landbouw, natuur en voedselkwaliteit

PEST RISK ANALYSIS

Leucinodes orbonalis (Guenée)

Assessors

D. J. van der Gaag, Division of Integrated Crop Protection

H. Stigter, Entomology Section – Diagnostics Division

Co-assessor

J.W. Lammers, Division of Phytosanitary Risk Management

M. van der Straten, Entomology Section – Diagnostics Division

Plant Protection Service, the Netherlands

December 2005

STAGE 1: INITIATION **Identify pest**		
This section examines the identity of the pest to ensure that the assessment is being performed on a real identifiable organism and that biological and other information used in the assessment is relevant to the organism in question.		
Question	**Yes / No / Score**	**Notes**
1. Is the organism clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank ? *if yes go to 3* *if no go to 2*	**Yes**	Taxonomic Tree Class: Insecta Order: Lepidoptera Superfamily: Pyraloidea Family: Crambidae Genus: Leucinodes Species: *Leucinodes orbonalis* (Guenée, 1854)
The PRA Area		
The PRA area can be a complete country, several countries or part(s) of one or several countries.		
3. Clearly define the PRA area.	***Go to 4.***	The PRA area is the Netherlands
Earlier analysis		
The pest, or a very similar pest, may have been subjected to the PRA process before, nationally or internationally. This may partly or entirely replace the need for a new PRA.		
4. Does a relevant earlier PRA exist ? *if yes go to 5* *if no go to 7*	**No**	

STAGE 2. PEST RISK ASSESSMENT

Section A: Qualitative criteria of a quarantine pest

Geographical criteria

This section considers the geographical distribution of the pest in the PRA area.

7. Does the pest occur in the PRA area ? *if yes go to 8* *if no go to 9*	**No**	The pest status of *L. orbonalis* in the Netherlands is 'Absent, confirmed by survey'. *L. orbonalis* has not been observed during more than 100 survey inspections at Dutch glasshouse egg plant, tomato and sweet pepper production sites in 2005. Given the climate in its current area of distribution, permanent establishment of *L.orbonalis* outside in the Netherlands for a significant period of time is estimated to be very unlikely.

Potential for establishment

For the pest to establish, it must find a widely distributed host plant in the PRA area (do not consider plants which are accidentally / very occasional hosts or recorded only under experimental conditions). If it requires a vector, a suitable species must be present or its native vector must be introduced. The pest must also find environmental conditions suitable for survival, multiplication and spread, either in the field or in protected conditions.

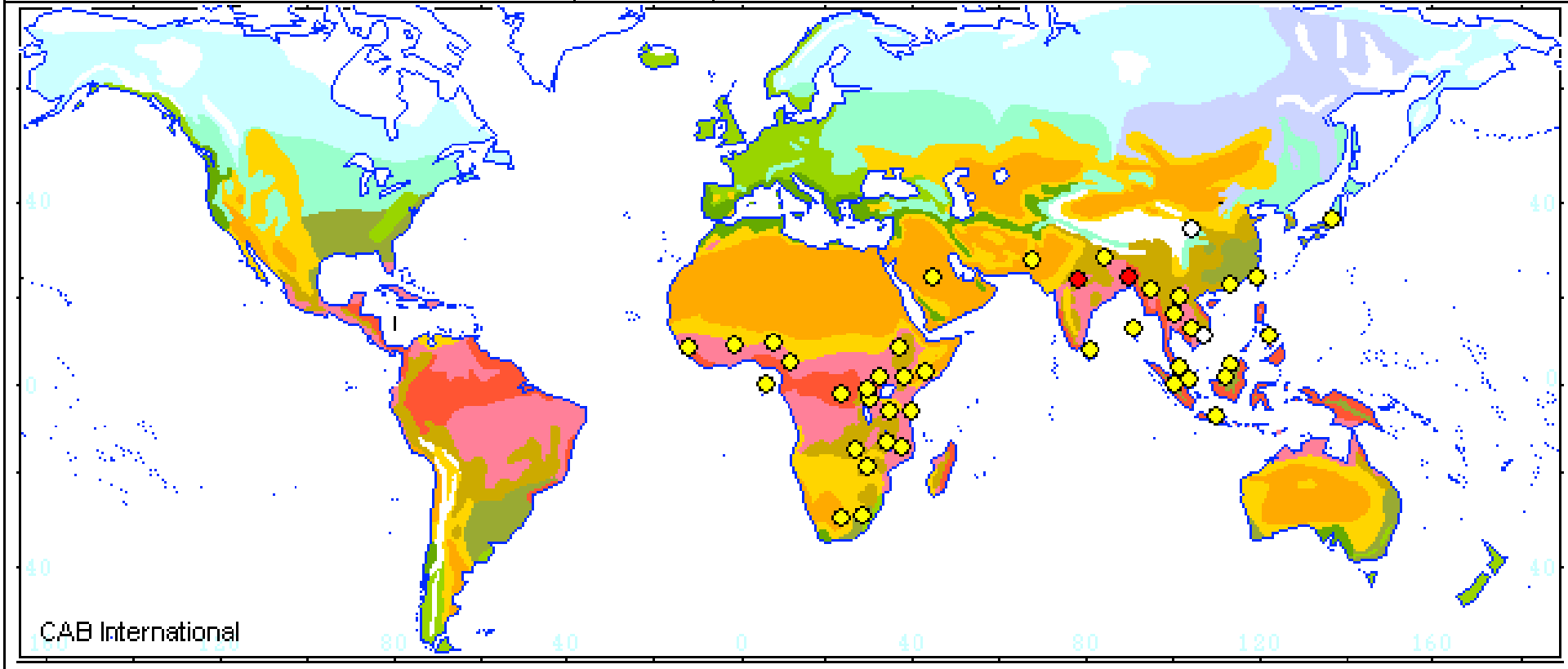
9. Does at least one host plant grow to a substantial extent in the PRA area, in the open, in protected cultivation or both ? *if yes go to 10* *if no go to 22*	**Yes**	Eggplant (*Solanum melongena*) is described as the most preferred host plant (Alam *et al*, 2003). Eggplant is grown under protected conditions in the Netherlands (ca. 89 hectares in 2004, CBS).

