB.)	bio-efficacy (no further specifications)	applied concentrations: 40, 30, 20, 15 g ai/ha treatments with all four concentrations resulted in higher efficiencies than endosulfan (Thiodan 35 EC) @ 350 g ai/ha	more efficient	69

Substance compared to Endosulfan	Treated species	Test criteria	Result	Conclusion	Source (Article No.)
monocrotophos	stem borer, leaf folder and case worm	reduction of population	treatment resulted in maximum reduction of population	more efficient	70
monocrotophos	stem borer, leaf folder and case worm	yield (q/ha)	treatment resulted in highest yield (34.17 q/ha)	more efficient	70
cypermethrin 0.0075 %	okra flea beetle, Podagrica bowringi Baly	leaf damage	treatment resulted in lowest mean per cent leaf damage	more efficient	71
lambda cyhalothrin 0.0015 %	okra flea beetle, Podagrica bowringi Baly	leaf damage	treatment resulted in lower mean per cent leaf damage than treatment with endosulfan 0.05 %	more efficient	71
lambda cyhalothrin 0.0015 %	okra flea beetle, Podagrica bowringi Baly	yield (q/ha)	treatment resulted in maximum increased yield of 40.04 q/ ha	more efficient	71
beta-cyfluthrin	tomato fruit borer [Helicoverpa armigera (Hübner)]	yield	applied concentrations: 12.50, 18.75 and 25.00 g ai/ha treatments resulted in higher yield than treatment with endosulfan	more efficient	74
Imidacloprid 0.008 %	Hyadaphis coriandari Das.	seed yield (q/ha)	13.14 q/ha (yield with endosulfan 0.07 %: 9.15 q/ha)	more efficient	75
profenofos 0.07 %	Hyadaphis coriandari Das.	seed yield (q/ha)	12.71 q/ha (yield with endosulfan 0.07 %: 9.15 q/ha)	more efficient	75
dimethoate 0.03 %	Hyadaphis coriandari Das.	seed yield (q/ha)	11.27 q/ha (yield with endosulfan 0.07 %: 9.15 q/ha)	more efficient	75
thiamethoxam 0.008 %	Hyadaphis coriandari Das.	seed yield (q/ha)	11.05 q/ha (yield with endosulfan 0.07 %: 9.15 q/ha)	more efficient	75
malathion 0.05 %	Hyadaphis coriandari Das.	seed yield (q/ha)	8.46 q/ha (yield with endosulfan 0.07 %: 9.15 q/ha)	less efficient	75
Imidacloprid 0.008 %	Hyadaphis coriandari Das.	benefit cost ratio	9.91 (3.69 with endosulfan)	more efficient	75
profenofos 0.07 %	Hyadaphis coriandari Das.	benefit cost ratio	9.17 (3.69 with endosulfan)	more efficient	75
thiamethoxam 0.008 %	Hyadaphis coriandari Das.	benefit cost ratio	3.54 (3.69 with endosulfan)	less efficient	75
acephate 75SP	early shoot borer and internode borer (Chilo infuscatellus SNELLEN)	damage	applied concentration: 1 mg/lt substance was found to be the most effective (compared with other insecticides, inter alias endosulfan 35EC) in minimizing the damage	more efficient	76
acephate 75SP	early shoot borer and internode borer (Chilo infuscatellus SNELLEN)	yield	applied concentration: 1 mg/lt substance was found to be the most effective (compared with other insecticides, inter alias endosulfan 35EC) in increasing the yield over check	more efficient	76
acephate 75SP	early shoot borer and internode borer (Chilo infuscatellus SNELLEN)	over all mean efficacy	substance was more efficient than endosulfan 35 EC	more efficient	76
malathion 50EC	early shoot borer and internode borer (Chilo infuscatellus SNELLEN)	over all mean efficacy	substance was less efficient than endosulfan 35 EC	less efficient	76

Substance compared to Endosulfan	Treated species	Test criteria	Result	Conclusion	Source (Article No.)
dimethoate 30EC	early shoot borer and internode borer (Chilo infuscatellus SNELLEN)	over all mean efficacy	substance was less efficient than endosulfan 35 EC	less efficient	76
Lambda-cyhalothrin	shoot and fruit borer (Earias vitella)	efficiency	applied concentration: 30g a.i./ha substance was was significantly superior to all other treatments (inter alias endosulfan @ 500 g a.i./ha)	more efficient	78
Lambda-cyhalothrin	shoot and fruit borer (Earias vitella)	net benefit (rs./ha)	maximum net benefit (Rs.7018/ha) was obtained with Lambda-cyhalothrin	more efficient	78
Lambda-cyhalothrin	shoot and fruit borer (Earias vitella)	incremental cost-benefit ratio	treatment @ 15g a.i. ha−1 recorded maximum cost-benefit ratio of 1:4.73 as compared to other treatments	more efficient	78

The following is a compilation of evaluated literature sources and abstracts:

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1 Pestology

Volume 33, Issue 6, June 2009, Pages 29-33

Evaluation of some new insecticides against mealy bug, phenacoccus so/enopsis (Tinsley) [hemiptera: Pseudococcidae] on cotton

Naveen, A., Vikas, J., Vikram, S.

Abstract

A total of nine treatments of spirotetramat and imidacloprid in mixtures and alone at different doses including two checks, thiodicarb (Larvin 75WP) and profenofos (Curacron 50EC) were compared to test their effectiveness against mealy bug infestation on RCH 134 Bt cotton in 2007 at farmer's field. A total of two sprays were done and the per cent mortality over control was calculated at 1, 3 and 7 days after spraying (DAS). After 1st spray profenofos 50 EC and thiodicarb 75 WP (checks) were at par with each other and proved superior over other treatments in terms of the per cent mortality. Both the. checks remained at par with each other after 2nd spray again however, at 3 DAS profenofos 50 EC (check) recorded 93.73 per cent mortality over control and was at par with spirotetramat 12% + imidacloprid 36% 480 SC (36+108 g ai/ha) (85.09% mortality) and thiodicarb 75 WP 750 g ai/ha (84.48% mortality). Similar trend was observed at 7 DAS with profenofos 50 EC recording the highest (98.18%) mortality over control and further at par with spirotetramat 12% + imidacloprid 36% 480 SC (24+72 g ai/ha) (91.80%), spirotetramat 12% + imidacloprid 36% 480 SC (36+108 g ai/ha) (95.03%) and thiodicarb 75 WP750 g ai/ha (97.72%). The mortality of mealy bug due to single, molecules at different doses ranged between 53.04 and 62.39 per cent and further all these were at par with each other. The checks showed the promising results as compared to other treatments after the first spray whereas spirotetramat + imidacloprid mixture of different concentrations proved better as compared to their individual applications and were at par with the checks only after their 2nd spray.

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2 Pestology

Volume 31, Issue 1, January 2007, Pages 35-38

Comparative efficacy of organophosphates, organochlorines, pyrethroids and biopesticides in long-term protection of Pea pod borer, Lampides boeticus (Linn.) under natural condition

Shantibala, T., Singh, T.K.

Abstract

An experiment was conducted to study the efficacy of organophosphates, organochlorines, pyrethroids and biopesticides in long-term protection of Pea pod borer, Lampides boeticus (Linn.) in the experimental field of Department of Life Sciences, Manipur University. Among the treatments evaluated against the pod borer, L. boeticus on pea crop, Monocrotophos (0.05%) afforded highest reduction (88.63% in 2000 and 93.72% in 2001) in both the years. Endosulfan

(0.05%) was also observed at par in reducing the pod damage percent with Monocrotophos (0.05%). From rest of the treatments, Biopesticides such as Bioneem registered effective treatment with the reduction percent of 78.99 in 2000 and 89.26 in 2001.

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3 Annals of Biology

Volume 19, Issue 1, June 2003, Pages 105-107

Relative toxicity of insecticides against whitefly (Bemisia tabaci Genn.)

Singh, D., Jaglan, R.S.

Abstract

On the basis LC_{50}, values, the order of toxicity of different insecticides against adult whitefly was found to be: dimethoate>ethion, profenophos and triazophos>imidacloprid>monocrotophos>endosulfan> polytrin>spark > methyl demeton. Comparison of relative toxieities of different insecticides revealed that dimethoate, ethion, profenophos, triazophos, imidacloprid, monocrotophos, endosulfan, polytrin and spark were 15, 10, 10, 10, 5, 3.75, 3.33, 3 and 3 times more toxic when methyl demeton was taken as standard.

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4 Pestology

Volume 32, Issue 1, January 2008, Pages 19-22

Insecticide resistance in field population of American bollworms, Helicoverpa armigera hub. (Lepidoptera: Noctuidae)

Bhosale, S.V., Suryawanshi, D.S., Bhede, B.V.

Abstract

Insecticide resistance studies on Helicoverpa armigera (Hubner) have been carried out at Insecticide Resistance Management Laboratory of Department of Entomology, Marathwada Agricultural University, Parbhani, Maharashtra (India) to monitor the resistant frequencies in H. armigera during peak cotton growth periods to different groups of insecticides and resistance development during 2005-06 crop season. The resistance monitoring was carried out against cypermenthrin, chlopyriphos, quinalphos, endosulfan, methomyl and spinosad. Among these, synthetic pyrethroid i.e. cypermethrin have shown high resistance frequencies (84-88%). Moderate resistance frequencies have shown against chlorpyriphos, quinalphos and methomyl. Low resistance frequencies was recorded against endosulfan (25-30%). The population was near about susceptible to spinosad. The LD_{50} values of cypermethrin, chlorpyriphos quinalphos, profenophos, endosulfan, methomyl and spinosad were 1.399, 0.729, 0.680, 0.320, 3.359, 1.515 and 0.0641 µg/larva, respectively. H. armigera has developed more resistance i.e. 279.80 folds resistance against cypermethrin followed by chlorpyriphos (36.45) and methomyl (11.65). Whereas, only 6.01, 6.09 and 6.27 folds resistance was observed against quinalphos, endosulfan and profenophos, respectively.

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5 Crop Protection

Impact assessment of certain insecticides used in rice on green miridbug, Cyrtorhinus lividipennis Reuter (Hemiptera: Miridae)

Preetha, G., Stanley, J., Suresh, S. , Kuttalam, S., Samiyappan, R.

Abstract

The green miridbug, Cyrtorhinus lividipennis, an important natural enemy of the rice brown planthopper (BPH), Nilaparvata lugens plays a major role as a predator in suppressing the pest population. The study assessed the impact of certain potential insecticides used in the rice ecosystem on the miridbug through contact and persistent toxicity. Ten insecticides, including neonicotinoids, diamides, azomethine pyridines, carbamates, pyrethroids, organophosphates and cyclodienes were selected to test their toxicities against the 6-7 days old nymphs of C. lividipennis. Median lethal concentration (LC_{50}) was determined for each insecticide using an insecticide-coated vial (scintillation) residue bioassay, which revealed BPMC as the highly toxic chemical with and LC_{50} of 0.003 ppm followed by ethofenprox and clothianidin with LC_{50} of 0.006 ppm at 48 HAT. Among the insecticides tested, the cyclodiene compound, endosulfan had the lowest acute toxicity (LC_{50} = 66.651 ppm at 48 HAT), but caused 100% mortality one day after treatment at 48 h in persistence toxicity test. The neonicotinoid compound, thiamethoxam and the combination insecticide, chlorantraniliprole + thiamethoxam were the most persistent insecticides, i.e., causing mortality up to 28 days after application, followed by clothianidin (21 days). Imidacloprid, BPMC, chlorantraniliprole and acephate also persisted for

14 days. Pymetrozine showed the lowest persistence for six days with least mortality. Among the insecticides tested, pymetrozine and imidacloprid are regarded as safer to C. lividipennis.

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6 Pestology

Volume 30, Issue 9, September 2006, Pages 13-16

Bioefficacy of some newer insecticides against the major insect pests of short duration pigeonpea

Meena, R.S., Srivastava, C.P., Joshi, N.

Abstract

The field experiment was conducted at the farm of Institute of Agricultural Sciences, Banaras Hindu University during kharif 2004 to evaluate the bioefficacy of some newer insecticides against the major insect pests of short duration Pigeonpea, Cajanus cajan (L.) Millsp. The grain damage by pod fly, Melanagromyza obtusa Malloch was recorded lowest (13.2%) in the plots treated with Bifenthrin 10 EC @ 80 g a.i./ha and highest (19.0%) in the control plot. The pod damage by gram pod borer, Helicoverpa armigera (Hubner) on sprayed plots ranged from 9.2 per cent in flubendiamide 20 WG @ 50 g a.i./ha to 18.1 per cent in endosulfan 35 EC applied @ 700 g a.i./ha. However, all the treatments were found superior to control. Emamectin 5 WSG @ 11 g a.i./ha sprayed twice at 15 days interval gave highest grain yield to the tune of 810 kg/ha and it was closely followed by the treatment of Bifenthrin 10 EC @ 80 g a.i./ha which yielded 800 kg/ha. However, minimum (370 kg/ha) grain yield was obtained in control plot.

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7 Pestology

Volume 23, Issue 7, July 1999, Pages 60-64

Efficacy of Indoxacarb (avaunt 15% SC) against pigeonpea pod borer Helicoverpa armigera (Hubner)

Yelshetty, S., Gowda, D.K.S., Patil, B.V.

Abstract

The efficacy of Indoxacarb 15% SC, a new oxadiazine group of insecticide was tested for three years (1996-99) on pigeonpea pod borer Helicoverpa armigera (Hubner) at five dosages, viz., 25, 50, 75, 100 and 150 g ai per ha. In comparison with other recommended insecticides such as methomyl 12.5L (240 g ai per ha) and cypermethrin 25EC (60 g ai per ha) treated check (sequential spray of monocrotophos followed by endosulfan followed by quinalphos) and untreated check. The results over the years indicate Indoxacarb 15% SC @ 50 g ai per ha recorded lower pod damage and higher grain yield as compared to methomyl, cypermethrin, treated check and untreated check.

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8 Pestology

Volume 30, Issue 4, 2006, Pages 18-20

Field efficacy of newer molecules of insecticides against pod borer (Helicoverpa armigera HUB.) in Chickpea

Raghvani, B.R.[a c] , Poshiya, V.K.[a b]

Abstract

Field testing of Novaluron at 50, 75 and 100 g a.i./ha, emamectin benzoate 8, 9 and 11 g a.i./ha, spinosad 60 g a.i./ha, profenofos 750 g a.i./ha, methomyl 250 g a.i./ha, indoxacarb 72.5 g a.i./ha and endosulfan 350 g a.i./ha was done for their bioefficacy against Chickpea pod borer, Helicoverpa armigera (Hubner) at Pulses Research Station, Junagadh Agricultural University, Junagadh (Gujarat) during 2004-05 rabi season. Novaluron 100 g a.i./ha registered lower pod damage (4.83%) followed by emamectin benzoate 11 g a.i./ha (5.13%) and spinosad 60 g a.i./ha (6.83%). Pod damage for the other insecticides varied from 7.16 to 8.62 per cent. All the insecticidal treatments exhibited higher grain yield over control. All the insecticides were at par with each other.

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9 Pestology

Volume 32, Issue 12, December 2008, Pages 23-25

Efficacy of indoxacarb against tomato fruit borer, Helicoverpa armigera Hubner

Shivalingaswamy, T.M., Kumar, A., Satpathy, S., Rai, A.B.

Abstract

Field trials were conducted at farmers field during 2001-02 and 2002-03 cropping seasons in tomato to evaluate the efficacy of a new carbamate insecticide, indoxacarb 15 SC (50, 60 and 75 g ai/ha) compared with endosulfan (750 g ai/ha) and Bacillus thuringiensis (Bt) formulation (500 g/ha) for the management of tomato fruit borer, Helicoverpa armigera. The insecticides were applied at weekly interval just after 50% flowering stage. During the post treatment periods at 3, 5 and 7 days after treatment, indoxacarb 15 SC recorded significantly less fruit damage in all the test doses compared to endosulfan and Bt. The efficacy was observed upto 7 days in indoxacarb treated plots which suffered significantly less fruit damage (7.87%, 10.10% and 12.93 %) over endosulfan (15.13 %). Bt (19.80 %) and untreated control (25.20 %). Significantly highest yield (260.78 q/ha) was obtained from indoxacarb (75 g ai/ha) treatment followed by other two doses of the same insecticide (259.78 and 257.35 q/ha).

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10 Pestology

Volume 32, Issue 10, October 2008, Pages 29-32

Bio-efficacy of never newer insecticides against pod borer, helicoverpa armigera HUB (noctuidae: Lepidoptera) on Pigeonpea

Tamboli, N.D., Lolage, G.R.

Abstract

The field experiment was conducted during Kharif season of 2006 to evaluate the bioefficacy of some newer insecticides like flubendiamide 20 WDG spinosad 45 SC, indoxacarb 15 SC, 24% thiocloprid + 24% flubendiamide 480 SC, endosulfan 40 SC and novaluron 15 EC against pod borer, Helicoverpa armigera, Hub on pigeon pea. All insecticides except thiocloprid 240 SC were found effective in reducing the incidence of H. armigera. Spinosad 45 SC @ 90 g a.i./ha was the most potent insecticide in reducing the larval population (0.29 larvae/plant), pod damage (5.62 %), grain damage (22.85 %) and highest grain yield of 1681 kg/ha. It was followed by flubendiamide 20 WDG @ 50 g a.i./ha, and novaluron 10 EC @ 75 g a.i/ha.

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11 HortTechnology

Volume 14, Issue 2, April 2004, Pages 188-191

Potential acaricides for management of blueberry bud mite in michigan blueberries

Isaacs, R.[a] , Morrone, V.[a] , Gajek, D.[b]

Abstract

The goal of this study was to evaluate potential alternatives to endosulfan for control of the blueberry bud mite (Acalitus vaccinii), because the availability of this acaricide may be restricted in the future. Laboratory evaluations of potential acaricides showed that endosulfan and a combination of abamectin plus oil provided 97% and 100% control, respectively. Pyridaben and fenpropathrin were less effective, reducing mite survival by 49% and 57%, respectively. Further laboratory evaluation of the abamectin plus oil treatment showed that each component applied alone provided a high level of control of blueberry bud mite. Field trials in Michigan on a mature highbush blueberry (Vaccinium corymbosum) planting were conducted to compare control of this pest by postharvest applications of endosulfan, delayed-dormant application of oil, or a combination of both treatments. The oil provided a 40% reduction in mite scores, while endosulfan was more effective (48%) and similar to the combination of endosulfan and oil (52%). A separate field trial using a multifan/nozzle sprayer that applied the pesticide in 233.8 $L \cdot ha^{-1}$ (25 gal/acre) of water suggested that the level of control from one application of endosulfan was not as effective as two applications. Results are discussed in relation to developing future bud mite control programs in blueberry and the need to address gaps in our understanding of the biology of blueberry bud mite. Endosulfan (Thiodan 50 WP), Endosulfan (Thiodan 3 EC), Abamectin (AgriMek 0.15 EC), Fenpropathrin (Danitol 2.4 EC), Pyridaben (Pyramite 60 WP).

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12 Pestology

Volume 12, Issue 7, 1998, Pages 5-7

Comparative efficacy of newer insecticides against pigeonpea pod borers

Sanap, M.M., Patil, J.V.

Abstract

A field experiment was conducted for three seasons from Kharif 1994-95 to 1996-97 for the control of pod borers infesting pigeonpea at Mahatma Phule Krishi Vidyapeeth, Rahuri. The combination products. viz.,Polytrin C- 44% EC (Profenofos 40% + cypermethrin 4%) and Spark 36 EC (Triazophos 35% + Deltamethrin 1%) along with asymethrin 5 EC, Quinalphos 20 AF, methomyl 40 SP, Profenofos 50 EC and chlorpyriphos 20 EC were evaluated in comparison with presently recommended insecticide, endosulfan 35 EC and untreated control. All the newer insecticides were observed to be at par with each other in controlling pigeonpea pod borers. However, the highest yield (947 kg/ha) with maximum net profit of Rs.4884/ ha was obtained from the treatment with Polytrin-C. The highest returns of Rs.3.71 per rupee investment was obtained from the treatment with endosulfan followed by Polytrin-C (Rs.2.22) and chlorpyriphos (Rs.2.20).

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13 Sugar Tech

Volume 5, Issue 1-2, March 2003, Pages 77-78

Chemical Control of Sugarcane Yellow Mite (Oligonychus sacchari Hirst)

Singh, M. , Jadaun, V.C., Singh, S.R., Singh, A., Lal, K., Singh, S.B.

Abstract

An experiment was conducted on chemical control of yellow mite (Oligonychus sacchari) using sugarcane variety CoS 767 during 3 consecutive years (1997-99) at farmer's fields in Chhata factory zone of Mathura district. The chemical treatments included the spraying of plants with Endosulfan 35 EC, Monocrotophos 36 EC, Diclorvas 76 EC, Quinolphos 25 EC, Nethrin (each @ 1.2S lit/ha) and spraying of Lime sulphur wash (1:30). The results revealed that the spraying of plants with Lime-sulphur (1:30) as well as Nethrin (@ 1.25 lit/ha) gave significant and maximal reduction in the frequency of mite infestation as compared to rest of the treatments including control. The highest cane yield was also recorded under these treatments. Other chemical treatments were also effective in controlling the mite infestation but these were significantly inferior to Lime-sulphur and Nethrin. Hence, application of Lime-sulphur (1:30) and Nethrin (@ 1.25 lit/ha) may be recommended for effective control of yellow mite of sugarcane.

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14 Pest Management Science

Volume 60, Issue 12, December 2004, Pages 1231-1236 **(Article available)**

The contact toxicity of indoxacarb and five other insecticides to Orius insidiosus (Hemiptera: Anthocoridae) and Aphidius colemani (Hymenoptera: Braconidae), beneficials used in the greenhouse industry

Bostanian, N.J. , Akalach, M.

Abstract

The contact toxicity of indoxacarb, abamectin, endosulfan, insecticide soap, S-kinoprene and dimethoate to Orius insidiosus (Say) and Aphidius colemani Viereck were studied in the laboratory. These beneficials are often used in the greenhouses to manage various insect pests. Indoxacarb is slow acting and therefore, to estimate lethal dosages, observations should be continued for several days until data stabilize. Seven days after treatment, the LC_{50} was 0.119 g AI $litre^{-1}$ for O insidiosus adults and 0.019 g AI $litre^{-1}$ for A colemani. At that time, the recommended field concentration was 0.479 times the LC_{50} for O insidiosus adults and three times the LC_{50} for A colemani. In contrast, indoxacarb had no adverse effect on the reproductive capacity of wasps surviving a treatment or the developing wasps in the aphid mummy. Among the other insecticides S-kinoprene was the most innocuous while dimethoate was the most toxic to the two beneficials. The other insecticides had overlapping toxicities. © 2004 Society of Chemical Industry.

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15 Pestology

Volume 30, Issue 10, October 2006, Pages 29-32

Bioefficacy of acaricides including botanigals against Oligonychus indicus hirst on sorghum

Chundawat, G.S.[a] , Sharma, U.S.[a b] , Swaminathan, R.[a] , Desai, H.R.[a]

Abstract

Field trials were conducted to evaluate the bioefficacy of thirteen acaricides including botanicals and animal by-product against Sorghum mite, Oligonychus indicus Hirst in Sorghum during kharif 2003 and 2004 at Agronomy Research Farm at Rajasthan College of Agriculture, MPUAT, Udaipur. Dicofol (0.04%) was found to be most effective acaricide against O. indicus on Sorghum which gave 75.60 and 75.75 per cent population reduction during 2003 and 2004, respectively. It was statistically at par with Endosulfan (0.075%). Maximum C:B ratio was recovered from the plot treated with Ethion (0.1%) i.e., 1:2.38 and 1:2.50 during 2003 and 2004, respectively.

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16 Indian Journal of Agricultural Sciences

Volume 73, Issue 9, September 2003, Pages 518-520

Bioefficacy and persistence of beta-cyfluthrin in or on tomato (Lycopersicon esculentum)

Sharma, I.D.[a] , Nargaeta, D.S.[a] , Chandel, R.S.[b] , Sharma, K.C.[a]

Abstract

β-cyfluthrin, a synthetic pyrethroid, was evaluated during 1999 and 2000 crop seasons for its efficacy against the tomato fruitborer [Helicoverpa armigera (Hübner)] and its persistence on tomato (Lycopersicon esculentum Miller nom. cons), β-cyfluthrin @ 12.50, 18.75 and 25.00 g ai/hawas compared with cypermethrin and endosulfan. It was more effective @ 25.00 g ai/ha, giving significantly higher yield of tomato. However, the lower dose (12.50 g ai/ha) was also effective and resulted in more yield than those with cypermethrin or endosulfan. The residue levels reached half of the initial deposits after 1.56-1.86 days with waiting period of 5-7 days, irrespective of doses and seasons.

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17 Pestology

Volume 31, Issue 8, August 2007, Pages 16-19

Efficacy of Bacillus thuringiensis var. kurstaki alone and in combination with insectides under laboratory conditions

Desai, V.S., Kapadia, M.N.

Abstract

A field cum laboratory trial was conducted at Gujarat Agril. University, Junagadh campus to study the bio-efficacy of Btk alone and in combinations with reduced doses of insecticides in 2001. The insecticides alone showed 100 per cent mortality one day after treatment except malathion. The Btk at the rate of 1.0 kg/ha combined with 0.035% endosulfan and 0.0075 per cent fenvalerate showed 100 per cent mortality in two days. The cypermethrin 0.005 in combination with Btk 1.0 kg/ha resulted in 100 per cent mortality in three days.

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18 Pestology

Volume 32, Issue 7, July 2008, Pages 13-18

Potentiation effect of nimbecidine 0.03% EC formulation in improving the performance of insecticide on Spodoptera litura (Fab.)

Ramarethinam, S. , Marimuthu, S., Murugesan, N.V.

Abstract

The combined effect of Nimbecidine 0.03% EC - a neem oil based EC formulation with other two synthetic chemcial pesticides namely, Endosulfan and Cypermethrin was tested against Spodoptera litura. Probit analysis showed that the individual treatments viz. Endosulfan, Cypermethrin and Nimbecidine recorded an LC_{50} of 6.094 ml /lit, 5.846 ml/lit and 6.156 ml/lit respectively for S. litura. Endosulfan + Nimbecidine and Cypermethrin + Nimbecidine combinations (mixed @ 1:1 ratio) recorded an LC_{50} of 0.399 ml/lit and 0.483 which is 15 and 12 times respectively lower than the stand alone treatment. The rate of mortality (24 hours after application) have also showed that the addition of Nimbecidine individually with Endosulfan and Cypermethrin @ 1:1 ratio has increased the efficacy of the respective pesticides by 15

and 12 fold. Thecombination treatment recorded a cotoxic coefficient which is significantly higher than that of the individual and control treatments. The degree of potentiation calculated from the available data in this study, have not only brought to light the additive effect of Nimbecidine but also the capability of Nimbecidine in potentiating the Endosulfan and Cypermethrin while used in combination against S. litura.

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19 Pestology

Volume 33, Issue 3, March 2009, Pages 27-29

Efficacy of some insecticides alone and in combination with Neem products against adults of Aulacophora foveicollis (Lucas)

Ambekar, N.M., Bhole, S.R., Patil, R.S.

Abstract

Laboratory studies were conducted to evaluate efficacy of some insecticides alone and in combination with Neem products against adults of Aulacophora foveicollis. The data recorded 24, 48, 72 and 96 hours post treatment against adults of Aulacophora foveicollis on the basis of adult mortality. The highest adult mortality was observed in 0.003 per cent cypermethrin, 0.003 per cent cypermethrin + 0.5 per cent Nimbecidine and 0.04 per cent endosulfan. The data also recorded 24,48,72 & 96 hours post treatment against adults of Aulacophora foveicollis on the basis of per cent protection revealed. The treatment with 0.003 per cent cypermethrin, 0.04 per cent endosulfan, 0.04 per cent endosulfan + 0.5 per cent Neem oil and 0.04 per cent endosulfan + 0.5 per cent Nimbecidine offered highest per cent protection.

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20 Pestology

Volume 33, Issue 3, March 2009, Pages 21-23

Chemical control of major pests of teak nursery

Raut, P.R., Ambekar, N.M., Bhole, S.R., Patil, P.D.

Abstract

Field studies on the chemical control of some major pests of teak nurseries viz, E. mochaeralis, Hyblea puero were conducted during 1998 at College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.). The studies revealed that 0.005 per cent cypemethrin was the most effective treatment against E. machaeralis followed by 0.05 per cent endosulfan and 0.05 per cent monocrotophos. Similarly for the control of H. puera the treatments of 0.005 per cent cypermethrin, 0.05 per cent endosulfan were found most effective.

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21 Legume Research

Volume 32, Issue 2, 2009, Pages 145-148

Efficacy of different insecticides against Helicoverpa armigera (Hubner) (Lepidoptera: Noctuidae) on seed crop of berseem in Punjab

Randhawa, H.S., Aulakh, S.S., Bhagat, I., Chhina, J.S.

Abstract

Five insecticides i.e. Endosulfan 35 EC @ 1250 ml, standard check, Endosulfan 35 EC @ 2500 ml, Spinosad 48 SC @ 150 ml, Indoxacarb 15 EC @ 500 ml, Cypermethrin 25 EC @ 200 ml, Chlorpyriphos 20 EC 2500 ml per hectare along with untreated control were evaluated against gram caterpillar, Helicoverpa armigera on seed crop of berseem. Total two sprays were given first was gmin when the attack of young larvae was observed in the field after the last cutting of crop and 2nd spray was given 10 days after the first spray. All the treatments reduced the larval population of test insect significantly except the standard check. Out of these insecticides Spinosad 48 SC found to be the most effective insecticide for the control H. armigera and this insecticide was closely followed by Indoxicarb 15 EC. But Cypermethrin 25 EC was the heapest one. Therefore alternative sprays of different insecticides are recommended for the control of H. armigera in seed crop of berseem.

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22 Pestology

Volume 32, Issue 10, October 2008, Pages 47-49

Bioefficacy of some newer insecticides against Earias vittella (FAB.) infesting okra

Sharma, R.P., Bhati, K.K.

Abstract

Studies were conducted at Rajasthan College of Agriculture, Udaipur from July to December 2006 to evaluate the comparative efficacy of some newer insecticides against Earias vittella (Fab.) on okra, Abelmoschus esculentus (L.) Moench. Amongst all the treatments, Indoxacarb @ 75g a.i./ha showed maximum reduction (78.6%) in the population after rive days of second spray, which was significantly superior to all other treatments. Lambda-cyhalothrin @ 50 g a.i./ha also resulted into high reduction in pest population (71.2%) and was statistically at par with the result obtained with Indoxacarb @ 50 g a.i./ha. The treatment Alpha-cypermethrin @ 25 g a.i./ha was at par with Alpha-cypermethrin @ 20 g a.i./ha. Endosulfan @ 500 g a.i./ha was found to be least effective against okra fruit borer.

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23 Crop Protection

Volume 8, Issue 6, December 1989, Pages 399-404

Interactions of fungicide-insecticide combinations against Rhizoctonia solani in vitro and in soil

Kataria, H.R.[a] , Singh, H.[a] , Gisi, U.[b]

Abstract

The inhibition of mycelial growth of Rhizoctonia solani in vitro was strongest with pencycuron, followed by tolclofos-methyl, carboxin and thiabendazole. Against cowpea seedling rot in soil infested with R. solani, tolclofos-methyl was most effective, followed by pencycuron, thiabendazole and carboxin. Of nine insecticides tested, only parathion-methyl and quinalphos suppressed mycelial growth of R. solani in vitro, although their activity was much lower than that of the four tested fungicides. The inhibition of mycelial growth by fungicide-insecticide mixtures was antagonistic in only two out of 36 combinations; it was additive in most cases or synergistic, e.g. for most mixtures of pencycuron and insecticides. Quinalphos, applied to the soil, was the only insecticide which reduced cowpea seedling rot in soil infested with R. solani. Soil application of parathion-methyl, phorate, aldicarb or carbofuran and seed treatment with phosphamidon, monocrotophos, endosulfan or dimethoate had little or no effect on seedling rot. Carboxin gave better disease control when applied to the seed already coated with phosphamidon, monocrotophos, endosulfan or dimethoate and when carboxin-treated seeds were sown in soil treated with quinalphos, parathion-methyl, aldicarb or carbofuran. Efficacy of thiabendazole seed treatment was slightly higher in the presence of insecticides, particularly dimethoate. Pencycuron and tolclofos-methyl as seed treatment gave nearly 100% disease control both in the presence and absence of insecticides. The synergistic interactions detected between fungicides and insecticides represent interesting opportunities for the control of R. solani. © 1989.

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24 International Journal of Pest Management

Volume 43, Issue 4, October 1997, Pages 253-259

Effect of time of application of chemicals on management of maize stem borer, Chilo partellus (Swinhoe)

Ganguli, R.N.[a] , Chaudhary, R.N.[a b] , Ganguli, J.[a]

Abstract

One of the major reasons for the low productivity of maize is damage by insect pests, notably the stem borer, Chilo partellus (Swinhoe) (Lepidoptera: Pyralidae). Investigations have been carried out to evaluate the efficacy of certain insecticides and neem-based formulations for the management of maize stem borer. Evaluation of the efficacy of 0·035% endosulfan for the management of maize stem borer at different stages of infestation has also been undertaken. The experiments were conducted in India during the monsoon season of 1993 and 1994. A single application of carbofuran 3G (at 7·5 kg/ha in leaf whorl) in a 15 day-old crop proved to be most effective in protecting against the borer, if the infestation occurs up to 6 days after application. Also, a single application of 0·035% endosulfan was highly effective in protecting the crop when applied 2 days after borer infestation and moderately effective when applied up to 6 days after borer infestation. Insecticidal spraying in later stages proved to be ineffective.

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25 Journal of Advanced Zoology

Volume 24, Issue 1-2, December 2003, Pages 64-66

Toxicity of some insecticides on the larvae of weevil Myllocerus viridanus fabricius (Coleoptera:Curculionidae) - A pest of tasar food plants

Mishra, P.K Jayaswal, J.

Abstract

The toxicity of Carbofuran, Phorate, Malathion, Methyl Parathion, Endosulfan and BHC to first and fifth instar larvae of weevil M. viridanus was estimated after 24 and 48 hours in soil as contact poisons. Among all these insecticides tested, Carbofuran and OP group insecticides were more toxic than organochlorines. The order of toxicity was Carbofuran > Phorate > Malathion > Methyl Parathion > Endosulfan and BHC. High efficacy of insecticides against first instar larvae at a very low concentration was observed.

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26 Pestology

Volume 23, Issue 4, April 1999, Pages 23-24

Bioefficacy of lambdacyhalothrin against tomato leafhopper and fruit borer

Naitam, N.R., Ukey, S.P.

Abstract

A new pyrethroid, lambdacyhalothrin was evaluated against tomato leafhopper and fruit borer during kharif and rabi seasons of 1997-98 at Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. The pooled data of two seasons revealed that 0.2% carbaryl gave highest reduction in leafhopper population followed by 0.01% lambdacyhalothrin and 0.04% endosulfan. In case of tomato fruit borer, 0.01% lambdacyhalothrin was most effective followed by 0.04% endosulfan. The highest yield was obtained due to 0.01% lambdacyhalothrin followed by 0.2% carbaryl and 0.0125% fenvalerate.

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27 Journal of Asia-Pacific Entomology

Volume 6, Issue 1, May 2003, Pages 83-90

Relative Efficacy of Some Insecticides Against Brinjal Fruit and Shoot Borer, Leucinodes orbonalis Guen., and Their Impact on Fruit Yield

Abrol, D.P. , Singh, J.B.

Abstract

Six insecticides and their eight combinations were tested for their efficacy against brinjal fruit and shoot borer, Leucinodes orbonalis. Endosulfan + deltamethrin (0.07%, 0.0025%) and endosulfan + fenvalerate (0.07% + 0.005%) were highly effective against fruit borer that recorded only 13.3% damage as compared to 69.8% in control. The other promising treatments which significantly reduced the fruit damage over the control were in the order: carbaryl + fenvalerate = dichlorvos + fenvalerate (14.9%) > malathion + fenvalerate (16.4%) > fenvalerate + deltamethrin (16.6%) > dichlorvos = carbaryl + deltamethrin = malathion = dichlorvos + deltamethrin = malathion + deltamethrin (18.3%) > endosulfan (20.0%) > carbaryl (21.6%) with mean percentage of damage 14.9, 16.4, 18.3, 20.0, 21.6 and 69.8%, respectively. Carbaryl was least effective, but its combinations with pyrethroids were proved superior over carbaryl alone. Cost - benefit ratio ranged from a minimum of 1: 5.10 (carbaryl) to a maximum of 1: 20.44 (fenvalerate). Dichlorvos + fenvalerate combination gave the highest yield of 263.45 q/ha, whereas carbaryl was least effective giving 225.7 q/ha. with a net gain of Rupees 42,443.00 (US$ 886.00) and 28,141.00 (US$ 587.49), respectively. The other treatments were intermediate between the two insecticide regimes. However, all the treatments were superior over the control which produced 113.58 q/ha with a net gain of Rupees 340.00 only.

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28 Annals of Biology

Volume 19, Issue 2, December 2003, Pages 213-216

Efficacy and economics of some insecticides against gram pod borer, Helicoverpa armigera (Hubner) on chickpea

Ahmad, H., Arora, R.K.

Abstract

Five insecticides viz., monocrotophos (36 WSC), endosulfan (35 EC), carbaryl (50 WP), cypermethrin (25 EC) and neem oil (0.15 EC) were evaluated for the control of gram pod borer, Helicoverpa armigera (Hubner) on chickpea. All insecticidal treatments were significantly superior over control in reducing the per cent pod infestation and increase in yield. Cypermethrin (0.009, 0.0075 and 0.006%) was found to be the most effective followed by monocrotophos (0.08, 0.06 and 0.04%) and endosulfan (0.13, 0.1 and 0.07%). Carbaryl (0.3, 0.2 and 0.1%) and neem oil (0.30, 0.20 and 0.10%) were least effective in controlling the gram pod borer.

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28 African Journal of Biotechnology

Volume 2, Issue 11, 2003, Pages 456-462

Comparative efficacy of microbial and chemical insecticides on four major lepidopterous pests of cotton and their (insect) natural enemies

Fadare, T.A. , Amusa, N.A.

Abstract

Three microbial (biotrol, dipel and thuricide) and three chemical insecticides (monocrotophos, endosulfan and carbaryl) were compared for efficacy on four major lepidopterans and their natural enemies in replicated field trials at Moor Plantation, Ibadan. Thuricide was evaluated at different combinations with monocrotophos in a second trial. The results showed that the microbials caused the mortalities of destructive bollworms and leafroller but allowed the survival of their natural enemies. The chemicals on the other hand caused mortalities of both destructive and useful species. Both groups of insecticides enhanced seed cotton yields. Application of thuricide followed by monocrotophos was better than other combinations evaluated.

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29 Journal of Economic Entomology

Volume 99, Issue 5, October 2006, Pages 1805-1812

Susceptibility of immature stages of Homalodisca coagulata (Hemiptera: Cicadellidae) to selected insecticides

Prabhaker, N.[a] , Castle, S.J.[b] , Toscano, N.C.[a]

Abstract

Susceptibility of immatures of the glassy-winged sharpshooter, Homalodisca coagulata (Say) (Hemiptera: Cicadellidae), to 10 insecticides that included chlorpyrifos, dimethoate, endosulfan, bifenthrin, cyfluthrin, esfenvalerate, fenpropathrin, acetamiprid, imidacloprid, and thiamethoxam was evaluated in the laboratory. All five instars were exposed to different doses of each foliar insecticide by the petri dish technique, whereas a systemic uptake method was used to assess the toxicity to imidacloprid and thiamethoxam. All test insecticides exhibited high toxicity to all immature stages of H. coagulata at concentrations below the field recommended rates of each insecticide. Although all five instars were susceptible to test insecticides, mortality was significantly higher in first instars than in the older immatures based on low LC_{50} values (ranging from 0.017 to 5.75 ng(AI)/ml) with susceptibility decreasing with each successive stage. Fifth instars were generally the least sensitive (LC_{50} values ranging from 0.325 to 216.63 ng(AI)/ml). These results show that mortality was directly related to age of the insect and suggest that chemical treatment at early stages is more effective than at late stages. Acetamiprid (neonicotinoid) and bifenthrin (pyrethroid) were the most toxic to all five instars, inducing most mortality within 24 h and showing lower LC_{50} values ranging from 0.017 to 0.686 ng/ml compared with other insecticides (LC_{50} values ranging from 0.191 to 216.63 ng(AI)/ml). Our data suggest that a diverse group of very effective insecticides are available to growers for controlling all stages of H. coagulata. Knowledge on toxicity of select insecticides to H. coagulata immatures may contribute to our understanding of resistance management in future for this pest by targeting specific life stages instead of the adult stage alone.