(Possible) host plants which grow / are grown in the Netherlands

Scientific name	Acreage[1] (ha) in NL	Natural host?	References
Solanum melongena (eggplant)	89 (protected cultivation)	Yes	Alam *et al*, 2003; CAB International, 2004; Naresh *et al,* 1986 ; etc.
Solanum tuberosum (potato)	164.000	Yes	Ishahaque and Chaudhuri, 1985; Srinivasan and Buba, 1998; Murthy and Nandihalli, 2003
Solanum nigrum (Black nightshade)	Weed, generally occurring[2]	Yes	Das and Patnaik, 1970; Mehto et al., 1980; Ishahaque and Chaudhuri, 1985
Various *Solanum* spp. (container grown plants and weeds)	Less than 10 ha protected cultivation (pot plants) and some generally occurring weeds	Uncertain	No references [3]
Lycopersicon esculentum (tomato)	1.200 (protected cultivation)	Yes	Das and Patnaik, 1970; Srinivasan and Buba, 1998; Reddy and Kumar, 2004
Capsicum annuum (sweet pepper)	1.200 (protected cultivation)	Uncertain	Anonymous, 1984; CAB International, 2004; No experimental/field data, but intercepted in USA[4]
Cucurbita spp	Small acreage. Also limited use as rootstocks for cucumber production	Uncertain	Anonymous, 1984: *Cucurbita maxima*; No experimental/field data, but intercepted in USA[4]
Pisum sativum (pea)	4.860	Uncertain	Anonymous, 1984; CAB International, 2004; No experimental/field data

		1) Acreage in 2003 or 2004 according to Statistics Netherlands (CBS, 2004; 2005) 2) Mennema *et al*, 1985; Van der Meijden *et al*, 1989; Van der Meijden, 1996; 3) All *Solanum* spp. are considered as possible host plants. *L. orbonalis* has been found in fruits of *S. torvum* and *S. aculeatissimum* during import inspections in the Netherlands and on *S. mammosum* and *S. integrifolium* during baggage checks of passengers entering the USA. 4) APHIS interception data (J.P. Floyd, APHIS, personal communication to J.W. Lammers, 2005) ***Uncertainty***: It is uncertain which *Solanum* species are host plants besides *Solanum melongena, S. tuberosum* and *S. nigrum,* but possibly several or all *Solanum* spp. are host plants: *L. orbonalis* has been intercepted on various other *Solanum* spp. in the USA (*S. torvum, S. mammosum* and *S. integrifolium*) and in the NL (*S. torvum* and *S. aculeatissimum*). *L. orbonalis* has been observed on *S. aethiopicum* and *S. macrocarpon* (R. Srinivasan, AVRDC, Taiwan, personal communication to D.J. van der Gaag, 2005). We, therefore, assume that (most) *Solanum* species are potential host plants. It is not known which *Capsicum* and *Cucurbita* species were found infested by APHIS during import inspections. In this PRA we assume that all species from these genera are potential host plants. It is uncertain if pea could act as a host plant as no experimental data or records has been found with this crop in literature.
10. Does the pest have to pass part of its life cycle on a host plant other than its major host (*i.e.* obligate alternate host plant) ? *if yes go to 11* *if no go to 12*	**No**	
12. Does the pest require a vector (*i.e.* is vector	**No**	