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30 Indian Journal of Agricultural Sciences

Volume 78, Issue 9, September 2008, Pages 821-823

Relative efficacy of certain insecticides against mustard aphid (Lipaphis erysimi) on Indian mustard (Brassica juncea)

Singh, R.K.[a b] , Verma, R.A.[a c]

Abstract

Field efficacy of 8 insecticides was evaluated against mustard aphid during 2004-05 and 2005-06. Acetamiprid followed by dimethoate and imidacloprid provided 91.73, 88.73 and 86.02% aphid reduction over the control respectively, after 7 days of application. Novaluron and endosulfan reduced the population up to 78.73 and 77.89% respectively after 3 days of application. Neem-seed kernal extract and neemarin were also found effective.

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31 Experimental and Applied Acarology

Volume 20, Issue 9, 1996, Pages 495-502

A laboratory-based method to measure relative pesticide and spray oil efficacy against broad mite, Polyphagotarsonemus lotus (Banks)(Acari: Tarsonemidae)

Herron, G.[a] , Jiang, L.[a] , Spooner-Hart, R.[b]

Abstract

Six pesticides and two spray oils were tested against Polyphagotarsonemus latus. The chemicals were evaluated under laboratory conditions, requiring the development of a novel bioassay method, which is reported here. The pesticide toxicities fell into three distinct groups, namely abamectin, conventional pesticides and oils. The relative pesticide toxicities at the LC_{50} level wereabamectin 4.9×10^{-8} g ai 1^{-1}, endosulfan 1.1×10^{-3} g ai 1^{-1}, fenpyroximate 2.3×10^{-3} g ai 1^{-1}, pyridaben 4.1×10^{-3} g ai 1^{-1}, tebufenpyrad 4.4×10^{-3} g ai 1^{-1}, dicofol 4.5×10^{-3} g ai 1^{-1}, petroleum spray oil 3.4×10^{-1} g ai 1^{-1} and canola oil 4.1×10^{-1} g ai 1^{-1}. The calculation of the $LC_{99.9}$ values allows for resistance monitoring in P. latus and the suggested discriminating concentrations are abamectin 1.0×10^{-4} g ai 1^{-1}; endosulfan, pyridaben and dicofol 1.0×10^{-1} g ai 1^{-1} fenpyroximate and tebufenpyrad 5.0×10^{-1} g ai 1^{-1}.

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32 Pest Management Science

Volume 62, Issue 4, April 2006, Pages 334-339

The effect of indoxacarb and five other insecticides on Phytoseiulus persimilis (Acari: Phytoseiidae), Amblyseius fallacis (Acari: Phytoseiidae) and nymphs of Orius insidiosus (Hemiptera: Anthocoridae)

Bostanian, N.J. , Akalach, M.

Abstract

A laboratory study assessed the contact toxicity of indoxacarb, abamectin, endosulfan, insecticidal soap, S-kinoprene and dimethoate to Amblyseius fallacis (Garman), Phytoseiulus persimilis Athias-Henriot and nymphs of Orius insidiosus (Say). Amblyseius fallacis is a predacious phytoseiid mite and an integral part of integrated pest management (IPM) programmes in North American apple orchards. The other two beneficials are widely used in greenhouses to manage various arthropod pests infesting vegetable and ornamental crops. Indoxacarb is a slow-acting insecticide, so toxicity data were recorded 7 days post-treatment when the data had stabilised. It showed no toxicity to O. insidiosus nymphs or to A. fallacis or P. persimilis adults. The LC_{50} values for O. insidiosus nymphs and P. persimilis could not be estimated with their associated confidence limits, because the g values were greater than 0.5 and under such circumstances the lethal concentration would lie outside the limits. The LC_{50} for A. fallacis was 7.6x the label rate. The fecundity of P. persimilis was reduced by 26.7%. The eclosion of treated eggs from both species of beneficial mites was not affected adversely. Among the other pest control products, S-kinoprene and endosulfan affected adversely at least one species of the predators, whereas dimethoate, abamectin and insecticidal soap were very toxic to all three beneficials. Indoxacarb should be evaluated as a pest control product in IPM programmes.

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33 Pest Management Science

Volume 58, Issue 9, September 2002, Pages 967-971

Insecticide resistance in field populations of Frankliniella occidentalis (Pergande) in Murcia (south-east Spain)

Espinosa, P.J.[a] , Bielza, P.[a] , Contreras, J.[a] , Lacasa, A.[b]

Abstract

Thirty-nine field populations of Frankliniella occidentalis (Pergande) were collected from different crops (sweet pepper, tomato, lettuce, artichoke, melon, cucumber, carnation, broad bean, peach and plum) in Murcia (south-east Spain). All populations were reared separately in the laboratory to obtain enough individuals for bioassays. Female thrips were bioassayed, using a standard topical application method, against methiocarb, methamidophos, acrinathrin, endosulfan, delta-methrin and formetanate. Methiocarb was the only insecticide that showed a high efficacy against F occidentalis at field dose rates. Acrinathrin and methamidophos were moderately effective, while endosulfan and deltamethrin were ineffective. Only moderate levels of resistance (Resistance Ratios at LC_{50} of 10-30) were detected for the selective insecticides methiocarb, formetanate and acrinathrin used against F occidentalis in crops where these insecticides are used intensively. This generalized and low level of resistance to these insecticides, coupled with a lack of efficacy for the three broad-spectrum insectides, was observed even in intensively managed vegetable crops. Implementation of IPM strategies in Murcia has contributed to more successful insecticide anti-resistance management. © 2002 Society of Chemical Industry.

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34 Indian Journal of Agricultural Sciences

Volume 69, Issue 9, September 1999, Pages 660-663

Management of tobacco ground beetle, Mesomorphus villiger with insecticide baits on flue cured Virginia tobacco

Sitaramaiah, S., Rama Prasad, G., Sreedhar, U.

Abstract

Tobacco ground beetle, Mesomorphus villiger Blanch (Tenebrionidae: Coleoptera) is one of the important pests of transplanted tobacco crop causes loss to an extent of 40 % under drought conditions. Investigations on the efficacy of 4 insecticides against Mesomorphus villiger on tobacco in northern light soils of Andhra Pradesh during 1995-97 showed that the insecticide baits of monocrotophos, endosulfan and chlorpyrifos were most effective followed by fenvalerate bait, phorate granules, keeping grass heaps and dusting with carbaryl/chlorpyrifos. Neem cake was found to be least effective. The order of toxicity to ground beetle is monocrotophos bait > chlorpyrifos bait > endosulfan bait > fenvalerate bait > phorate granule > carbaryl dust > chlorpyrifos dust. Observations on yield data revealed that all the treatments except neem cake powder showed better grade index than untreated check. Economics and benefit: cost ratio for different treatments revealed that endosulfan bait recorded maximum net returns of Rs 26 270 and a benefit: cost ratio of 1.92:1 followed by monocrotophos bait Rs 25 280 and 1.89:1, chlorpyrifos bait Rs 24 469 and 1.86:1, phorate granules Rs 23 001 and 1.82:1, fenvalerate bait Rs 22 419 and 1,79:1, carbaryl dust Rs 21 991 and 1.78:1, chlorpyrifos dust Rs 21 940 and 1.78:1 and neem cake Rs 12 857 and 1.46:1.

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35 Pestology

Volume 24, Issue 8, 2000, Pages 65-67

Efficacy of some insecticides against Helicoverpa armigera. (HUB)

Mane, P.N., Deshmukh, S.D., Rao, N.G.V., Dandale, H.G., Tikar, S.N., Nimbalkar, S.A.

Abstract

Laboratory studies were conducted on efficacy of some individual insecticides, ready-mix and tank-mix insecticides against the larvae of Helicoverpa armigera. These studies revealed that cypermethrin + chlorpyriphos was the most toxic whereas fenvalerate + profenofos the least toxic. The mixtures exhibited the following descending order of toxicity, viz., cypermethrin + chlorpyriphos > profenofos > chlorpyrifos > methomyl > thiodicarb > cypermethrin > quinalphos > deltamethrin + endosulfan > deltamethrin + triazophos > endosulfan > cypermethrin + profenofos > fenvalerate + quinalphos > alanycarb > cypermethrin + quinalphos > fenvalerate + profenofos.

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36 Pakistan Journal of Biological Sciences

Volume 9, Issue 3, March 2006, Pages 360-364

Time trends in mortality for conventional and new insecticides against leaf worm, Spodoptera litura (Lepidoptera: Noctuidae)

Ahmad, M.[a] , Saleem, M.A.[a] , Ahmad, M.[b] , Sayyed, A.H.[c d]

Abstract

To determine time trends in mortality for various insecticides, which are being used against cotton pests, the fourth instar larvae of Spodoptera litura was collected from Muzaffar Garh and tested for pyrethroids, organophosphate and new chemistry insecticides. The efficacy of the insecticides was examined by time-oriented mortality at LC_{50}, through leaf-dip bioassays in the laboratory. In sodium channel agonists, endosulfan was the most efficient insecticide. The cholinesterase inhibitors tested, chlorpyrifos showed high efficiency while phoxim performed better in time-oriented mortality. Emamectin benzoate proved to be the most efficient insecticide in new chemistry insecticides tested. Spinosad and indoxacarb had almost similar LC_{50} and LT_{50} values. The least effective insecticide found was abamectin. The results are discussed in relation to Integrated Pest Management (IPM). © 2006 Asian Network for Scientific Information.

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37 Proceedings of the 1999 Beltwide Cotton Conference, January 1999, Orlando, Florida, USA

1999, Pages 1168-1169

Summary of insecticide performance for boll weevil (Anthonomus grandis) control in Arkansas cotton

Page, L.M., Johnson, D.R., Maret, M.P., Amaden, S.R.

Abstract

Organophosphates, pyrethroids, tank mixes, and other insecticides were compared for efficacy against the boll weevil in Lonoke county, Arkansas over a nine year period. Results from all of these tests have been compiled and summarized to show each treatment's relative performance. Boll weevil control was calculated from damage levels in the treated plots compared to the untreated. Each insecticidal treatment was grouped into one of six categories based upon its chemical makeup. The best performing groups included: fipronil (Regent), averaging 64 percent control; pyrethroids, averagin 65 percent control; and tank mixes, averaging 66 percent control. Other groups included; organophosphates, averaging 36 percent control; endosulfan (Phaser/Thiodan), averaging 45 percent control; and oxymyl (Vydate) averaging about 48 percent control.

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38 Journal of Economic Entomology

Volume 93, Issue 2, 2000, Pages 300-303

Lethal and sublethal effects of selected insecticides and an insect growth regulator on the boll weevil (coleoptera: curculionidae) ectoparasitoid Catolaccus grandis (hymenoptera: pteromalidae)

Elzen, G.W.[a] , Maldonado, S.N.[a] , Rojas, M.G.[a b]

Abstract

A laboratory culture of Catolaccus grandis (Burks), an ectoparasitoid of the boll weevil, Anthonomus grandis grandis Boheman, was exposed to lethal and sublethal doses of insecticides and an insect growth regulator using a spray chamber bioassay. Materials tested were azinphos-methyl, endosulfan, fipronil, malathion, cyfluthrin, dimethoate, spinosad, methyl parathion, acephale, oxamyl, and tebufenozide. At full rates, spinosad was significantly less toxic to female C. grandis than other treatments except endosulfan. Fipronil and malathion were significantly more toxic to females than other treatments. Most of the chemicals tested were highly toxic to male C. grandis; spinosad was least toxic. At reduced rates, most of 4 selected chemicals tested were low in toxicity to C. grandis; however, a reduced rate of malathion was significantly more toxic to females than other treatments. No C. grandis pupae developed from parasitism during a24-h treatment period with malathion or spinosad. The sex ratio of progeny from sprayed adults appeared to be unaffected by the treatments.

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39 Indian Journal of Agricultural Sciences

Volume 79, Issue 12, December 2009, Pages 1003-1006

Toxicity of various insecticides against Delhi and Palla population of brown plant hopper (Nilaparvata lugens)

Srivastava, C.[a] , Chander, S.[a] , Sinha, S.R.[a b] , Palta, R.K.[a b]

Abstract

Toxicity of different insecticides recommended to control brown plant hopper Nilaparvata lugens (Stal) was evaluated in the laboratory against insect populations collected from Delhi and in its surrounding village Palla. Results showed that endosulfan was most effective with lowest lethal concentrations being 0.0007% against both populations. The values of relative toxicity when calculated in comparison to LC_{50} value of monocrotophos it was observed that acetamiprid, thiamethoxam, flubendamide, clothinidine and mixture of flubendamide + fipronil were less toxic than monocrotophos, whereas imidacloprid, chlorpyriphos and endosulfan were more toxic to N. lugens. Based on relative toxicity derived on the basis of LC_{50} and $LC_{97.5}$ values, endosulfan was highly toxic and most effective insecticides among the insecticides tested.

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40 Journal of Economic Entomology

Volume 92, Issue 1, 1999, Pages 220-227

Damage loss assessment and control of the cabbage seedpod weevil (Coleoptera: Curculionidae) in winter canola using insecticides

Buntin, G.D.

Abstract

Experiments examining the efficacy, timing, and number of applications of various insecticides were used to assess cabbage seedpod weevil, Ceutorhynchus assimilis (Paykull), yield loss relationships in winter canola, Brassica napus L. Typically, the pyrethroid insecticides bifenthrin, esfenvalerate, permethrin, and zetacypermethrin were more effective than the currently registered insecticides endosulfan and methyl parathion in reducing adult numbers and preventing pod infestation by larvae. Two insecticide applications during flowering usually were needed to effectively reduce adult numbers and to prevent seed injury. Larval injury primarily affected grain weight by reducing seed weight and number of seeds per pod. One, 2, and 3 larvae per pod reduced seed weight per pod by 20.2, 38.1 and 52.2%, respectively. Larval injury did not consistently affect kernel weight or grain oil content. Yield loss increased linearly by □1.7% for each 1% increase in percentage of infested pods, when larval infestation of pods exceeded 23% infested pods. These results support findings from Europe that canola can tolerate pod infestations of ≥26% without measurable yield loss. However, depending on control costs and commodity value, preemptive insecticidal control was not justified until pod infestations exceeded 26-40% infested pods. These results provide a quantitative basis for the development of decision rules for C. assimilis which will minimize unnecessary insecticide use on canola in the United States.

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41 Journal of the Kansas Entomological Society

Volume 79, Issue 4, October 2006, Pages 321-324

Endosulfan and bifenthrin: Applied alone, alternatively or in combination for control of the silverleaf whitefly Bemisia argentifolii bellows and perring (Homoptera: Aleyrodidae) in cotton

Wolfenbarger, D.A.[a], Loera-Gallardo, J.[b]

Abstract

Insecticide treatments against the silverleaf whitefly, Bemisia argentifolii, has been the most important control method for this pest. In this study, the efficacy of bifenthrin and endosulfan applied alone, alternatively or as a tank mixture was evaluated against the silverleaf whitefly. Adult populations were reduced from 27 to 60% following 10 sprays of bifenthrin alone or the bifenthrin + endosulfan tank mixture. All insecticidal treatments resulted in lower numbers of 2nd and 3rd larval stages and were significantly different from the untreated control. Yield was the lowest in the control where the populations of whitefly adults, eggs, larval stages and pupae were consistently greater than in each insecticidal treatment. Applications of both bifenthrin and endosulfan, alternatively or as a tank mixture, did not increase control of whitefly over each insecticide applied alone. Bifenthrin alone was more effective than endosulfan alone.

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42 Pest Management Science

Volume 63, Issue 8, August 2007, Pages 747-752

Current status of the greenhouse whitefly, Trialeurodes vaporariorum, susceptibility to neonicotinoid and conventional insecticides on strawberries in southern California

Bi, J.L. , Toscano, N.C.

Abstract

Since 1998, the greenhouse whitefly, Trialeurodes vaporariorum Westwood (Homoptera: Aleyrodidae), has emerged as a major insect pest of many horticultural crops in coastal California. Control of this pest has been heavily dependent upon chemical insecticides. Objectives of this study were to determine the status of the greenhouse whitefly susceptibility to neonicotinoid and conventional insecticides on strawberries in Oxnard/Ventura, a year-round intensive horticultural production area of southern California. For bioassay tests, adult whiteflies were collected from commercial strawberry crops, and immatures were directly developed from eggs laid by these adults. LD_{50} values of soil-applied imidacloprid, thiamethoxam and dinotefuran were respectively 8.7, 3.2 and 4.9 times higher for the adults, 1.8, 1.2 and 1.5 times higher for the first-instar nymphs and 89.4, 390 and 10.4 times higher for the third-instar nymphs than their top label rates. LC_{50} values of foliar-applied imidacloprid, thiamethoxam and acetamiprid were respectively 6.1, 6.0 and 1.7 times higher for the adults and 3.8, 8.7 and 4.4 times higher for the second-instar nymphs than their top label rates. For the adults, LC_{90} values of endosulfan, malathion, methomyl, bifenthrin and fenpropathrin were 2.2, 1.2, 1.9, 2.3 and 4.9 times lower than their respective top label rates. Chlorpyrifos was not very effective against the adults, as indicated by its LC_{90} being 120% higher than its top label rate. The present results strongly emphasize the need to develop resistance management strategies in the region. © 2007 Society of Chemical Industry.

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43 Pestology

Volume 24, Issue 8, 2000, Pages 17-20

Comparative efficacy of various insecticides against Helicoverpa armigera Hub. and their safety to Apis cerana Fab. on sunflower

Singh, K.I., Singh, M.P.

Abstract

Field trials conducted during Rabi seasons of 1994 and 1995 to evaluate sixteen conventional insecticides, namely, quinalphos (0.05%), phosalone (0.05%), dimethoate (0.03%), chlorpyriphos (0.05%), malathian (0.05%), ethofenprox (0.05%), BPMC (0.05%), BHC (0.05%), triazophos (0.05%), monocrotophos (0.05%), carbaryl (0.20%), methyl parathion (0.05%), phosphamidon (0.03%), cypermethrin (0.01%), endosulfan (0.05%) and dichlorvos (0.05%) against the capitulum borer, Helicoverpa armigera Hub. infesting sunflower crop. Studies were also on their safety margin to Indian hive bee, Apis cerana Fab. The results revealed that cypermethrin and endosulfan were more effective than other treatments with lowest borer population of 0.50 and 0.73 larvae/5 heads, respectively and highest seed yield of 20.58 and 21.31 q/ha, respectively against 5.42 larvae/5 heads and 16.93 q/ha seed yield recorded in untreated control. The population of bee pollinator was least affected by endosulfan which recorded significantly higher population than other insecticidal treatments and at par with untreated control.

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44 Journal of Cotton Science

Volume 13, Issue 3, 2009, Pages 189-195

Comparative efficacy of selected insecticide alternatives for boll weevil (Coleoptera: Curculionidae) control using laboratory bioassays

Castro, B.A.[a] , Armstrong, J.S.[b]

Abstract

The boll weevil, Anthonomus grandis grandis (Boheman), is a major pest of cotton (Gossypium hirsutum L.), and responsible for an estimated $300 million in annual losses (National Cotton Council of America 2009, Texas Boll Weevil Eradication Foundation, Inc. 2009). Current boll weevil eradication programs depend on malathion ULV to achieve and maintain eradication status. Should this effective and economical insecticide become unavailable, eradication efforts could be jeopardized. The objective of this project was to evaluate the efficacy of selected insecticides as alternatives to malathion ULV on field collected boll weevils. The study was conducted in the Lower Rio Grande Valley of Texas in 2007. Insecticides included malathion ULV, endosulfan, bifenthrin, encapsulated methyl parathion, oxamyl, carbaryl and cyfluthrin. Malathion ULV was applied using an ULV, controlled-droplet applicator. Other insecticides were applied with a hand-held, CO2-charged sprayer. Leaf disks were removed from treated cotton, placed in culture plates and infested with individual adult boll weevils. Boll weevil mortality in the malathion ULV, endosulfan, encapsulated methyl parathion and bifenthrin treatments was at or near 100%. Mortality with cyfluthrin and carbaryl was low and inconsistent. Mortality in the oxamyl treatment was intermediate between the two above groups. Highest mortality after 24 h was observed with malathion ULV (97.9%), endosulfan (86.6%) and bifenthrin (80.2%). After 48 h, mortality reached 100% with malathion ULV but was not significantly different from those of encapsulated methyl parathion (96.1%), bifenthrin (95%) and endosulfan (94.9%). Results indicate that malathion ULV is a highly effective material for boll weevil control and that encapsulated methyl parathion, bifenthrin and endosulfan also cause high mortality.

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45 Pestology

Volume 11, Issue 11, 1997, Pages 35-37

Relative efficacy of some insecticides against cashew leaf miner, Acrocercops syngramma Meyrick (Lepidoptera: Gracillaridae)

Athalye, S.S., Patil, R.S.

Abstract

A field trial conducted to evaluate the relative efficacy of six insecticides against cashew leaf miner, Acrocercops syngramma revealed that all insecticides tested during present investigation were significantly effective over control in causing larval mortality at one, three and five days after application. Overall results indicated that 0.05 per cent triazophos recorded highest mean per cent larval mortality and was statistically on par with 0.0075 per cent cypermethrin, 0.05 per cent endosulfan, 0.03 per cent dimethoate and 0.04 per cent phosphamidon. The treatment with 0.07 per cent acephate was relatively less effective.

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46 Pestology

Volume 24, Issue 6, June 2000, Pages 43-44

Bioefficacy of some newer insecticides against pod borers of blackgram

Ganapathy, N., Durairaj, C.

Abstract

Bioefficacy of some newer insecticides like profenofos (Curacron 50 EC), Alanycarb (Onic 30 EC) and quinalphos (Ekalux 20AF) was evaluated against the pod borers of blackgram along with five conventional insecticides during three consecutive seasons (1996, 1997 and 1998). The cumulative pod borer damage level caused by Catechrysops cnejus F., Maruca vitrata Gey., Helicoverpa armigera Hb. and Etiella zinckenella Tret. was the lowest in quinalphos 0.04% (6.2%) followed by profenofos 0.1% (6.5%), alanycarb 0.06% (6.6%), endosulfan 0.07% (7.5%), dimethoate 0.03% (7.5%) and acephate 0.075% (7.7%). Grain yield was also maximum in quinalphos 0.04% (378.3 kg/ha) with high Cost:Benefit ratio (1:2.9).

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47 Pestology

Volume 25, Issue 6, June 2001, Pages 25-27

Bio-efficacy of new molecules of insecticides against mango leafhoppers on crop variety Alphonso

Girish Kumar, H.M., Giraddi, R.S.

Abstract

Ten insecticides were evaluated in field for the control of mango leafhoppers Idioscopus niveosparsus (Leth.), Idioscopus clypealis (Leth.) and Amritodus atkinsoni (Leth.) on 15-year-old Alphonso trees at Dryland Horticultural Farm, Kumbapur, UAS, Dharwad. New molecules lambda cyhalothrin (Karate 5 EC) and Imidacloprid (Confidor 200 SL) were highly effective recording least (0.03) population of mango leafhoppers upto 21 days after the spray, totally two sprays were required to manage the mango leafhoppers. Monocrotophos, cypermethrin, acephate and difenthiuron were the next best treatments (0.59 to 1.45 leafhopper/inflorescence) and were on par with one another. Fipronil and endosulfan were the least effective treatments (1.59 and 2.06 leafhopper/inflorescence) and were superior to untreated control which registered maximum population of 6.72 leafhoppers.

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48 Pestology

Volume 29, Issue 5, May 2005, Pages 34-39

Management of pests of chrysanthemum by using various modern synthetic insecticides

Nalawade, P.S.[a] , Khaire, V.S.[a b] , Palande, P.R.[a] , Palande, N.R.[a]

Abstract

Management of aphid, Macrosiphoniella sanborni Gillete and American serpentine leafminer, Liriomyza trifoil Burgess in Chrysanthemum (Chrysanthemum morifolium Ramat) was carried out. Studies on efficacy of different insecticides against M. sanborni indicated that 3 sprays of imidacloprid 0.01% at 15 days interval proved to be the best treatment recording 2.67 aphids per shoot. It was followed by acephate 0.075%, fipronil 0.02%, dimethoate 0.03%, chlorpyriphos 0.05%, quinalphos 0.05%, monocrotophos 0.05%, endosulfan 0.05% and cypermethrin 0.01%. In the case of L. trifolii, the treatment with chlorpyriphos 0.05% was found to be most effective which was at par with cypermethrin 0.01%. This was followed by acephate 0.075%, fipronil 0.02%, quinalphos 0.05%, imidacloprid 0.01%, dimethoate 0.03%, endosulfan 0.05% and monocrotophos 0.05%.

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49 Pestology

Volume 30, Issue 2, 2006, Pages 31-34

Efficacy of insecticides and neem oil against sucking insect pests of brinjal (Solanum melongena LINN.)

Sarangdevot, S.S., Sharma, U.S., Ameta, O.P.

Abstract

To test the efficacy of Neem oil @ 5, 7.5 and 10 ml/litre of water, Acephate 0.5, 1.0 and 1.5 g/litre of water along with Endosulfan 35% EC (2 ml/lit.) and Malathion 50% EC (1 ml/lit.) against sucking insect pests of Brinjal was conducted at Rajasthan College of Agriculture, Udaipur. The results revealed that two applications of Acephate @ 1.5 g/lit. at three weeks interval was the most effective against aphid, jassid and whiteflies in Brinjal. However, two application of Neem oil @ 10 ml/lit, at three weeks interval was found at par not only to Acephate at two doses of 0.5 at 1.0 g/lit. of water but also to the standard checks Endosulfan 35% EC and Malathion 50% EC in reduction the population of sucking insect pests in Brinjal. The Neem oil @ 10 ml./lit. also yielded significantly higher to that of Malathion 50% EC @ 1 ml/lit. Endosulfan 35% EC @ 2 ml/lit, and Acephate at 0.5 g/lit. It was found at par to the Acephate @ 1.0 g/lit. in terms of the marketable yield.

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50 Pestology

Volume 31, Issue 2, February 2007, Pages 33-34

Evaluation of new insecticides against mango hoppers Amritodus atkinsoni L

Bhaskar, L.V., Manjunath, J., Gopal, A.V.

Abstract

A field trial was carried out for three years (2002-2004) on efficacy of different insecticides viz., Profenofos (0.05%), Imidacloprid (0.05%), Acetamiprid (0.005%), Thiodicarb (0.01%), Acephate (0.1%), and Endosulfan (0.07%) against mango hoppers Amritodus atikinsoni Lethierry. The data revealed that the efficacy of Imidacloprid (0.05%) was high with 96.56 percent reduction over control followed by Acetamiprid (0.005%) with 94.39 percent reduction over control and the least effective of insecticides were Profenofos (0.05%) followed by Thiodicarb (0.01%) when compared to untreated control.

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51 Phytoparasitica

Volume 37, Issue 3, June 2009, Pages 209-215

Toxicity of selected insecticides to Trichogramma chilonis: Assessing their safety in the rice ecosystem

Preetha, G.[a] , Stanley, J.[a c] , Suresh, S.[a] , Kuttalam, S.[a] , Samiyappan, R.[b]

Abstract

Nine insecticides, namely, imidacloprid, thiamethoxam, chlorantraniliprole, clothianidin, pymetrozine, ethofenprox, BPMC, endosulfan, acephate, and the product Virtako® (Syngenta; chlorantraniliprole 20% + thiamethoxam 20%) were tested to determine their toxicity to the parasitoid Trichogramma chilonis using an insecticide-coated vial (scintillation) residue bioassay. All the insecticides tested showed different degrees of toxicity to the parasitoid. Thiamethoxam showed the highest toxicity to T. chilonis with an LC_{50} of 0.0014 mg a.i. l^{-1}, followed by imidacloprid (0.0027 mg a.i. l^{-1}). The LC_{50} values of acephate and endosulfan were 4.4703 and 1.8501 mg a.i. l^{-1}, exhibiting low toxicity when compared with other insecticides tested. Thiamethoxam was found to be 3,195, 1,395 and 1,322 times more toxic than acephate, chlorantraniliprole and endosulfan, respectively, as revealed by the LC_{50} values to T. chilonis. Based on risk quotient, which is the ratio between the field-recommended doses and the LC_{50} of the beneficial, only chlorantraniliprole was found to be harmless to T. chilonis. The insecticides thiamethoxam, imidacloprid, Virtako®, ethofenprox and BPMC were found to be dangerous to the parasitoid. Since T. chilonis is an important egg parasitoid of leaf folders, reported to reduce the pest population considerably and often released augmentatively in rice IPM programs, the above noted dangerous chemicals should be avoided in the rice ecosystem.

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52 Biological Control

Volume 11, Issue 1, January 1998, Pages 70-76

Lethal and sublethal effects of insecticides on two parasitoids attacking Bemisia argentifolii (Homoptera: Aleyrodidae)

Jones, W.A.[a] , Ciomperlik, M.A.[b] , Wolfenbarger, D.A.[a]

Abstract

The long-term goal of this report is the documentation of the sublethal effects of pesticides to parasitic Hymenoptera. The objective of this laboratory study was to determine if parasitoids can be conserved or augmented against Bemisia argentifolii in crops where insecticides are also applied for other pests. Lethal and sublethal effects were measured for six insecticides applied in the laboratory to host larvae containing two different developmental stages each of Eretmocerus mundus Mercet from Spain and a common local species Eretmocerus tejanus Rose and Zolnerowich. Survival varied according to insecticide and developmental stage. When applied 5 days after parasitoid oviposition, thiodicarb allowed the highest rates of adult emergence by E. tejanus (65.9%) and E. mundus (35.8%). Endosulfan was the next least-toxic material, followed by the organophosphates azinphos-methyl and methyl parathion, and the insect growth regulator buprofezin. The pyrethroid bifenthrin was most toxic to both parasitoids in both developmental stages. When applied just before the expected emergence of adults, survival ranged from 47.2 to 92.2% with buprofezin, thiodicarb, and endosulfan. Some significant differences among treatments in longevity of emerged adults were detected, but females of both parasitoid species that survived the least-toxic materials were able to mate and reproduce. These findings demonstrate that there exists a wide range of responses by Bemisia parasitoids across a variety of chemicals, and that sublethal effects on the subsequent longevity and reproductive ability among survivors of the least-toxic chemicals were not severe. This study demonstrates the value of assessing sublethal effects of pesticides by showing that adult parasitoids that survive pesticides applied to immature stages within their host do not necessarily suffer latent detrimental effects on important biological parameters.

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53 Journal of Economic Entomology

Volume 94, Issue 1, 2001, Pages 55-59

Lethal and sublethal effects of insecticide residues on Orius insidiosus (Hemiptera: Anthocoridae) and Geocoris punctipes (Hemiptera: Lygaeidae)

Elzen, G.W.

Abstract

Laboratory-reared predators, the insidious flower bug, Orius insidiosus (Say), and big-eyed bug Ceocoris punctipes (Say), were exposed to 10 insecticides, including three newer insecticides with novel modes of action, using a residual insecticide bioassay. These species are important predators of several economic pests of cotton. Insecticides tested were: azinphos-methyl, imidacloprid, spinosad, tebufenozide, fipronil, endosulfan, chlorfenapyr, cyfluthrin, profenofos, and malathion. There was considerable variation in response between both species tested to the insecticides. Tebufenozide and cyfluthrin were significantly less toxic to male O. insidiosus than malathion. Tebufenozide was also significantly less toxic to female O. insidiosus than malathion. Imidacloprid, tebufenozide, and spinosad were significantly less toxic to male G. punctipes than chlorfenapyr, endosulfan, and fipronil. Spinosad, tebufenozide, and azinphos-methyl were significantly less toxic to female G. punctipes than fipronil and endosulfan. Fecundity of O. insidiosus was significantly greater in the spinosad treatment compared with other treatments including the control. Consumption of bollworm, Helicoverpa zea (Boddie), eggs by O. insidiosus was significantly lower in the fipronil, profenofos, and cyfluthrin treatments compared with other treatments including the control. Consumption of H. zea eggs by G. punctipes was significantly lower in the malathion, profenofos, endosulfan, fipronil, azinphos-methyl, and imidacloprid treatments

compared with the control. Egg consumption by G. punctipes was not significantly different in the tebufenozide treatment compared with the control. The lower toxicity of spinosad to G. punctipes is consistent with other reports. Based on these results, the following insecticides are not compatible with integrated pest management of cotton pests: malathion, endosulfan, profenofos, fipronil, and cyfluthrin; while imidacloprid, tebufenozide, azinphos-methyl, and spinosad should provide pest control while sparing beneficial species.

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54 Crop Protection

Volume 21, Issue 10, December 2002, Pages 1003-1013

Insecticide resistance of Helicoverpa armigera to endosulfan, carbamates and organophosphates: The spanish case

Torres-Vila, L.M.[a] , Rodríguez-Molina, M.C.[a] , Lacasa-Plasencia, A.[b] , Bielza-Lino, P.[c]

Abstract

Helicoverpa armigera is a major pest on a wide range of crops in Europe, Africa, Asia and Australia. Insecticide treatments are currently indispensable for its control in almost all crops, which has resulted in insecticide resistance occuring in some situations. However, since information about insecticide resistance of H. armigera in Europe is very limited, the current resistance status of this pest was investigated in Spain from 1995 to 1999. Toxicological bioassays were conducted in the laboratory, LD_{50}S estimated by probit analysis and resistance factors (RF) calculated at the LD_{50} level. Eleven chemicals, including endosulfan, carbamates (carbaryl, methomyl, thiodicarb) and organophosphates (chlorpyrifos, fenitrothion, methamidophos, azinphos-methyl, trichlorphon, acephate, monocrotophos) were tested. Ninety-seven percent of insecticide-strain combinations showed susceptibility (RF=1) or low insecticide resistance (RF=2-10) (157 of 162, 97%). Moderate resistance (RF=11-18) was only recorded to carbamates (carbaryl, methomyl and/or thiodicarb) in five strains. Insecticide resistance of H. armigera in Spain was therefore not as high or widespread as in other areas of the world. Since insecticide pressure against the pest in Spain is not likely to be lower, nor IPM implementation better, than elsewhere, additional factors that potentially account for low levels of insecticide resistance of H. armigera, including migration and cropping structure leading to the existence of refugia are discussed from an agroecological perspective.

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55 Crop Protection

Volume 12, Issue 4, June 1993, Pages 310-314

Insecticidal control of Eysarcoris trimaculatus (Distant) (Heteroptera: Pentatomidae) and Leptocorisa acuta (Thunberg) (heteroptera: alydidae) on rice in north Queensland, Australia

Kay, I.R.[a] , Brown, J.D.[a] , Mayer, R.J.[b]

Abstract

The efficacy of insecticides against Eysarcoris trimaculatus (Distant) and Leptocorisa acuta (Thunberg), grain-feeding pests of rice in north Queensland, was assessed using a bioassay technique. Field plots of rice were sprayed, panicles collected, and the mortality of insects caged on them in the laboratory was recorded. Preliminary experiments identified promising insecticides that were further assessed in replicated trials. Diazinon (280 g a.i. ha^{-1}), carbofuran (1000 g a.i. ha^{-1}) and dimethoate (135 g a.i. ha^{-1}) were ineffective against both insects. Acephate (750 g a.i. ha^{-1}) caused 100% mortality of L. acuta, but was inconsistent against E. trimaculatus. Trichlorfon (625 g a.i. ha^{-1}) and carbaryl (1040 g a.i. ha^{-1}) were inconsistent against both species. On the day of spraying, monocrotophos (300 g a.i. ha^{-1}) killed 99% of L. acuta and 75-100% of E. trimaculatus, whereas fenthion (440 g a.i. ha^{-1}) caused 100% mortality of both species. Endosulfan (735 g a.i. ha^{-1}) killed > 99% of both species on the day of spraying and had some residual effect after 2 days. Chlorpyrifos at 500 g a.i. ha^{-1} and 750 g a.i. ha^{-1} killed almost 100% of both species on the day of spraying; at 250 g a.i. ha^{-1} it killed > 98% of L. acuta and 83% of E. trimaculatus. It had little residual effect at any application rate. Chlorpyrifos (750 g a.i. ha^{-1}) will be recommended to control E. trimaculatus and L. acuta on rice in north Queensland.

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56 Pesquisa Agropecuaria Brasileira

Volume 32, Issue 2, February 1997, Pages 133-136

Effect of insecticides on the natural infection of velvetbean caterpillar by Nomuraea rileyi

Barbosa, F.R.[a] , Fernandes, P.M.[b] , Moreira, W.A.[a] , Santos, G.[c]

Abstract

The entomopathogenic fungus Nomuraea rileyi is an important natural biological control agent for Anticarsia gemmatalis Hübner population at the West Central Region, in Brazil. The objective of the current study was to examine the influence of nine insecticides on the natural infection of A. gemmatalis by the entomogenous fungus N. rileyi, during two consecutive years in Senador Canedo, Goiás, Brazil, using the insecticides recommended commercial dosages. The experimental design was a randomized complete block with ten treatments and four replications. The effect of trichlorfon and chlorpyriphos ethyl did not differ from the untreated check. Baculovirus anticarsia, diflubenzuron, endosulfan, methamidophos, monocrothophos, methyl parathion and thiodicarb had similar performance and caused a significant decrease on the percentage of infected larvae.

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57 Neotropical Entomology

Volume 31, Issue 4, 2002, Pages 615-621

Selectivity of insecticides to Chrysoperla externa (Hagen) (Neuroptera: Chrysopidae)

Carvalho, G.A., Carvalho, C.F., Souza, B., Ulhôa, J.L.R.

Abstract

The objective of this work was to evaluate the effect the insecticides endosulfan (1.05 g a.i./L), esfenvalerate (0.075 g a.i./L), fenpropathrin (0.09 g a.i./L), trichlorfon (0.09 g a.i./L) and triflumuron (0.0375 g a.i./L), used to control Alabama argillacea (Hübner), on eggs and larvae of Chrysoperla externa (Hagen), under greenhouse conditions. Egg viability, duration of the embryonic period and survival of first-instar larvae ecloded from treated eggs were evaluated. For first, second and third-instar larvae treated with the insecticides, subsequent survival of the larvae and pupae, as well as viability of the eggs produced by the emerged adults, were evaluated. The insecticides esfenvalerate and triflumuron caused a significant increase in the embryonic period of C. externa. Endosulfan, fenpropathrin, trichlorfon and triflumuron were highly toxic to larvae, with mortality rates ranging from 71% to 100%. Esfenvalerate caused only about 20% mortality of the first- and third-instar larvae and 38% of the second-instar larvae. Besides causing low larval mortality, esfenvalerate did not affect pupae survival or the reproductive capacity of the adults in the studied period, thus showing good potential for use in integrated pest management in cotton crops.

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58 Biocontrol Science and Technology

Volume 13, Issue 2, March 2003, Pages 261-267

Susceptibility to insecticides of Glyptapanteles militaris (Hymenoptera: Braconidae), a parasitoid of pseudaletia unipuncta (Lepidoptera: Noctuidae)

Raposo, F., Oliveira, L. , Garcia, P.

Abstract

The susceptibility of cocoons and adults of Glyptapanteles militaris (Walsh) were studied. One organophosphate insecticide (trichlorfon), one organochlorine insecticide (endosulfan), one pyrethroid (deltamethrin) and a commercial formulation of Bacillus thuringiensis subsp. Kurstaki were selected for testing. All the tests were carried out with fresh solutions of commercial insecticides applied on host larvae at the recommended concentration. One- and 6-day-old cocoons were sprayed with the insecticide solutions by means of a Potter Tower and held for adult emergence. Adults were exposed to residues of insecticides inside plastic vials. The B. thuringiensis formulation had no harmful effect on the cocoons nor on the adults. Trichlorfon and endosulfan were highly toxic to all the tested stages. Deltamethrin was highly toxic to adults but relatively safe when applied on parasitoid cocoons. Based on these results, field applications of deltamethrin would be least disruptive of tested insecticides to populations of G. militaris.

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59 Neotropical Entomology

Volume 32, Issue 4, 2003, Pages 699-706

Effects of insecticides used on cotton crop on chrysoperla externa (Hagen) (Neuroptera: Chrysopidae)

Carvalho, G.A., Bezerra, D., Souza, B., Carvalho, C.F.

Abstract

The physiological action of the insecticides trichlorfon, triflumuron, endosulfan, fenpropathrin, chlorpiryfos, tebufenozide and esfenvalerate to 2nd-instar larvae of Chrysoperla externa (Hagen) and subsequent effects on 3rd-instar larvae, pupae and adults were evaluated. The bioassays were carried out under greenhouse conditions. The effect on larvae fed on eggs of Anagasta kuehniella (Zeller) treated with the insecticides was evaluated, as well as the contact effect on 2nd-instar larvae kept on sprayed cotton plants. The survival percentage of individuals in the second- and 3rd-instar and in the pupae stage was determined. For adults, the daily and total production of eggs during 30 days, the viability and the fertility of eggs were evaluated. Endosulfan, tebufenozide and esfenvalerate were selective to 2nd-instar larvae by contact on sprayed plants as well as by suction of treated eggs. For 3rd-instar larvae, neither endosulfan, tebufenozide, esfenvalerate nor triflumuron were harmful. The survival of pupae from treated 2nd-instar larvae with fenpropathrin and tebufenozide was not affected. Trichlorfon, fenpropathrin and tebufenozide caused no reduction in the total number of eggs produced by females derived from 2nd- instar larvae fed with treated eggs of A. kuehniella. Females originated from larvae thatkept contact with sprayed cotton plants with esfenvalerate, had no significant reduction in the total egg production. Although tebufenozide affected the reproductive traits of C. externa, it can be recommended for controlling the pests on cotton crop in association with inundative releases of this predator.