transmission the only means of dispersal) ? *if yes go to 13* *if no go to 14*		
14. Does the known geographical distribution of the pest include eco-climatic zones comparable with those of the PRA area ? *if yes go to 18* *if no go to 15*	**No**	The pest is currently known to be present in tropical regions in South Asia and Africa: Bangladesh, Brunei Darussalam, Cambodia, China, India, Indonesia, Japan, Laos, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Saudi Arabia, Singapore, Sri Lanka, Thailand, Vietnam, Burundi, Cameroon, Congo, Ethiopia, Ghana, Kenya, Lesotho, Malawi, Mozambique, Nigeria, Rwanda, Sao Tome and Principe, Sierra Leone, Somalia, Southa Africa, Tanzania, Uganda, Zambia and Zimbabwe (CPC, 2005).



Map. Current area of distribution of *L. orbonalis* and the World Climates (CBC, 2005)

15. Is it probable, nevertheless, that the pest could survive and thrive in a wider eco-climatic zone that could include the PRA area ? *if yes go to 18* *if no go to 16*	**No**	Temperature plays an important role in the development of *Leucinodes orbonalis*. For example, the optimum temperature for pupae and adults is more than 27ºC (Katiyar and Mukharji, 1973).
16. Could the eco-climatic requirements of the pest be found in protected conditions in the PRA area ? *if yes go to 17* *if no go to 22*	**Probably yes**	No records of *Leucinodes orbonalis* in heated greenhouses have been found. Temperatures in glasshouses in the Netherlands for the production of egg plants are usually between 20 and 25°C and may exceed 30ºC during warm periods. These temperatures are favourable for *L. orbonalis*. Examples of non-native Lepidoptera species are known that have succesfully established themselves in heated glasshouses in the PRA area and which cause significant economical damage (*Opogona sacchari*, *Spodoptera exigua* and *Duponchelia fovealis*). A Mediterranean species, *Cacoecimorpha pronubana* (carnation leafroller), has successfully established outdoor in the Netherlands.
17. Is a host plant grown in protected conditions in the PRA area ? *if yes go to 18* *if no go to 22*	**Yes**	See question 9.
Potential economic importance		
18. With specific reference to the host plant(s) which occur(s) in the PRA area, and the parts of those plants which are damaged, does the pest in its present range cause significant damage or loss ? *if yes go to 21* *if no go to 19*	**Yes**	During the past two decades, eggplant in South Asia has been increasingly ravaged by *Leucinodes orbonalis*, of which the larvae bore into the eggplant shoots and fruits. Farmers have resorted to frequent sprays of insecticides to kill the larvae before it enters the fruit. Yield losses in Asia vary from season to season and location to location, but the whole crop can be destroyed (Alam *et al*., 2003).
21. This pest could present a risk to the PRA area **Go To Section B**		

Section B: Quantitative evaluation

The second part of the risk assessment process firstly estimates the probability of the pest being introduced into the PRA area (its entry and establishment) and secondly makes as assessment of the likely economic impact if that should happen. From these two aspects, it should be possible to arrive at the level of "pest risk" presented by the pest; this can then be used in the pest risk management phase to decide whether it is necessary to take phytosanitary measures to prevent the introduction of the pest, or if the measures chosen are appropriate for the level of risk. The questions in this section require an evaluation from minimum probability or impact (1) to maximum probability or impact (9). This must be done by an expert who can make an estimate according to the information provided (following the format of the checklist of EPPO , 1993) and also according to comparison with other pests.
Answer as many of the following questions as possible, insofar as they are relevant to the pest concerned. If you cannot answer a particular question, do not give any score. Note whether this is because of lack of information or because the question is irrelevant to the pest concerned.

Questions marked with an asterisk (*) are to be considered as more important than the others in the same section.

1. Probability of introduction

Introduction, as defined by the FAO Glossary of Phytosanitary Terms, is the entry of pest resulting in its establishment.

Entry

List all the pathways that the pest could possibly be carried on. *<u>Note</u>: a pathway can be any form of human activity that could transport the pest from a particular origin: e.g. plants and plant products moving in trade, any other traded commodity, containers and packing, ships, planes, trains, road transport, passengers, mail etc. Note that similar means of pest transport from different origins can present greatly different probabilities of*		1. *Solanum* fruit - *Mainly S. melongena, S. torvum, S. aculeatissimum, S. mammosum, S. integrifolium* 2. *Capsicum* fruit 3. *Lycopersicon* fruit (tomato) 4. *Cucurbita* fruit 5. *Abelmoschus esculentus* fruit (okra) Note 1: *L. orbonalis* was intercepted in *S. melongena, S. torvum* and *S. aculeatissimum* during import inspections in the Netherlands. In the USA, *L. orbonalis* has also been intercepted in fruits of *S. mammosum* and *S. integrifoliumi*, *Capsicum* sp., *Lycopersicon* sp., *Cucurbita* sp.

introduction, depending on the concentration of the pest in the area of origin. The pathways given should be only those already in operation, or proposed.		and *Abelmoschus esculentus* in baggage from passengers traveling into the USA (Source: Animal and Plant Health Inspection Service (APHIS), U.S. Department of Agriculture (USDA), J.P. Floyd, personal communication to J.W. Lammers, 2005). Note 2: (Some) *Solanum* plants for planting are probably suitable pathways. However, import of these plants (except if originating from European and Mediterranean countries) is forbidden according to Council Directive 2000/29/EC. For this reason, this pathway is not analyzed in the assessment. **<u>Uncertainty</u>** It is not known which *Capsicum* and *Cucurbita* species were found infested by APHIS during import inspections. In this PRA we assume that all fruits from these genera might act as a pathway.
1.1 How many pathways could the pest be carried on? *few = 1* *many = 9*	**1** **few**	
1.2 For each pathway, starting with the most important pathway identified above (*i.e.* that which carries the greatest trade or which is most likely to act as a means of introduction) and then in descending order of importance, answer questions 1.3 to 1.13. If one of the questions 1.3a, 1.5a, 1.7a or 1.12a is answered by 'no', the pathway could not act as a means of entry for the pest and the scheme will return directly to this point, omitting later questions. Use expert judgement to decide how many pathways to consider.		
1.3a Could the pest be associated with the pathway at origin? *Note: does the pest occur in the area of origin? Is the pest in a life-stage which would be associated with commodities,*	**Yes**	

containers or conveyances? *if yes go to 1.3b* *if no go to 1.2*		
		Table 1. Number of *L. orbonalis* interceptions in the USA, since 1983 (Source: Animal and Plant Health Inspection Service (APHIS), 2005) and the Netherlands (Sept. 2004 – Nov. 2005)

Fruit	**Number of interceptions – USA** (1983 – 2005) **passenger baggage**	**Number of interceptions – NL** (Sep 2004 – Nov 2005) **commercial consignments**
Solanum melongena	2274	52
Solanum sp.	1609	14
Capsicum sp.	76	-
Solanaceae	37	-
Cucurbita sp.	17	-
Solanum torvum	17	23
Solanum acculeatissimum		4
Solanum mammosum	4	-
Abelmoschus esculentus	3	-
Lycopersicon sp.	3	-
Solanum integrifolium	2	-
Others	11	-

1.3b How likely is the pest to be associated with the pathway at origin? *not likely = 1* *very likely = 9*	**9** **Very likely**	***Solanum* fruit** *Leucinodes orbonalis* is a major pest of eggplant in the regions of origin and it is regularly found during inspections of *Solanum* fruits imported from those regions. *L. orbonalis* was found in 32 lots, mainly *Solanum melongena* and *S. torvum* fruits, during import inspections from August to December 2004. From January – October 2005, *L. orbonalis* was intercepted in 34 out of about 650 lots of *S. melongena* fruits originating from countries where the pest organism is present and which were inspected during this period. In the same period, *L.*