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60 Journal of Economic Entomology

Volume 83, Issue 5, 1990, Pages 1806-1812

Effects of pesticides on pecan aphid predators Chrysoperla rufilabris (Neuroptera: Chrysopidae), Hippodamia convergens, Cycloneda sanguinea (L.), Olla v-nigrum (Coleoptera: Coccinellidae), and Aphelinus perpallidus (Hymenoptera: Encyrtidae)

Mizell III, R.F., Schiffhauer, D.E.

Abstract

Fungicides and acaricides caused <50% mortality to all the species, indicating compatibility of the predators and the parasite with chemicals used for disease and mite control. Endosulfan and phosalone were least toxic, but none of the insecticides were safe for all of the species tested. Pyrethroids were not toxic to larvae and adult C. rufilabris but organophosphates and carbamates were. There were differences in response by the egg, larva, and adult C. rufilabris to fenvalerate, cypermethrin, phosalone, endosulfan, lindane and dicofol. Pyrethroids were toxic to O. v-nigrum but phosalone, methidathion, ethion, lindane, and malathion were not. Only lindane was not toxic to adult H. convergens. All chemicals tested caused >70% mortality to C. sanguinea. Phosalone, lindane, fluvalinate, endosulfan, and azinphos-methyl were not toxic to A. perpallidus. -from Authors

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61 Acta Horticulturae

Volume 752, 2007, Pages 531-534

Efficacy of Different Insecticides as Foliar sprays against bean thrips, Megalurothrips distalis (Karny) in mungbean

Kooner, B.S., Cheema, H.K., Taggar, G.K.

Abstract

Three insecticides viz. triazophos 40 EC, ethion 50 EC and endosulfan 35 EC alongwith standard insecticide dimethoate 30 EC were evaluated as foliar sprays against bean thrips, Megalurothrips distalis in mungbean (Vigna radiata) variety SML 668 during summer 2002, 2004 and 2005 at Punjab Agricultural University, Ludhiana. All the insecticides were found effective in reducing the incidence of bean thrips and they significantly increased the yield during these years. Triazophos 40 EC at 1.5 L/ha was the most potent treatment in reducing the damage, resulting in significantly higher mean yield (1393 kg/ha) as compared to control (1162 kg/ha) during the three years, followed by endosulfan 35 EC at 2.25 L/ha and ethion 50 EC at 2.0 l/ha (1360 kg/ha and 1334 kg/ha, respectively) which did not differ significantly between themselves. Triazophos 40 EC fetched the highest net returns (Rs.2717/ha) over control.

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62 Pestology

Volume 33, Issue 11, November 2009, Pages 25-29

Evaluation of bipm module against cabbage pest complex

Palande, P.R., Pokharkar, D.S.

Abstract

The biointensive integrated pest management (BIPM) module with parasitoid and microbial agents was evaluated in comparison with recommended chemical control schedule of Maharashtra state against pest complex on cabbage. The chemical control schedule consisting sprays of dimethoate 0.03 per cent, endosulfan 0:07 per cent, quinalphos 0.05 per cent and cypermethrin 0.0075 per cent given at 10 days interval commencing from 15 days after transplanting resulted in minimum mean surviving pests population (0.91 aphid/3 leaves, 1.11 larvae of DBM/plant, 0.51 larva of H. armigera/plant) with 59.00, 55.60 and 74.63 per cent reduction in aphid, DBM and H. armigera population respectively. Also, this treatment recorded maximum of 383.7 q/ha marketable cabbage heads andn proved to be the most effective. However, the BIPM module consisting two sprays of V. lecanii @ 1.5 x 10^{12} cfu/ha at 10 days interval, five releases of T. bactrae @ 50,000 adults/ha/release at weekly interval with two intermittent sprays of B. thuringensis @ 1 kg/ha at 10 days interval and a spray of HaNPV @ 250 LE/ha (1.5 x 10^{12} POBs/ha) starting from 15 days after transplanting of cabbage seedlings registered mean surviving pests population of 1.18 aphids/3 leaves, 1.24 larvae of DBM/plant and 0.63 larva of H. armigera with 378.7 q/ha yield of marketable cabbage heads. The BIPM module found statistically comparable with chemical control schedule in respect of surviving population of DBM and H. armigera after three weeks from treatment initiation and yield parameters.

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63 Pestology

Volume 31, Issue 5, May 2007, Pages 50-57

Bioefficacy of diafenthiuron 50 SC (Polo 50 SC) against grapevine pests and its effect on natural enemies and plants

Balikai, R.A.[a b]

Abstract

A field trial was conducted to evaluate the efficacy of Diafenthiuron 50 SC (Polo 50 SC) against grape pests viz., thrips (Thrips palmi Karny and Scirtothrips dorsalis Hood), mites [Tetranychus urticae (Koch.)] and flea beetles (Sceledonta strigicollis Motschulsky) and its effect on natural enemies and vines during 2005-06 at the Horticulture Research Station, Bijapur, Karnataka. Results revealed that, Polo 50 WP @ 600 g/ha, Polo 50 SC @ 600 ml/ha, Polo 50 SC @ 400 ml/ha were highly effective against thrips. Only the lower dosage i.e., Polo 50 SC @ 400 ml/ha was as effective as Dicofol 18.5 EC @ 2500 ml/ha and Standard check (Monocrotophos 36 WSC @ 1000 ml/ha followed by Dimethoate 30 EC @ 1700 ml/ha) which in turn were on par with Phosalone 35 EC @ 2000 ml/ha and Endosulfan 35 EC @ 1000 ml/ha. Polo 50 SC @ 600 ml/ha, Dicofol 18.5 EC @ 2500 ml/ha, Standard check (Monocrotophos 36 WSC @ 1000 ml/ha followed by Dimethoate 30 EC @ 1700 ml/ha) and Polo 50 WP @ 600 g/ha were equaly effective in bringing down the mite population. Only the lower dosage i.e., Polo 50 SC @ 400 ml/ha was as effective as Polo 50 WP @ 600 g/ha and Phosalone 35 EC @ 2000 ml/ha. Polo 50 SC @ 600 ml/ha, Polo 50 SC @ 400 ml/ha and Polo 50 WP @ 600 g/ha were highly effective against flea beetles as compared to any of the treatments. The next best treatments included Dicofol 18.5 EC @ 2500 ml/ha, Phosalone 35 EC @ 2000 ml/ha and Standard check (Monocrotophos 36 WSC @ 1000 ml/ha followed by Dimethoate 30 EC 2 1700 ml/ha). Polo 50 SC @ 600 ml/ha recorded highest yield of 8.94 and did not differ statistically from Polo 50 WP @ 600 g/ha, Polo 50 SC @ 400 ml/ha, Standard check (Monocrotophos 36 WSC @ 1000 ml/ha followed by Dimethoate 30 EC @ 1700 ml/ha), Dicofol 18.5 EC @ 2500 ml/ha and Phosalone 35 EC @ 2000 ml/ha with 8.76, 8.75, 8.72, 8.70 and 8.54 kg/vine respectively. Endosulfan 35 EC @ 1000 ml/ha recorded lowest yield of 7.86 kg/vine and was on par with all other treatments except Polo 50 SC @ 600 ml/ha.

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64 Pestology

Volume 23, Issue 7, July 1999, Pages 49-51

Evaluation of deltamethrin 2.8 EC against bollworms on cotton

Latpate, C.B., Dhanorkar, B.K.

Abstract

A field experiment was conducted on NHH 44 cotton during kharif 1998 on farmer's field in Parbhani district to evaluate deltamethrin 2.8 EC with three dosages, i.e. 12.5, 25.0 and 50.0 g ai/ha against bollworms on cotton. The results

indicated that deltamethrin 2.8 EC @ 12.5 g ai/ha was found to be optimum and significantly superior to monocrotophos, endosulfan and untreated control as it reduced bollworms infestation and increased cotton yield.

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65 Pestology

Volume 29, Issue 1, 2005, Pages 31-33

Efficacy of insecticides against Brinjal shoot and fruit borer, leucinodes orbonalis (GUEN.)

Eswara Reddy, S.G.[a b], Srinivasa, N.[a]

Abstract

Field trials were conducted during kharif 98 and summer 99 to evaluate six commonly used insecticides including one new compound carbosulfan for the control of the shoot and fruit borer, Leucinodes orbonalis (Guen). Results revealed that endosulfan 0.07% recorded the least fruit borer (10.28%) damage and was on par with quinalphos 0.07% and carbosulfan 0.05% followed by chlorpyriphos 0.04%, carbaryl 0.2% and deltamethrin 0.003% but the marketable yield was maximum with carbosulfan 0.05% followed by deltamethrin 0.003% and quinalphos 0.04% in kharif. During summer deltamethrin 0.05% was superior with low fruit borer damage (11.11%) and recorded the highest marketable yield followed by carbosulfan 0.05%.

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66 Pestology

Volume 25, Issue 9, September 2001, Pages 48-50

Efficacy of chlorpyrifos and chlorpyrifos-methyl against pests of brinjal

Sawant, N.C., Dethe, M.D.

Abstract

Studies on bioefficacy of chlorpyrifos (Dursban 20 EC) and chlorpyrifos-methyl [Reldan 50 EC (=45% w/w)] were carried out against pests of brinjal viz., jassid, whitefly and fruit borer in comparison to monocrotophos and endosulfan. A treatment schedule consisting of three sprays at the dose of 0.5 to 0.75 kg a.i./ha/spray applied at an interval of 15 days by initiating the first 5 weeks after transplanting, not only lowered the incidence of sucking pests and fruit borer but also recorded more yield of healthy fruits (105 to 176 q/ha) compared to untreated control (66.2 q/ha).

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67 Tropical Pest Management

Volume 28, Issue 2, 1982, Pages 122-125

Field evaluation of some new ultra-low-volume (u.l.v.) insecticides for rainfed cotton in the Niger State of Nigeria.

Chaudhry, A.B.

Abstract

Endosulfan and monocrotophos were applied at 3/ha using a battery-operated Ulva micron sprayer. Monocrotophos gave an increased cotton yield of 938.5 and 1235.5 kg seed cotton/ha in the 1975-76 and 1976-77 seasons, respectively, when compared with controls. Similarly, endosulfan gave increased yields of 670.0 and 714.5 kg/ha. Carbaryl, applied at 1.1 kg w.p./ha using a knapsack sprayer, resulted in increased yields of 587.0 and 763.5 kg/ha, respectively. Monocrotophos u.l.v. is the thus most effective insecticide, and spraying is a prerequisite for an economical cotton crop.-from Author

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68 Pestology

Volume 29, Issue 10, 2005, Pages 41-44

Field efficacy of insecticides against pod borer [Helicoverpa armigera (Hb.)] and podfly (Melanagromyza obtusa Malloch) infesting pigeonpea cultivar Bahar

Kumar, A.[b] , Nath, P.[a]

Abstract

The experiments were conducted to find out the field efficacy of insecticides against pod borer [Helicoverpa armigera (Hb.)] and podfly (Melanagromyza obtusa Malloch) infesting pigeonpea cultivar Bahar at the Agriculture Research Farm, Banaras Hindu University, Varanasi during 1994-95 and 1995-96. All the insecticides, each applied in two different schedules, were found significantly superior over the control in reducing the pest population. The efficacy

against pod borer was in the descending order of endosulfan > fenvalerate > cypermethrin > deltamethrin > monocrotophos > carbaryl > malathion while against podfly the order was as monocrotophos > endosulfan > cypermethrin > fenvalerate > deltamethrin > carbaryl (D) > malathion (D) > control. The insecticides applied two times first at flowering and podding stage and second at 25 days after the first application were significantly superior over the single application i.e. at flowering and podding stage. The temporal distribution of the population of pod borer exhibited significant difference and the maximum population was recorded on 10th March and minimum on 24th March while podfly was observed maximum on 14th March and minimum on 4th April in both the years of experimentation. The maximum grain yield was obtained in case of monocrotophos treated plots (24.85 q/ha) while the minimum grain yield was recorded in the control plots (13.16 q/ha).

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69 Pestology

Volume 25, Issue 3, March 2001, Pages 10-12

Efficacy of lambda-cyhalothrin (karate 5 EC) against fruit borer (Helicoverpa armigera HUB.) in okra (Abelmoschus esculentus L.)

Rajkumar, S.[a], Sureshkumar, R.S.[b], Karthik, J.[a], Chozhan, K.[a], Regupathy, A.[b]

Abstract

The bio-efficacy of lambda-cyhahlothrin (Karate 5 EC) was assessed in comparison with endosulfan (Thiodan 35 EC) 350 g ai/ha against okra fruit borer. Lambda-cyhalothrin applied @ 30 and 40 g ai/ha was on par and found effective against the above said pest. The order of efficacy was lambda-cyhalothrin 40 = 30 g ai/ha > 20 g ai/ha > 15 g ai/ha > endosulfan 350 g ai/ha.

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70 Pestology

Volume 31, Issue 11, November 2007, Pages 60-61

Bioefficacy of some insecticides against few major insect pests of rice

Kalita, H.[a b], Bhuya, U.[a], Ahmed, T.[a]

Abstract

The efficacy of four different insecticides was evaluated during khatif, 2005 against certain Rice pests viz., stem borer, leaf folder and case worm by taking monocrotophos (Monocrown 36 SL) @ 500 g ai/ha as check. The results revealed that all the insecticidal treatments reduced the insect population significantly over control and incurred significantly higher yield. Among the treatments, monocrotophos 500 g ai/ha reduced maximum population of insect pests and gave highest yield (34.17 q/ha). Endosulfan (Thiodan 330 CCS) @ 500 g ai/ha showed at par result with monocrotophos (check), hence it may be a viable alternative for Rice pest management.

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71 Pestology

Volume 32, Issue 11, November 2008, Pages 22-24

Field efficacy of some pesticides against flea beetle, Podagrica bowringi Baly. (Coleoptera: Chrysomelidae) infesting okra

Thul, S.R.[a], Patil, R.S.[a b], Mule, R.S.[a b], Jalgaonkar, V.N.[a c]

Abstract

Results of the field experiment conducted to test efficacy of nine pesticides against okra flea beetle, Podagrica bowringi Baly. indicated that the significantly lowest mean per cent leaf damage was noticed in the treatment with 0.0075 per cent cypermethrin at both the observations recorded at 15 days after every spray. Applications of 0.0015 per cent lambda cyhalothrin and 0.05 per cent endosulfan were proved second and third best treatments in order of merit, respectively. Treatment with 0.0015 per cent lambda cyhalothrin also registered highest yield of marketable fruits of okra and gave maximum increased yield of 40.04 q/ ha. over untreated control.

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74 Indian Journal of Agricultural Sciences

Volume 73, Issue 9, September 2003, Pages 518-520

Bioefficacy and persistence of beta-cyfluthrin in or on tomato (Lycopersicon esculentum)

Sharma, I.D.[a] , Nargaeta, D.S.[a] , Chandel, R.S.[b] , Sharma, K.C.[a]

Abstract

β-cyfluthrin, a synthetic pyrethroid, was evaluated during 1999 and 2000 crop seasons for its efficacy against the tomato fruitborer [Helicoverpa armigera (Hübner)] and its persistence on tomato (Lycopersicon esculentum Miller nom. cons), β-cyfluthrin @ 12.50, 18.75 and 25.00 g ai/hawas compared with cypermethrin and endosulfan. It was more effective @ 25.00 g ai/ha, giving significantly higher yield of tomato. However, the lower dose (12.50 g ai/ha) was also effective and resulted in more yield than those with cypermethrin or endosulfan. The residue levels reached half of the initial deposits after 1.56-1.86 days with waiting period of 5-7 days, irrespective of doses and seasons.

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75 Pestology

Volume 31, Issue 7, July 2007, Pages 32-36

Field efficacy of some newer insecticides against coriander aphid (Hyadaphis coriandari Das.)

Meena, R.S., Gupta, H.C.L., Swaminathan, R.

Abstract

The efficacy of seven insecticides at two applications tested against the aphid in the field revealed that imidacloprid (0.008%) was most effective, followed by profenofos (0.07%). The next effective treatment were dimethoate (0.03%), thiamethoxam (0.008%) and ethion (0.07%) which ranked in middle order in their efficacy where as endosulfan (0.07%) and malathion (0.05%) were least effective against the aphid. The highest seed yield (13.14 q/ha) was obtained in the plots treated with Imidacloprid 0.008 per cent followed by profenofos 0.07 per cent (12.71 q/ha). The seed yield obtained in the plots treated with dimethoate 0.03 per cent thiamethoxam 0.008 per cent and ethioin 0.07 per cent were 11.27, 11.05 and 10.55 q/ha respectively, whereas as low as 9.15 q/ha yield in case of endosulfan 0.07 per cent and 8.46 q/ha yield in case of malathion 0.05 per cent were recorded. The highest benefit cost ratio of 9.91 was found in Imidacloprid 0.008 per cent, followed by profenofos 0.07% (9.17%), while it was lowest in the treatment of Thiamethoxam 0.008% (3.54) and endosulfan (3.69).

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76 Pestology

Volume 33, Issue 12, December 2009, Pages 46-49

Bioefficacy of selected insecticides against early shoot borerand internode borer (Chilo infuscatellus SNELLEN) in sugarcane

Bhavani, B., Rao, V.N., Rao, Ch.V.N.

Abstract

A field experiment was conducted for two consecutive years to evaluate the comparative bioefficacy of promising insecticides against early shoot borer and internode borer (Chilo infuscatellus Snellen) in sugarcane. The mean data of two years revealed that spraying of acephate 75SP @ 1 gm/lt and flufenoxuron 10 EC @1 ml/It were found to be the most effective in minimizing the damage due to early shoot borer and internode borer as well as in increasing the yields over check. AU the insecticidal treatments were significantly superior to untreated control in suppressing early shoot borer and internode borer incidence. The over all mean efficacy of the treatments in the descending order was acephate 75SP, flufenoxuron 10EC, endosulfan 35EC, profenophos 50EC + multineem, malathion 50EC, multineem, dimethoate 30EC.

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77 Pestology

Volume 33, Issue 12, December 2009, Pages 39-42

Bioefficacy of different insecticides against spodoptera Litura F. on potato (Solanum tuberosum L) in ZAHEERABAD, medak district (ANDHRA PRADESH)

Shankarappa, A.M., Bhushan, V.S.

Abstract

The present findings on management of cut worm, Spodoptera litura on potato with certain insecticides revealed that Iufenuron 10%EC @0.75ml/Iit was found to be best treatment with lowest incidence (20.99%) followed by endosulfon 35EC @2ml/lit (22.26%) and acephate 75 WP@lg/lit (23.83%) which were on par with each other. After 60 DAP Iufenuron was found to be best treatment with lowest incidence of (20.99%) defoliation followed by endosulfon (14.94%) and acephate (16.67%). maximum percent defoliation was noticed in NPV treatment plots during both treatments (33.55% and 24.73%) at 40 and 60 DAS respectively. The lowest percent of tuber damage on number basis was registered in the plots treated with Iufenuron (4.61%), endosulfan (637%), and acephate (6.45%) followed by carbaryl (737%) and poison bait (7.73%) which were on par with each other. Highest per cent of tuber damage was obtained from NSKE 5% (13.91%) and NPV (16.09%) treated plots. Highest yield of 75.69 qt/ha was recorded from Iufenuron which was on par with endosulfon (71.52 qt/ha) followed by acephate (63.19 qt/ha). The lowest yield recorded from NSKE and NPV (52.07 qt/ ha and 4930 qt/ha respectively) in treated plots The fallowings conclusions were drawn from the present studies. Among the seven insecticides evaluated Iufenuron 10 EC at 0.75 ml/liter recorded least damage of Spodoptera litura F. Fab.

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78 Annals of Plant Protection Sciences

Year : 2008, Volume : 16, Issue : 1

Bio-efficacy of Beta-cyfluthrin, Lambda - cyhalothrin and imidacloprid against *Earias vitella* Fab. in Okra

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[2]Bhagalpur Agricultural College, Sabour, Bhagalpur - 813 210, India

Abstract

The present investigation was carried out to evaluate the bio-efficacy of beta-cyfluthrin, lambda-cyhalothrin and imidacloprid against shoot and fruit borer (*Earias vitella*) in okra (*Abelmoschus esculentus* L.). All the insecticides recorded reasonably less shoot and fruit damage due to *E. vitella* in okra in comparison to untreated control. Lambda-cyhalothrin @ 30g a.i.ha^{-1} was significantly superior to all other treatments and on par with endosulfan @500 g a.i. ha^{-1} Maximum net benefit (Rs.7018 ha^{-1}) was obtained with lambda-cyhalothrin (30g a.i.ha^{-1}). In terms of incremental cost-benefit ratio (ICBR), lambda-cyhalothrin treatment @15g a.i. ha^{-1} recorded maximum cost-benefit ratio of 1:4.73 as compared to other treatments.

Annex III - Results from the screening risk assessment of chemical alternatives compared to endosulfan

For an evaluation of the safety of alternatives information on several risks indicators for adverse effects on the environment and health can be used. Appropriate risk indicators are POPs screening criteria (persistence, bioaccumulation, toxicity and potential for long-range transport) and several hazardous criteria (mutagenicity, carcinogenicity, reproductive toxicity, developmental toxicity, endocrine disruption, immune suppression, neuro-toxicity) (see UNEP/POPS/POPRC.5/6). As additional information with particular relevance for alternatives for endosulfan information on the toxicity of the alternatives to bees is relevant.

In addition to the risks, consideration should also be given to the exposure situation (see UNEP/POPS/POPRC.5/6) of the environment, workers, farmers and consumers. However, it is assumed that the exposure situation for different insecticides is more or less comparable due to usually comparable use conditions. It can be expected that exposure generally increases with the persistence and bioaccumulation potential of the insecticides. This is however already reflected in the above listed risk indicators.

Given the multitude of available alternatives a comprising assessment of risks related to alternatives is difficult. For a screening assessment of the risks related to the identified chemical alternatives, available information on the risk indicators has been compiled. On the basis of the compilation it is possible to evaluate the risks related to the identified alternatives and to indicate priorities for more and less appropriate alternatives (concerning their risks to environment and health) and to identify alternatives for which information on risk indicators is lacking. The results of a screening risk assessment of chemical alternatives are presented in

For the assessment information on the POP screening criteria of identified alternative substances was investigated. Information on PBT criteria was among other taken from [Greenpeace 2010]. The criterion “Bioccumulation” was furthermore based on the evaluation of the Log Kow values of the corresponding substances. The criterion was considered to be fulfilled if the Log Kow is > 4. The criterion “Toxicity” was furthermore based on the classification according to Regulation (EC) No 1272/2007. The criterion was considered to be fulfilled if (1st priority) according to Regulation (EC) No 1272/2007 the acute toxicity of the corresponding substance is classified 1 or 2 or if acute or chronic aquatic toxity is classified 1 or (2nd priority, if the substance is not classified according to Regulation (EC) No 1272/2007) if the substance is class Ia, Ib or II according to WHO toxicity classification (Ia = Extremely hazardous; Ib = Highly hazardous; II = Moderately hazardous). The information on the WHO classification was taken from [IOBC 2005].

Information on the further risk indicators was compiled from the classification according to Regulation (EC) No 1272/2007 (related to mutagenicity (M), carcinogenicity (C) and reproductive toxicity (R); criterion considered to be fulfilled if classified C, M or R according to Regulation (EC) No 1272/2007 or not considered to be fulfilled if not classified C, M or R) and from [IOBC 2005] and [Greenpeace 2010].

A ranking has been established by summing up for endosulfan and each chemical alternative the number of criteria fulfilled.

According to this procedure endosulfan obtains 4 points in the ranking because it fulfils the four criteria persistence, bioaccumulation, toxicity and potential for long range transport. Out of the identified chemical alternatives only 6 other substances fulfil four criteria (Bifenthrin, Deltamethrin, Dicofol, Lambda cyhalothrin, Phoxim and Propargite) and another 9 substances fulfil 3 criteria. 28 substances fulfil 2 criteria, 17 substances fulfil 1 criterion and 9 substances do not fulfil any of the criteria. For 16 substances no data have been identified.

Against the background of the screening risk assessment it can be assumed that if endosulfan will be replaced by a substance with a lower ranking it will be replaced by a safer alternative. This is the case for 63 chemical alternatives. For 16 substances a conclusion is not possible. 6 substances may cause equal risks as endosulfan (however these substances fulfil only one, two or three of the POP criteria risk indicators but in addition 1 to 3 of the adverse effect risk indicators; they could therefore be considered less hazardous than endosulfan which fulfils all POP criteria risk indicators). It can be concluded that if endosulfan would not be available for plant protection it would be replacable by safer alternatives in the majority of cases.

As additional information, Table 14 contains an overview on the bee toxicity properties of identified chemical alternatives to endosulfan. 34 of the alternatives are toxic to bees whereas 23 of the alternatives are not toxic to bees (in case of contradictory information both events are counted). For 35 alternatives information on bee toxicity has not been identified. The information on the bee toxicity of endosulfan itself is contradictory. According to IPEN, endosulfan is toxic to bees [IPEN 2010]. According to other sources it is not. A clear conclusion whether alternatives to endosulfan are more or less toxic to bees is not possible on the basis of the present information. However the distribution of bee toxic properties among possible chemical alternatives allows the assumption that in many situations it will be possible to replace endosulfan by alternatives without bee toxicity.

Table 14. Overview of results from the screening risk assessment of chemical alternatives compared to endosulfan

No	Substance	Risk indicators: POP criteria				Risk indicators: adverse effects							Ran-king	Other data
		P	B [log kow]	T	LRT	Muta-genicity	Carcino-genicity	Reproduc-tive tox.	Deve-lopmen-tal tox.	Endocrine disruption	Immune suppression	Neuro-toxicity		Bee toxicity 7)
0	**Endosulfan**	**y 1)**	**y 1) [3,6 to 4,7] 1)**	**y 6)**	**y 1)**	n 6)	n 6)	n 6)					**4**	**y 9) / n**
1	Bifenthrin		**y 8) [>6-8.15] (12)**	n (8)				**y 8)**		**y 8)**		**y 8)**	**4**	**y/n**
2	Lambda cyhalothrin		**y 8) [6,85] 10)**	**y 6)**		n 6)	n 6)	n 6)		**y 8)**		**y 8)**	**4**	N
3	Deltamethrin		**y [6,18] (10)**	**y 6)**		n 6)	n 6)	n 6)		**y 8)**		**y 8)**	**4**	**y 8)**
4	Dicofol	**y (8)**	**y [4 to 5]**	**y 6)**		n 6)	n 6)	n 6)				**y (8)**	**4**	**y 8)**
5	Propargite		**y [5.57] (12)**	**y 6)**		n 6)	**y 6)**	**y (8)**					**4**	
6	Phoxim	**y (8)**	**y [4.39] (12)**	**y 6)**		n 6)	n 6)	n 6)				**y (8)**	**4**	
7	Diazinon		n 8) [3,86] 10)	**y 6)**		n 6)	n 6)	**y 8)**				**y 8)**	**3**	**Y**
8	Chlorpyrifos		**y (8) (10) [4,66] (12)**	**y 6)**		n 6)	n 6)	n 6)				**y 8)**	**3**	**y (8)**
9	Carbaryl	n 8)	n (8) (12)	**y 6)**		n 6)	n 6)	n 6)		**y 8)**		**y 8)**	**3**	**Y**
10	Monocrotophos		n (12) [<-1]	**y 8)**		**y 6)**	n 6)	n 6)				**y 8)**	**3**	**y 8)**
11	Esfenvalerat		**y 8) [6,22]**	**y 6)**		n 6)	n 6)	n 6)				**y 8)**	**3**	**y 8)**
12	Permethrin		**y 4) [7,43] (12)**	**y 6)**		n 6)	n 6)	n 6)				**y**	**3**	**y (8)**
13	Phosalone		**y (10) [4,29] (12)**	**y 6)**		n 6)	n 6)	n 6)				**y (8)**	**3**	N

No	Substance	Risk indicators: POP criteria				Risk indicators: adverse effects							Ran-king	Other data
		P	B [log kow]	T	LR T	Muta-genicity	Carcino-genicity	Reproduc-tive tox.	Deve-lopmen-tal tox.	Endocrine disruption	Immune suppression	Neuro-toxicity		Bee toxicity 7)
14	Quinalphos		n [3,04] 10)	**y 6)**		n 6)	n 6)	n6)		**y (8)**		**y (8)**	**3**	**y (8)**
15	Flucythrinate	**y (8)**	**y [6,56] (10)**									**y (8)**	**3**	
16	Profenophos		**y (8) [4.82] (12)**	n (8)								**y (8)**	**2**	
17	Tralomethrin		**y (8) [7.56] (12)**	n (8)								**y (8)**	**2**	**y (8)**
18	Zeta cypermethrin		**y (8)**	n (8)								**y (8)**	**2**	**y (8)**
19	Beta-cyfluthrin		**y [6,18]**	**y 6)**		n 6)	n 6)	n 6)					**2**	
20	Methidathion		n (12) [1.58]	**y 6)**		n 6)	n 6)	n 6)				**y 8)**	**2**	**Y**
21	Azinphos-methyl		n (12)	**y 6)**		n 6)	n 6)	n 6)				**y 8)**	**2**	**Y**
22	Parathion-Methyl		n (12) [2,75] (10)	**y 6)**		n 6)	n 6)	n 6)				**y 8)**	**2**	
23	Methamidophos		n (12) [-0.8 to -0.93]	**y 6)**		n 6)	n 6)	n 6)				**y 8)**	**2**	**Y**
24	Dimethoate		n [0.28] (12)	**y 7)**		n 6)	**n 6)**	n 6)				**y**	**2**	**Y**
25	Carbofuran		n [2,32] (12)	**y 6)**		n 6)	n 6)	n 6)				**y 8)**	**2**	**Y**
26	Cypermethrin 2 substances: a-Cypermethrin and cis/trans Cyper-methrin 80/20		**y 8) [6,38] (10)**	**y 6)**		n 6)	n 6)	n 6)				**y 8)**	**2**	**n / y 8)**
27	Dichlorvos		n [1,9] (10)	**y 6)**		n 6)	n 6)	n 6)				**y 8)**	**2**	

No	Substance	Risk indicators: POP criteria				Risk indicators: adverse effects							Ran-king	Other data
		P	B [log kow]	T	LRT	Muta-genicity	Carcino-genicity	Reproduc-tive tox.	Deve-lopmen-tal tox.	Endocrine disruption	Immune suppression	Neuro-toxicity		Bee toxicity 7)
28	Formetanate hydrochloride		n (12)	**y 6)**		n 6)	n 6)	n 6)				**y 8)**	**2**	**Y**
29	Pyridaben		**y [5,47] (10)**	**y 6)**		n 6)	n 6)	n 6)					**2**	
30	Fenvalerat		**y [6,76] (10)**	**y 7)**									**2**	**Y**
31	Dicrotophos		n [-0.5 to -1.1] (12)	**y 6)**		n 6)	n 6)	n 6)				**y 8)**	**2**	**y 8)**
32	Fenpropathrin		**y [6,0]**	**y 7)**									**2**	N
33	Thiacloprid		n [1,26]	**y 7)**			**y**						**2**	N
34	Abamectin		n [2,0]	**y 7)**				**y**					**2**	**Y**
35	Methomyl		n [0,13]	**y 6) /9**		n 6)	n 6)	n6)				**y (8)**	**2**	**Y**
36	Naled		n [1,38]	**y 6)**		n 6)	n 6)	n 6)				**y (8)**	**2**	**y (8)**
37	Nicotin		n [1,17]	**y 6)**		n 6)	n 6)	**y (8)**				**y (8)**	**2**	
38	Oxamyl		n [-1.2] (12)	**y 6)**		n 6)	n 6)	n 6)				**y (8)**	**2**	**Y**
39	Phosmet		n [2.48] (12)	**y 6)**		n 6)	n 6)	n 6)				**y (8)**	**2**	
40	Pirimicarb	**y (8)**	n [1.4] (10) (12)	**y 6)**		n 6)	n 6)	n 6)				**y (8)**	**2**	N
41	Triazophos		n [3,55]	**y 6)**		n 6)	n 6)	n 6)				**y (8)**	**2**	N

No	Substance	Risk indicators: POP criteria				Risk indicators: adverse effects							Ran-king	Other data
		P	B [log kow]	T	LRT	Muta-genicity	Carcino-genicity	Reproduc-tive tox.	Deve-lopmen-tal tox.	Endocrine disruption	Immune suppression	Neuro-toxicity		Bee toxicity 7)
42	Fenobucarb		n [2,79] 10)	**y 6)**		n 6)	n 6)	n6)				**y (8)**	**2**	
43	Oxydemeton-S-Methyl		n (12) [-1.03]	n 6)		n 6)	n 6)	**y (8)**				**y (8)**	**2**	
44	Spiromesifen		**y (8)**										**1**	
45	Beta-cypermethrin											**y (8)**	**1**	
46	Etofenprox							**y (4)**					**1**	
47	Trichlorphon		n (!"9 [0:51] 8129	**y 6)**		n 6)	n 6)	n 6)					**1**	N
48	Imidacloprid		n (12) [0.56]	**y 7)**									**1**	**Y**
49	Clofentezine		n [3,1]	**n 7)**									**1**	N
50	Malathion		n [2,36 to 3,25]	**y 6)**		n 6)	n 6)	n 6)					**1**	
51	Pymetrozin		n [-0,18]	n 7)		n 6)	**y 6)**	n 6)					**1**	N
52	Isoprocarb		n [2,30] 10)	**y 6)**		n 6)	n 6)	n6)					**1**	
53	Acephate		n (12)	n 6) 7)		n 6)	n 6)	n 6)				**y**	**1**	**Y**
54	Neem base pesticide = **Azadirachtin**			n 7)								**y**	**1**	N
55	Spinosad			n 7)								**y**	**1**	**Y**
56	Cyromazine	**y (8)**	n (12) [0.96]	n 7)									**1**	**Y**
57	Spirodiclofen			n 7)			**y (8)**						**1**	**Y**
58	Tebufenozide	**y (8)**		n 6)		n 6)	n 6)	n 6)					**1**	N
59	Buprofezin		**y [4,3] (10)**										**1**	N

No	Substance	Risk indicators: POP criteria				Risk indicators: adverse effects							Ran-king	Other data
		P	B [log kow]	T	LRT	Muta-genicity	Carcino-genicity	Reproduc-tive tox.	Deve-lopmen-tal tox.	Endocrine disruption	Immune suppression	Neuro-toxicity		Bee toxicity 7)
60	Pyriproxyfen		**y (12) [5,55] 10)**										**1**	
61	Acetamiprid			n 7)									**0**	N
62	Flubendiamide			n 7)									**0**	N
63	Lime sulphur			n 7)									**0**	N
64	Insectical soap			n 7)									**0**	N
65	Mancozeb		n [1,33] (12)	n 7)		n 6)	n 6)	n 6)					**0**	N
66	Methoxyfenozide			n 7)									**0**	N
67	sulphur			n 7)									**0**	N
68	Difenthiuron			n 7)									**0**	**Y**
69	Indoxacarb			n 7)									**0**	N
70	Flonicamid												**no data**	
71	Imidaclothiz												**no data**	
72	Fipronil												**no data**	**y (8)**
73	Novaluron												**no data**	
74	Thiomethoxam Thiamethoxam												**no data**	**y (8)**
75	Emamectinbenzoate												**no data**	
76	Chlorantraniliprole												**no data**	
77	Thian												**no data**	
78	Alfama??												**no data**	
79	Kinoprene												**no data**	
80	Kaolin clay												**no data**	
81	Mineral oil												**no data**	
82	Pyrethrin/Piperonyl butoxide												**no data**	
83	Brofluthrinate												**no data**	

No	Substance	Risk indicators: POP criteria				Risk indicators: adverse effects							Ran-king	Other data
		P	B [log kow]	T	LRT	Muta-genicity	Carcino-genicity	Reproduc-tive tox.	Deve-lopmen-tal tox.	Endocrine disruption	Immune suppression	Neuro-toxicity		Bee toxicity 7)
84	NKSE = Neem kernel seed extract see Azadirachtin												**no data**	
85	Dinotefuran												**no data**	

Notes on information sources
1) Risk profile endosulfan, UNEP/POPS/POPRC.5/3
6) based on the classification according to Regulation (EC) No 1272/2007/EC
7) [IOBC 2005] IOBC wprs Working Group "Pesticides and Beneficial Organisms & IOBCwprs Commission “IP Guidelines and Endorsement” (05.12.2005 Comm.)
8) [Greenpeace 2010]
9) [IPEN 2010]
10) [Gerstel 2004]
11) EU Pesticides data base (http://ec.europa.eu/sanco_pesticides/public/index.cfm?event=activesubstance.selection)
12) [Miljominstriet 2004] (http://www2.mst.dk/common/Udgivramme/Frame.asp?http://www2.mst.dk/udgiv/publications/2004/87-7614-434-8/html/bred03_eng.htm)

Annex IV – Overview on information on costs for endosulfan and chemical alternatives in crop/pest specific applications in the USA

Table 15. Overview on costs for endosulfan and chemical alternatives in crop/pest specific applications (based on information from [U.S. EPA 2009 A] to [U.S. EPA 2009 H])

Substance	Cost impact factor per application, range and average value [US$/ha]	Pest	Region	Source
Apples - Endosulfan				
Endosulfan	64.50	Stink bugs	Pacific Northwest	[U.S.EPA 2009 H]
	27.63	Woolly apple aphid	East	[U.S.EPA 2009 H]
Range	27.63-64.50			
Average	46.06			
Apples - Alternatives				
Abamectin	82.75	Spirea aphid	East	[U.S.EPA 2009 H]
Acetamiprid	113.50	Woolly apple aphid	East	[U.S.EPA 2009 H]
	124.50	Stink bugs	West	[U.S.EPA 2009 H]
	58.00	Spirea aphid	East	[U.S.EPA 2009 H]
	58.00-124.50			
	98.67			
Azadirachtin	110.00	Spirea aphid	East	[U.S.EPA 2009 H]
Azinphos-methyl	29.00	Spirea aphid	West	[U.S.EPA 2009 H]
	25.25	Stink bugs	West	[U.S.EPA 2009 H]
	25.25-29.00			
	27.13			
Bifenazate	104.75	Spirea aphid	East	[U.S.EPA 2009 H]
Carbaryl	39.25	Woolly apple aphid	West	[U.S.EPA 2009 H]
	19.25	Spirea aphid	East	[U.S.EPA 2009 H]
	17.25	Spirea aphid	West	[U.S.EPA 2009 H]
	17.25-39.25			
	25.25			
Chlorpyrifos	31.25	Woolly apple aphid	East	[U.S.EPA 2009 H]
	34.50	Woolly apple aphid	West	[U.S.EPA 2009 H]
	25.75	Spirea aphid	East	[U.S.EPA 2009 H]
	39.75	Spirea aphid	West	[U.S.EPA 2009 H]
	25.75-39.75			
	32.81			
Clofentezine	92.25	Spirea aphid	East	[U.S.EPA 2009 H]
Deltamethrin	7.50	Spirea aphid	East	[U.S.EPA 2009 H]
Diazinon	33.25	Woolly apple aphid	East	[U.S.EPA 2009 H]
	43.75	Woolly apple aphid	West	[U.S.EPA 2009 H]
	19.25	Spirea aphid	East	[U.S.EPA 2009 H]
	19.25-43.75			
	32.08			
Dimethoate	14.50	Woolly apple aphid	East	[U.S.EPA 2009 H]
	24.00	Spirea aphid	West	[U.S.EPA 2009 H]
	14.50-24.00			
	19.25			
Emamectinbenzoate	72.50	Spirea aphid	East	[U.S.EPA 2009 H]
Esfenvalerate	12.75	Spirea aphid	East	[U.S.EPA 2009 H]
Extoxazole	107.00	Spirea aphid	East	[U.S.EPA 2009 H]
Fenpropathrin	32.35	Spirea aphid	East	[U.S.EPA 2009 H]
	52.75	Stink bugs	West	[U.S.EPA 2009 H]
	32.35-52.75			
	42.55			
Imidacloprid	63.05	Woolly apple aphid	East	[U.S.EPA 2009 H]
	37.50	Spirea aphid	West	[U.S.EPA 2009 H]
	46.00	Stink bug	East	[U.S.EPA 2009 H]
	37.50-63.05			
	48.85			
Indoxacarb	41.00	Spirea aphid	East	[U.S.EPA 2009 H]
Kaolin clay	52.25	Spirea aphid	East	[U.S.EPA 2009 H]
Malathion	13.25	Spirea aphid	East	[U.S.EPA 2009 H]
Methidathion	28.50	Spirea aphid	East	[U.S.EPA 2009 H]
Methomyl	27.00	Spirea aphid	East	[U.S.EPA 2009 H]

Substance	Cost impact factor per application, range and average value [US$/ha]	Pest	Region	Source
Methoxyfenozide	76.25	Woolly apple aphid	West	[U.S.EPA 2009 H]
	45.25	Spirea aphid	East	[U.S.EPA 2009 H]
	45.25-76.25			
	60.75			
Novaluron	65.25	Spirea aphid	East	[U.S.EPA 2009 H]
Oxamyl	36.00	Woolly apple aphid	East	[U.S.EPA 2009 H]
Oxydemeton-methyl	96.25	Spirea aphid	East	[U.S.EPA 2009 H]
Permethrin	33.25	Woolly apple aphid	East	[U.S.EPA 2009 H]
	16.50	Spirea aphid	West	[U.S.EPA 2009 H]
	16.50-33.25			
	24.88			
Phosmet	29.25	Spirea aphid	East	[U.S.EPA 2009 H]
Propargite	137.00	Woolly apple aphid	West	[U.S.EPA 2009 H]
Pyridaben	129.25	Spirea aphid	East	[U.S.EPA 2009 H]
Thiacloprid	58.75	Woolly apple aphid	East	[U.S.EPA 2009 H]
	63.25	Spirea aphid	East	[U.S.EPA 2009 H]
	58.75-63.25			
	61.00			
Thiomethoxam	58.75	Woolly apple aphid	East	[U.S.EPA 2009 H]
	58.00	Spirea aphid	East	[U.S.EPA 2009 H]
	58.00-58.75			
	58.38			
γ-cyhalothrin	17.50	Spirea aphid	East	[U.S.EPA 2009 H]
λ-cyhalothrin	21.25	Spirea aphid	East	[U.S.EPA 2009 H]
Comparison	Alternatives	Endosulfan		
Range	7.50-137.00	27.63-64.50		
Average	51.31	46.06		

Cantaloupe - Endosulfan				
Endosulfan	22.50	Aphid, whitefly, cabbage looper	California, Arizona	[U.S.EPA 2009 D]
Cantaloupe - Alternatives				
Abamectin	87.50	Aphid, whitefly, cabbage looper	West (California, Arizona)	[U.S.EPA 2009 D]
Bifenthrin	35.00	Aphid, whitefly, cabbage looper	West (California, Arizona)	[U.S.EPA 2009 D]
Carbaryl	17.50	Aphid, whitefly, cabbage looper	West (California, Arizona)	[U.S.EPA 2009 D]
Diazinon	17.50	Aphid, whitefly, cabbage looper	California, Arizona	[U.S.EPA 2009 D]
Esfenvalerate	17.50	Aphid, whitefly, cabbage looper	California, Arizona	[U.S.EPA 2009 D]
Imidacloprid	140.00	Aphid, whitefly, cabbage looper	West (California, Arizona)	[U.S.EPA 2009 D]
Methomyl	35.00	Aphid, whitefly, cabbage looper	West (California, Arizona)	[U.S.EPA 2009 D]
Oxamyl	60.00	Aphid, whitefly, cabbage looper	West (California, Arizona)	[U.S.EPA 2009 D]
Permethrin	12.50	Aphid, whitefly, cabbage looper	West (California, Arizona)	[U.S.EPA 2009 D]
Pymetrozine	40.00	Aphid	West (California, Arizona)	[U.S.EPA 2009 D]
Comparison	Alternatives	Endosulfan		
Range	12.50-140.00	22.50		
Average	46.25	22.50		

Cotton - Endosulfan				
Endosulfan	26.25	Lygus bug, whitefly	Arizona	[U.S.EPA 2002 B], [U.S.EPA 2009 A]
	11.63	Boll weevil, boll worm	Texas	[U.S.EPA 2002 B], [U.S.EPA 2009 A]
	27.50	Lygus bug, whitefly	California	[U.S.EPA 2009 A]

Substance	Cost impact factor per application, range and average value [US$/ha]	Pest	Region	Source
	12.50		Australia	[Australia 2010]
Range	11.63-27.50			
Average	19.47			
Cotton - Alternatives				
Acephate	20.00	Lygus bug	Arizona	[U.S.EPA 2009 A]
	20.00	Lygus bug, whitefly	Texas	[U.S.EPA 2009 A]
Acetamiprid	42.50	Lygus bug, whitefly	Texas	[U.S.EPA 2009 A]
	42.50	Lygus bug, whitefly	Arizona	[U.S.EPA 2009 A]
Aldicarb	99.50	Lygus bug	Arizona	[U.S.EPA 2009 A]
Bifenthrin	15.00	Lygus bug, whitefly	Texas	[U.S.EPA 2009 A]
Buprofezin	60.00	Whitefly	Texas	[U.S.EPA 2009 A]
Cypermethrin	7.50	Lygus bug	California	[U.S.EPA 2009 A]
	7.50	Lygus bug	Texas	[U.S.EPA 2009 A]
Deltamethrin	10.00	Lygus bug	Arizona	[U.S.EPA 2009 A]
	10.00	Lygus bug	Texas	[U.S.EPA 2009 A]
	10.00	Lygus bug	California	[U.S.EPA 2009 A]
Dicrotophos	7.50	Lygus bug	Texas	[U.S.EPA 2009 A]
Dimethoate	7.50	Lygus bug	Texas	[U.S.EPA 2009 A]
Esfenvalerate	10.00	Lygus bug	California	[U.S.EPA 2009 A]
	10.00	Lygus bug	Texas	[U.S.EPA 2009 A]
Fenpropathrin	30.01	Lygus bug, whitefly	Arizona	[U.S.EPA 2002 B]
	22.50	Whitefly	Texas	[U.S.EPA 2009 A]
	22.50	Whitefly	California	[U.S.EPA 2009 A]
	22.50-30.01			
	25.00			
Flonicamid	17.50	Lygus bug, whitefly	Arizona	[U.S.EPA 2009 A]
Imidacloprid	55.00	Lygus bug	Arizona	[U.S.EPA 2009 A]
	55.00	Lygus bug	California	[U.S.EPA 2009 A]
	55.00	Lygus bug	Texas	[U.S.EPA 2009 A]
Indoxacarb	36.35	Boll worm	Texas	[U.S.EPA 2009 A]
	30.00	Lygus bug	California	[U.S.EPA 2009 A]
	30.00-36.25			
	33.18			
Malathion	12.50	Boll weevil	Texas	[U.S.EPA 2002 B]
Methamidophos	15.00			[U.S.EPA 2009 A]
Methidathion	35.00	Lygus bug	Arizona	[U.S.EPA 2009 A]
Methomyl	15.00	Lygus bug	Texas	[U.S.EPA 2009 A]
Naled	15.00	Lygus bug	Arizona	[U.S.EPA 2009 A]
Novaluron	22.50	Lygus bug	Arizona	[U.S.EPA 2009 A]
Oxamyl	30.00	Lygus bug	Arizona	[U.S.EPA 2009 A]
	30.00	Lygus bug	California	[U.S.EPA 2009 A]
	30.00	Lygus bug	Texas	[U.S.EPA 2009 A]
Parathion-methyl	7.50		Arizona	[U.S.EPA 2009 A]
Pyriproxifen	83.08	Lygus bug, whitefly	Arizona	[U.S.EPA 2009 A]
	60.00	Lygus bug, whitefly	California	[U.S.EPA 2009 A]
	60.00-83.08			
	71.54			
Profenophos	17.50		Arizona, Texas, California	[U.S.EPA 2009 A]
Spirodiclofen	35.00		Arizona, Texas, California	[U.S.EPA 2009 A]
Tebufenozide	31.78	Boll weevil	Texas	[U.S.EPA 2002 B]
Thiomethoxam	20.00	Lygus bug	Arizona	[U.S.EPA 2009 A]
Tralomethrin	10.00	Lygus bug	California	[U.S.EPA 2009 A]
	10.00	Lygus bug	Texas	[U.S.EPA 2009 A]
ξ-Cypermethrin	20.00	Lygus bug	Arizona	[U.S.EPA 2009 A]
β-Cyfluthrin	17.50	Whitefly, lygus bug	Texas	[U.S.EPA 2009 A]
	17.50	Whitefly, lygus bug	Arizona	[U.S.EPA 2009 A]
λ-Cyhalothrin	15.98	Boll worm	Texas	[U.S.EPA 2002 B]
Comparison	Alternatives	Endosulfan		
Range	7.50-99.50	11.63-27.50		
Average	26.68	19.47		

Substance	Cost impact factor per application, range and average value [US$/ha]	Pest	Region	Source
Cucumber - Endosulfan				
Endosulfan	16.88		Florida	[U.S.EPA 2009 C]
	16.78		Georgia	[U.S.EPA 2009 C]
	16.88		Michigan	[U.S.EPA 2009 C]
	16.88		North Carolina	[U.S.EPA 2009 C]
Range	16.78-16.88			
Average	16.86			
Cucumber - Alternatives				
Azadirachtin	21.88			[U.S.EPA 2009 C]
Bifenthrin	33.19	Whitefly, pickleworm, aphid, cucumber beetle	Georgia	[U.S.EPA 2009 C]
Carbaryl	15.00	Pickleworm, cucumber beetle		[U.S.EPA 2009 C]
Esfenvalerate	12.50	Whitefly, pickleworm, cucumber beetle		[U.S.EPA 2009 C]
Fenpropathrin	20.00	Cucumber beetle		[U.S.EPA 2009 C]
Imidacloprid	98.75	Whitefly, aphid, cucumber beetle		[U.S.EPA 2009 C]
Malathion	11.25	Pickleworm, aphid, cucumber beetle		[U.S.EPA 2009 C]
Methomyl	31.88	Pickleworm, aphid, cucumber beetle		[U.S.EPA 2009 C]
Methoxyfenozide	27.50	Pickleworm		[U.S.EPA 2009 C]
Oxamyl	56.25	Aphid		[U.S.EPA 2009 C]
Oxydemeton-methyl	63.75	Aphid, cucumber beetle		[U.S.EPA 2009 C]
	71.88	Whitefly		[U.S.EPA 2009 C]
	63.75-71.88			
	67.82			
Permethrin	14.38	Whitefly, pickleworm, aphid, cucumber beetle		[U.S.EPA 2009 C]
Pymetrozine	37.50	Whitefly, aphid		[U.S.EPA 2009 C]
Spinosad	62.50	Pickleworm		[U.S.EPA 2009 C]
Thiomethoxam	72.50	Aphid		[U.S.EPA 2009 C]
β-cyfluthrin	8.13	Pickleworm, cucumber beetle		[U.S.EPA 2009 C]
λ-cyhalothrin	13.13	Whitefly, pickleworm, aphid, cucumber beetle		[U.S.EPA 2009 C]
Comparison	Alternatives	Endosulfan		
Range	8.13-98.75	16.78-16.88		
Average	37.33	16.86		

Grapes				
Endosulfan	18.70	Not specified	New York	[U.S.EPA 2002 B]
Clofentezine	31.35	Not specified	New York	[U.S.EPA 2002 B]

Melons - Endosulfan				
Endosulfan	17.50	Aphid, whitefly, rindworm	Florida	[U.S.EPA 2009 D]
	20.00	Aphid, whitefly, rindworm	Arizona	[U.S.EPA 2009 D]
	15.00	Aphid, whitefly, rindworm	Texas	[U.S.EPA 2009 D]
Range	15.00-20.00			
Average	17.50			
Melons - Alternatives				

Substance	Cost impact factor per application, range and average value [US$/ha]	Pest	Region	Source
Abamectin	122.50	Aphid, whitefly	Texas	[U.S.EPA 2009 D]
	102.50	Aphid, whitefly	Florida	[U.S.EPA 2009 D]
	127.50	Aphid, whitefly	Arizona	[U.S.EPA 2009 D]
	102.50-122.50			
	117.50			
Bifenthrin	36.25	Aphid, whitefly, rindworm	Texas	[U.S.EPA 2009 D]
	25.00	Aphid, whitefly, rindworm	Southeast (Florida)	[U.S.EPA 2009 D]
	37.50	Aphid, whitefly, rindworm	West (Arizona)	[U.S.EPA 2009 D]
	25.00-37.50			
	32.92			
Carbaryl	17.50	Whitefly	Texas	[U.S.EPA 2009 D]
	15.00	Whitefly	Southeast (Florida)	[U.S.EPA 2009 D]
	17.50	Whitefly	West (Arizona)	[U.S.EPA 2009 D]
	15.00-17.50			
	16.67			
Esfenvalerate	12.50	Whitefly	Texas	[U.S.EPA 2009 D]
	17.50	Whitefly	West	[U.S.EPA 2009 D]
	12.50	Whitefly	Florida	[U.S.EPA 2009 D]
	12.50-17.50			
	14.17			[U.S.EPA 2009 D]
Fenpropathrin	37.50	Aphid, whitefly, rindworm	Texas	[U.S.EPA 2009 D]
	37.50	Aphid, whitefly, rindworm	Southeast (Florida)	[U.S.EPA 2009 D]
	37.50	Aphid, whitefly, rindworm	West (Arizona)	[U.S.EPA 2009 D]
Imidacloprid	117.50	Aphid, whitefly	Texas	[U.S.EPA 2009 D]
	142.50	Aphid, whitefly	Southeast (Florida)	[U.S.EPA 2009 D]
	137.50	Aphid, whitefly	West (Arizona)	[U.S.EPA 2009 D]
	117.50-142.50			
	132.50			
Malathion	12.50	Aphid, rindworm	Texas	[U.S.EPA 2009 D]
	15.00	Aphid, rindworm	Southeast	[U.S.EPA 2009 D]
	15.00	Aphid, rindworm	West	[U.S.EPA 2009 D]
	12.50-15.00			
	14.17			
Methomyl	25.00	Aphid, rindworm	Southeast (Florida)	[U.S.EPA 2009 D]
	25.00	Aphid, rindworm	Texas	[U.S.EPA 2009 D]
	40.00	Aphid, rindworm	West (Arizona)	[U.S.EPA 2009 D]
	25.00-40.00			
	32.50			
Permethrin	17.50	Whitefly, rindworm	Texas	[U.S.EPA 2009 D]
	12.50	Whitefly, rindworm	Southeast	[U.S.EPA 2009 D]
	15.00	Whitefly, rindworm	West (Arizona)	[U.S.EPA 2009 D]
	15.00-17.50			
	15.00			
Pymetrozine	42.50		Texas	[U.S.EPA 2009 D]
	42.50		Southeast (Florida)	[U.S.EPA 2009 D]
	42.50		West (Arizona)	[U.S.EPA 2009 D]
Thiomethoxam	120.00	Aphid, whitefly	Texas	[U.S.EPA 2009 D]
	120.00	Aphid, whitefly	Southeast (Florida)	[U.S.EPA 2009 D]
	102.50	Aphid, whitefly	West (Arizona)	[U.S.EPA 2009 D]
	102.50-120.00			
	114.17			
Comparison	Alternatives	Endosulfan		
Range	12.50-142.50	15.00-17.50		
Average	51.55	17.50		

Pecans - Endosulfan				
Endosulfan	15.58	Not specified	Georgia	[U.S.EPA 2002 B]

Substance	**Cost impact factor per application, range and average value [US$/ha]**	**Pest**	**Region**	**Source**
Pecans - Alternatives				
Chlorpyrifos	18.95	Not specified	Georgia	[U.S.EPA 2002 B]
Tralomethrin	33.35	Not specified	Georgia	[U.S.EPA 2002 B]
Comparison	Alternatives	Endosulfan		
Range	18.95-33.35	15.58		
Average	26.15	15.58		

Potato - Endosulfan				
Endosulfan	20.00	Potato beetle, leafhopper, tuberworm	Pacific Northwest, Midwest	[U.S.EPA 2009 B]
Potato - Alternatives				
Abamectin	72.50	Potato beetle, potato tuberworm	Pacific Northwest, Midwest	[U.S.EPA 2009 B]
Acetamiprid	30.00	Potato beetle, tuberworm	Pacific Northwest, Midwest	[U.S.EPA 2009 B]
Aldicarb	150.00	Potato beetle	Pacific Northwest	[U.S.EPA 2009 B]
Carbaryl	15.00	Potato beetle, leafhopper, tuberworm	Pacific Northwest, Midwest	[U.S.EPA 2009 B]
Carbofuran	20.00	Potato beetle, leafhopper, tuberworm	Pacific Northwest and Midwest	[U.S.EPA 2009 B]
Deltamethrin	12.50	Potato beetle, leafhopper, tuberworm	Pacific Northwest and Midwest	[U.S.EPA 2009 B]
Dimethoate	7.50	Potato beetle, leafhopper, tuberworm	Pacific Northwest and Midwest	[U.S.EPA 2009 B]
Esfenvalerate	12.50			[U.S.EPA 2009 B]
Imidacloprid	60.00	Potato beetle, leafhopper	Pacific Northwest	[U.S.EPA 2009 B]
Methamidphos	45.00	Potato beetle, tuberworm	Pacific Northwest	[U.S.EPA 2009 B]
Methomyl	35.00	Potato leafhopper, tuberworm	Pacific Northwest and Midwest	[U.S.EPA 2009 B]
Nicotine	45.00			[U.S.EPA 2009 B]
Novaluron	32.50	Potato beetle, tuberworm	Pacific Northwest, Midwest	[U.S.EPA 2009 B]
Parathion-methyl	17.50			[U.S.EPA 2009 B]
Permethrin	12.50	Potato beetle, leafhopper	Pacific Northwest and Midwest	[U.S.EPA 2009 B]
Phosmet	17.50	Potato beetle, leafhopper, tuberworm	Pacific Northwest, Midwest	[U.S.EPA 2009 B]
Pymetrozine	33.25	Potato tuberworm	Pacific Northwest	[U.S.EPA 2009 B]
Spinosad	62.50	Potato beetle, tuberworm	Pacific Northwest, Midwest	[U.S.EPA 2009 B]
Thiomethoxam	75.00	Potato beetle, leafhopper	Pacific Northwest, Midwest	[U.S.EPA 2009 B]
β-cyfluthrin	10.00	Potato beetle, potato tuberworm	West	[U.S.EPA 2009 B]
Comparison	Alternatives	Endosulfan		
Range	7.50-150.00	20.00		
Average	38.29	20.00		

Pumpkin - Endosulfan				
Endosulfan	17.50	Aphid, cucumber beetle, squash bug	Pennsylvania	[U.S.EPA 2009 E]

Substance	Cost impact factor per application, range and average value [US$/ha]	Pest	Region	Source
Pumpkin - Alternatives				
Bifenthrin	27.50	Aphid, cucumber beetle, squash bug	Pennsylvania	[U.S.EPA 2009 E]
Carbaryl	20.00	Aphid, squash bug, cucumber beetle	Midwest	[U.S.EPA 2009 E]
Carbofuran	30.00	Aphid, cucumber beetle	Midwest	[U.S.EPA 2009 E]
Esfenvalerate	15.00	Aphid, cucumber beetle, squash bug	Midwest	[U.S.EPA 2009 E]
Fenpropathrin	35.00	Aphid, cucumber beetle, squash bug	Pennsylvania	[U.S.EPA 2009 E]
Imidacloprid	130.00	Aphid, cucumber beetle	Midwest	[U.S.EPA 2009 E]
Malathion	12.50	Squash bug, cucumber beetle, aphid	Midwest	[U.S.EPA 2009 E]
Methoxyfenozide	45.00		Midwest	[U.S.EPA 2009 E]
Oxydemeton-methyl	45.00	Cucumber beetle	Midwest	[U.S.EPA 2009 E]
Permethrin	15.00	Aphid, cucumber beetle, squash bug	Midwest	[U.S.EPA 2009 E]
Pymetrozine	45.00	Aphid, cucumber beetle	Midwest	[U.S.EPA 2009 E]
Thiomethoxam	72.50	Cucumber beetle, aphid	Midwest	[U.S.EPA 2009 E]
Comparison	Alternatives	Endosulfan		
Range	12.50-130.00	17.50		
Average	41.04	17.50		

Squash - Endosulfan				
Endosulfan	15.63		Florida	[U.S.EPA 2009 F]
Squash - Alternatives				
Bifenthrin	40.00		US	[U.S.EPA 2009 F]
Buprofezin	20.00		US	[U.S.EPA 2009 F]
Carbaryl	17.50		US	[U.S.EPA 2009 F]
Esfenvalerate	15.00	Aphid, cucumber beetle, squash bug	US	[U.S.EPA 2009 F]
Fenpropathrin	37.50		US	[U.S.EPA 2009 F]
Imidacloprid	130.00		US	[U.S.EPA 2009 F]
Malathion	12.50		US	[U.S.EPA 2009 F]
Methomyl	27.50		US	[U.S.EPA 2009 F]
Methoxyfenozide	45.00		US	[U.S.EPA 2009 F]
Oxamyl	50.00		US	[U.S.EPA 2009 F]
Oxydemeton-methyl	45.00		US	[U.S.EPA 2009 F]
Permethrin	12.50		US	[U.S.EPA 2009 F]
Pymetrozine	40.00		US	[U.S.EPA 2009 F]
Spinosad	55.00		US	[U.S.EPA 2009 F]
Thiomethoxam	52.50		US	[U.S.EPA 2009 F]
β-cyfluthrin	15.00		US	[U.S.EPA 2009 F]
λ-cyhalothrin	12.50		US	[U.S.EPA 2009 F]
Comparison	Alternatives	Endosulfan		
Range	12.50-130.00	15.63		
Average	36.91	15.63		

Strawberry - Endosulfan				
Endosulfan	77.26		Canada	[Canada 2010 Ref 1]
Strawberry - Alternatives				
Abamectin	453.25	Tarnished plant bug, cyclamen mite	Canada	[Canada 2010 Ref 1]
Cypermethrin	71.90	Tarnished plant bug, cyclamen mite	Canada	[Canada 2010 Ref 1]
Comparison	Alternatives	Endosulfan		
Range	71.90-453.25	77.26		
Average	262.58	77.26		

Substance	Cost impact factor per application, range and average value [US$/ha]	Pest	Region	Source
Tobacco - Endosulfan				
Endosulfan	20.55		Ohio, Tennessee, Kentucky, River Valleys	[U.S.EPA 2002 B]
Tobacco - Alternatives				
Acephate	25.53		Kentucky	[U.S.EPA 2002 B]
Imidacloprid	74.41		Tobacco	Kentucky
Spinosad	30.58		Tobacco	Kentucky
Comparison	Alternatives	Endosulfan		
Range	25.53-74.41	20.55		
Average	43.50	20.55		
Tomatoes - Endosulfan				
Endosulfan	20.00		Florida	[U.S.EPA 2002 B], [U.S.EPA 2009 G]
Tomatoes - Alternatives				
Bifenthrin	20.75		Florida	[U.S.EPA 2009 G]
Esfenvalerate	22.50		Florida	[U.S.EPA 2009 G]
Imidacloprid	433.75		Florida	[U.S.EPA 2002 B]
β-cyfluthrin	19.25		Florida	[U.S.EPA 2009 G]
λ-cyhalothrin	24.40		Florida	[U.S.EPA 2002 B]
Comparison	Alternatives	Endosulfan		
Range	20.75-433.75	20.00		
Average	104.13	20.00		

Annex V – Information submitted by ISC on use quantities and registered uses of endosulfan

ISC has provided the following information on registered uses and application rates of endosulfan in specific countries [ISC 2010]:

Argentina

Endosulfan is important to Argentina:

- Because of its role in the cost effective and environmentally sound production of crops for food and other uses, making lower prices for the consumer, more profit for the farmer and a more competitive position for Argentina in the world market place;
- Because of its usefulness in Integrated Pest Management (IPM), resulting from its characteristic of being able to be used for years without insects building a resistance to it; and
- Because beneficial insects continue to thrive in the crops where it is used making available an abundant population of pollinating insects and honey.

In Argentina, endosulfan is registered as an insecticide for use by SENASA (Nacional de Sanidad y Calidad Agroalimentaria) in 45 different crops (Official newspaper Nº 31.546) with its main use being to combat the insects that afflict soybean, sunflower and cotton crops.

Soybean is a major export crop for Argentina with over 50 million metric tonnes produced, which aids not only Argentina from an economic perspective but makes food and energy more affordable to the nation. Without endosulfan, some of the pests encountered today cannot be controlled by the existing replacement insecticides.

In Argentina the sunflower crop involves US$ 1.402 billion per year. Argentina is the main exporter of sunflower oil in the world with 2,400,000 ha devoted to this crop. The yield is 4 million tonnes of seeds and 1.6 million tonnes oil. Sunflower production is dependant on the IPM containing endosulfan.

Cotton is an important crop for the economy of Argentina. It represents one of the largest export products of Argentina including cotton fiber and cotton seed oil.

Argentina is the world's leading producer of sunflower oil followed by Russia and Ukraine.

Sunflower oil is the fourth most important production worldwide after soy, palm and colza oils. It represents a major export product for Argentina. Argentina is reliant on endosulfan as part of an IPM for protection of the crop from pests.

Volume 1,500 metric tones

Table 16. Registered uses and application rates of endosulfan in Argentina (1,500 t/y)

Crop	Pest	Rate
Alfalfa	Chinche de la alfalfa (Piezodorus guildinii)	PC 35%: 1,2 - 1,5 l/ha PC 50/: 0,8 - 1 kg/ha
	Isoca de la Alfalfa (Colias lesbia)	PC 35%: 0,7 l/ha PC 50%: 0,5 kg/ha
	Isoca medidora (Rachiplusia nu)	PC 35%: 1,2 - 1,5 l/ha PC 50%: 0,8 - 1 kg/ha
Cotton	Chinche rayada (Horcias nobilellus) Chinche sanguinolenta, Chinche del Poroto (Athaumastus haematicus) Chinche verde (Nezara viridula)	PC 35%: 1,5 -3 l/ha PC 50%: 1 - 1,4 kg/ha
	Oruga de la hoja (Alabama argillacea)	PC 35%: 1 - 1,5 l/ha PC 50%: 0,7 - 1 kg/ha
	Oruga del capullo del algodonero (Helicoverpa gelotopoeon)	PC 35%: 2 - 2,5 l/ha PC 50%: 1,4 - 1,7 kg/ha
	Picudo del algodonero (Anthomonomus grandis)	PC 35%: 1,5 - 2 l/ha
	Pulgón del algodonero (Aphis gossypii)	PC 35%: 100 - 150 cm3/hl PC 50%: 70 - 100 g/hl
	Trips (Thrips spp.)	PC 35%: 1 - 1,4 l/ha PC 50%: 0,7 - 1 kg/ha
Cereals	Oruga militar tardía (Spodoptera frugiperda)	PC 35%: 1,5 - 2 l/ha PC 50%: 1 - 1,4 kg/ha
	Oruga militar verdadera (Pseudaletia adultera)	PC 35%: 2 - 2,5 l/ha PC 50%: 1,4 - 1,75 kg/ha
Flowers Vegetables	Alquiche chico (Edessa meditabunda)	PC 35%: 1.5 - 3 l/ha PC 50%: 1 - 1,4 kg/ha
	Bicho moro de la papa (Epicauta adpersa)	PC 35%: 300 cm3/hl PC 50%: 200 g/hl
	Brucho de la arveja (Bruchus pisorum)	PC 35%: 1,5 l/ha PC 50%: 1,1 kg/ha
	Chinche verde PC 35%: 1,5 - 3 l/ha (Nezara viridula)	PC 50%: 1 - 1,4 kg/ha PC 35%: 1,5 - 3 l/ha
	Cotorrita (Empoasca fabae)	PC 35%: 1,5 - 3 l/ha PC 50%: 1 - 1,4 kg/ha
	Gusanos cortadores (Agrotis spp.)	PC 35%: 1,7 l/ha PC 50%: 1,4 kg/ha
	Marandova de las solanáceas (Protoparce sexta paphus)	PC 35%: 1,5 - 2 l/ha PC 50%: 1 - 1,4 kg/ha
	Oruga militar tardía (Spodoptera frugiperda)	PC 35%: 1,5 - 2 l/ha PC 50%: 1 - 1,4 kg/ha
	Oruga militar verdadera (Pseudaletia adultera)	PC 35%: 2 - 2,5 l/ha PC 50%: 1,4 kg/ha
	Polilla de la papa (Gnorimoschema operculella)	PC 35%: 1,5 - 3 l/ha PC 50%: 1 - 1,4 kg/ha
	Pulgón de la papa (Macrosiphum euphorbiae) Pulgón del crisantemo (Macrosiphoniella sanborni) Pulgón del repollo (Brevicoryne brassicae) Pulgón del rosal (Macrosiphum rosae) Pulgón verde del duraznero, Pulgón rojo (Myzus persicae)	PC 35%: 100 - 150 cm3/hl PC 50%: 70 - 100 g/hl
	Pulguilla (Epitrix argentinensis)	PC 35%: 0,9 - 1,5 l/ha PC 50%: 1 - 1,4 kg/ha
	Trips	PC 35%: 1,5 -3 l/ha

Crop	Pest	Rate
	(Thrips spp.)	PC 50%: 1 - 1,4 kg/ha
	Vaquita (Diabrotica vittegera)	PC 35%: 1,5 - 3 l/ha PC 50%: 1 - 1,4 kg/ha
Pome fruit	Agalla de la Hoja del Peral (Eriophyes piri)	PC 35%: 150 cm3/hl PC 50%: 100 g/hl
	Bicho canasto (Oiketicus platensis)	
	Enrulador de la hoja (Eulia loxonephes)	
	Herrumbre del Peral (Epitrimerus piri)	
	Psílido del peral (Cacopsyla pyricola)	
	Pulgón lanígero (Eriosoma lanigerum)	PC 35%: 100 - 150 cm3/hl PC 50%: 70 - 100 g/hl
Sunflower	Gusano cortador o Gusano variado (Peridroma saucia) Gusanos cortadores (Agrotis spp.)	PC 35%: 1,7 l/ha PC 50%: 1,2 kg/ha
	Isoca medidora (Rachiplusia nu)	PC 35%: 1,5 l/ha PC 50%: 1 kg/ha
	Oruga militar tardía (Spodoptera frugiperda)	PC 35%: 1,5 - 2 l/ha PC 50%: 1 - 1,4 kg/ha
	Polilla del girasol (Homoeosoma heinrichi)	PC 35%: 1,5 -3 l/ha PC 50%: 1 kg/ha
Flax	Oruga del capullo del algodonero (Helicoverpa gelotopoeon)	PC 35%: 2 - 2,5 l/ha PC 50%: 1,4 - 1,75 kg/ha
Corn	Gusano cogollero (Heliothis virescens)	PC 35%: 1,5 l/ha PC 50%: 1 kg/ha
	Gusanos cortadores (Agrotis spp.)	PC 35%: 1,7 l/ha PC 50%: 1,2 kg/ha
	Isoca de la espiga (Heliothis zeae)	PC 35%: 2 - 2,5 l/ha PC 50%: 1,4 - 1,75 kg/ha
Peanut	Gusano cortador o Gusano variado (Peridroma saucia)	PC 35%: 1.7 l/ha PC 50%: 1,2 kg/ha
	Gusanos cortadores (Agrotis spp.)	PC 35%: 1,7 l/ha PC 50%: 1,2 kg/ha
	Oruga militar tardía (Spodoptera frugiperda)	PC 35%: 1,5 - 2 l/ha PC 50%: 1 - 1,4 kg/ha
Soybean	Chinche de la alfalfa (Piezodorus guildinii)	PC 35%: 1,2 - 1,5 l/ha PC 50%: 0,8 - 1 kg/ha
	Chinche verde (Nezara viridula)	PC 35%: 1,2 - 1,5 l/ha PC 50%: 0,8 - 1 kg/ha
	Isoca bolillera (Heliothis sp.)	PC 35%: 1,5 l/ha
	Isoca de la Alfalfa (Colias lesbia)	PC 35%: 0,7 l/ha PC 50%: 0,5 kg/ha
	Isoca medidora (Rachiplusia nu)	PC 35%: 1,2 - 1,5 l/ha PC 50%: 0,8 - 1 kg/ha
	Oruga de las leguminosas (Anticarsia gemmatalis)	PC 35%: 0,6 l/ha PC 50%: 0,5 kg/ha
	Oruga del capullo del algodonero (Helicoverpa gelotopoeon)	PC 35%: 1,5 l/ha PC 50%: 1 kg/ha
	Oruga militar tardía (Spodoptera frugiperda)	PC 35%: 1,5 - 2 l/ha PC 50%: 1 - 1,4 kg/ha
	Vaquita de San Antonio (Diabrotica speciosa)	PC 35%: 1,5 - 3 l/ha PC 50%: 1 - 1,75 kg/ha
Sorghum	Mosquita del sorgo (Contarinia sorghicola)	Mosquita del sorgo (Contarinia sorghicola)
	Siete de Oro (Astylus atromaculatus)	PC 35%:1,5 l/ha PC 50%: 1 kg/ha
Tobbaco	Cotorrita (Empoasca fabae)	PC 35%: 1,5 - 3 l/ha PC 50%: 1 - 1,4 kg/ha
	Gusano cogollero (Heliothis virescens)	PC 35%: 1,5 l/ha PC 50%: 1 kg/ha
	Gusanos cortadores (Agrotis spp.)	PC 35%: 1,7 l/ha PC 50%: 1,2 kg/ha

Crop	Pest	Rate
	Marandova de las solanáceas (Protoparce sexta paphus)	PC 35%: 1,5 - 2 l/ha PC 50%: 1 - 1,4 kg/ha
	Oruga militar tardía (Spodoptera frugiperda)	PC 35%: 1,5 - 2 l/ha PC 50%: 1 - 1,4 kg/ha
	Pulgón de la papa (Macrosiphum euphorbiae) Pulgón del repollo (Brevicoryne brassicae) Pulgón verde del duraznero, Pulgón rojo (Myzus persicae)	PC 35%: 100 - 150 cm3/hl PC 50%: 0,7 - 1 kg/ha
	Pulguilla (Epitrix argentinensis)	PC 35%: 0.9 - 1,5 /ha PC 50%: 0,6 - 1 kg/ha
	Trips (Thrips spp.)	PC 35%: 1,5 - 3 l/ha PC 50%: 0,7 - 1 kg/ha
	Vaquita (Diabrotica vittegera)	PC 35%: 1,5 - 3 l/ha PC 50%: 1 - 1,4 kg/ha

Brazil

Seventy percent of the product used in Brazil is formulated domestically, which creates thousands of direct and indirect jobs. Endosulfan provides the economy with an influx of more than one hundred million dollars per annum.

The major crops which are dependant on endosulfan for protection against pest in Brazil are cotton, soybean, cane sugar and coffee.

Brazil has an annual production of cotton of approximately five million bales. It is a major crop for them for national use and export. Cotton is dependant on endosulfan as part of an IPM for combating its target pests.

Sugar from cane drives Brazil's successful alternative fuel business which distinguishes it as the biofuel industry leader in the world. The beetle Migdolus can destroy a crop requiring replanting. Due to the resistance of Migdolus to other products, endosulfan as part of an IPM, is the chosen insecticide. Brazil is the second largest producer of soybeans in the world with a production of 57 million metric tons. Soybean accounts for 94.5% of oilseed crops, constituting the main export crop. The growing demand for export of soybean oil is having to compete with the use of soybean oil for the production of biodiesel. Without endosulfan, some of the pests encountered today cannot be controlled by the existing replacement insecticides. Endosulfan used as part of an IPM is the pesticide of choice because of the pests' increased resistance to other products.

Coffee is the number one cash crop of Brazil. Its importance is based on national consumption as well as export. From the discussion above coffee production is dependant on the availability of endosulfan.

Volume use 4,400 metric tones.

Table 17. Registered uses of endosulfan in Brazil (4,400 t/y)

Crop	Pest
Cotton	Boll weevil (Anthonomus grandis), leaf worm (Alabama argillacea), apples caterpillar (Heliothis virescens, Helicoverpa zea), mite (Polyphagotarsonemus latus) and aphid (Aphis gossypii)
Cane Sugar	Migdolus fryanus
Soybean	Caterpillar (Anticarsia gemmatalis), the Brown Stink Bug (Euschistusheros), Southern Green Stink Bug (Nezara viridula) and the Small Green Stink Bug (Piezodorus guildinni)
Coffee	Coffee berry borer (Hypothenemus hampei)

Table 18. Registered uses and application rates of endosulfan in India (5,000 t/y)

Crop	Pest	Dose (ml or g/ha)
Cotton	Jassid, Aphid, Thrips, Whiteflies, Leaf roller, Bollworm	500
Paddy	White jassid, Stem borer, Gall midge, Rice hispa	500
Gram	Aphid, Caterpillar	500
Groundnut	Jassid, Hairy caterpilar, Semi looper	1200
Okra/bhindi	Aphid	400
Chilli	Aphid	400
Tea	Flush worm, Thrips, Helicoverpa	1000
Mango	Hoppers, Fruit flies	1500
Jute	Bihar hairy caterpillar, Yellow mite	500
Red gram	Pod borer	1400
Brinjal	Fruit & Shoot borer	1400
Onion	Jassid, Aphid	500
Potato	Jassid, Aphid	500

Table 19. Registered uses and application rates of endosulfan in China (4,100 t/y)

Crop	Pest	Dose (ml or g/ha)
Cotton	Bollworms, Aphids, Thrips	1 l
Tea	Aphids, Thrips	1 l
Apple	Aphids	1 l
Citrus	Fruit borer, Fruit fly	1 l
tobacco	Aphid , Tobacco Warm	1 l

Table 20. Registered uses of endosulfan in USA (400 t/y)

Crop
Squash
Eggplant
Cantaloupe
Sweet potato
Broccoli
Pears
Pumpkins
Cotton
Tomatoes
potatoes

Table 21. Registered uses and application rates of endosulfan in Pakistan

Crop	**Pest**	**Dose (ml or g/ha)**
Cotton	Heliothis, Aphid, jassid	1 litre

Table 22. Registered uses and application rates of endosulfan in Mozambique

Crop	**Pest**	**Dose (ml or g/ha)**
Cotton	Jassid, Aphid, Thrips, Whiteflies, Leaf roller, African Bollworm	2000
Cowpea & Bean	Jassids, Aphids, Spodoptera, leafminer	1500
Maize	Stem borer	2000
Horticulture crops	Leaf Miner, Aphids, Thrips, Spodoptera	1000

Table 23. Registered uses and application rates of endosulfan in Zambia

Crop	Pest	Dose (ml or g/ha)
Cotton	Jassid, Aphid, Thrips, Whiteflies, Leaf roller, African Bollworm	1500
Cowpea & Bean	Jassids, Aphids, Spodoptera, leafminer	1500
Maize	Stem borer	2000

Table 24. Registered uses and application rates of endosulfan in Ethiopia

Crop	Pest	Dose (ml or g/ha)
Cotton	Jassid, Aphid, Thrips, Whiteflies, Leaf roller, African Bollworm	2000
Cowpea & Bean	Jassids, Aphids, Spodoptera, leafminer	2000
Maize & Cereals	Stem borer	1000
Vegetables, Oilseeds & Pulses	Leaf Miner, Aphids, Thrips, Spodoptera, Diamond Back moth	1000
Sweet potato	Sweet Potato Butterfly	2000

Table 25. Registered uses and application rates of endosulfan in Uganda

Crop	Pest	Dose (ml or g/ha)
Cotton	Jassid, Aphid, Thrips, Whiteflies, Leaf roller, African Bollworm	1500
Cowpea & Bean	Jassids, Aphids, Spodoptera, leafminer	1500
Maize	Stem borer	2000
Tomato/ vegetable	Leaf Miner, Aphids, Thrips, Spodoptera	1500

Table 26. Registered uses and application rates of endosulfan in Sudan

Crop	Pest	Dose (ml or g/ha)
Cotton	Jassid, Aphid, Thrips, Whiteflies, Leaf roller, Bollworms, Spodoptera	1800

Table 27. Registered uses and application rates of endosulfan in Nigeria

Crop	Pest	Dose (ml or g/ha)
cotton	Jassid, Aphid, Thrips, Whiteflies, Leaf roller, African Bollworm	2000
Cowpea & Bean	Jassids, Aphids, Spodoptera, leafminer	2000
Maize	Stem borer 2500	2500
Tomato/ vegetable	Leaf Miner, Aphids, Thrips, Spodoptera	1500

Table 28. Registered uses and application rates of endosulfan in Guinee

Crop	Pest	Dose (ml or g/ha)
Cotton	Jassid, Aphid, Thrips, Whiteflies, Leaf roller, African Bollworm	2000
Cowpea & Bean	Jassids, Aphids, Spodoptera, leafminer	2000
Maize	Stem borer	2500
Tomato/ vegetable	Leaf Miner, Aphids, Thrips, Spodoptera	1500

Table 29. Registered uses and application rates of endosulfan in Ghana

Crop	Pest	Dose (ml or g/ha)
Cotton	Jassid, Aphid, Thrips, Whiteflies, Leaf roller, Bollworm	1000