		orbonalis was also found in 20 lots of other *Solanum* fruits imported from African en Asian countries in which *L. orbonalis* is present. In the UK, *L. orbonalis* has also been intercepted several times in imported *Solanum (melongena)* fruit (www.defra.gov.uk/). In the USA, more than 90% of the interceptions were on *Solanum* fruit of which *S. melongena* fruit was most important (Table 1).
	1 **Not likely**	***Capsicum* fruit** The USA interception data show that it is possible, but not likely that *L. orbonalis* is associated with *Capsicum* fruit at origin (*Capsicum* represents 1,9% off all *L. orbonalis* interceptions in the USA).
	1 **Not likely**	***Lycopersicon* fruit** The USA interception data show that it is possible, but not likely that *L. orbonalis* is associated with *Lycopersicon* fruit (tomato) at origin (*Lycopersicon* represents 0,1% off all *L. orbonalis* interceptions in the USA).
	1 **Not likely**	***Cucurbita* fruit** The USA interception data show that it is possible, but not likely that *L. orbonalis* is associated with *Cucurbita* fruit at origin (*Cucurbita* represents 0,4% off all *L. orbonalis* interceptions in the USA).
	1 **Not likely**	***Abelmoschus esculentus* fruit** The USA interception data show that it is possible, but not likely that *L. orbonalis* is associated with *Abelmoschus esculentus* fruit at origin (*Capsicum* represents 0,1% off all *L. orbonalis* interceptions in the USA).
1.4 Is the concentration of the pest on the pathway at origin likely to be high? *not likely = 1*	**6** **Likely**	**All pathways** In South Asia, the species is widespread. Little is known about its distribution in several parts of Africa.

very likely = 9		
1.5a Could the pest survive existing cultivation or commercial practices? *Note: these are practices mainly in the country of origin, such as pesticide application, removal of substandard produce, kiln-drying of wood.* *if yes go to 1.5b* *if no go to 1.2*	**Yes**	
1.5b How likely is the pest to survive existing cultivation or commercial practices? *not likely = 1* *very likely = 9*	**8** **Very likely** **8** **Very likely**	***Solanum* fruit** *L. orbonalis* is difficult tot control since the larvae bore inside fruits and shoots where they cannot be hit by insecticidal sprays. In Bangladesh, farmers spray insecticides up to 84 times during 6-7 months and even than some fruits become infested (Bangladesh Agricultural Research Institute, 1995). *L. orbonalis* is also frequently found in *Solanum* fruits imported from South East Asia and Africa. **All other fruit pathways** *L. orbonalis* is difficult to control and crop damage can probably not completely be prevented by commercial practices.
1.6 How likely is the pest to survive or remain undetected during existing phytosanitary procedures? *not likely = 1* *very likely = 9*	**7** **Likely**	**All pathways** *Leucinodes orbonalis* is known as an internal feeder and borer in shoots and fruits and larvae live in a so-called “protected environment”. Damage by young larvae can be easily overlooked during phytosanitary inspections, because the boring holes can be very small. Eggs are single laid on the fruits and are very difficult to detect during inspection. Moreover, passengers travelling from infested areas to the Netherlands might carry infested fruits in their baggage, as is shown by the US interception data (Table 1).

1.7a Could the pest survive in transit? *if yes go to 1.7b* *if no go to 1.2*	**Yes**	
1.7b How likely is the pest to survive in transit? *not likely = 1* *very likely = 9*	**9** **very likely**	**All pathways** Living larvae (different stages) of *Leucinodes orbonalis* have been intercepted several times during import inspections.
1.8 How likely is the pest to multiply during transit? *not likely = 1* *very likely = 9*	**1** **not likely**	**All pathways** Multiplication during transit will not occur. Development time (egg – adult) at 20ºC is about 55 days. Transport from place of origin to place of destination is rather short and takes normally less than 7 days.
1.9 How large is movement along the pathway? *Note: the volume of material being moved* *not large = 1* *very large = 9*	 **3** **not large** **4** **Moderately large**	All of the below-mentioned fruits may also enter the Netherlands in the baggage of passengers traveling from infested areas, the frequency and volume is unknown. ***Solanum* fruit** In 2003 and 2004, about 130 and 60 tons of *Solanum melongena* fruits, respectively, were imported into the Netherlands from countries where *L. orbonalis* is present. In the EU, 400 and 828 tons of *Solanum melongena* fruits were imported in 2003 and 2004, respectively, from Asian and African countries where the pest organism occurs (Eurostat, 2005). In 2004, an estimated 10 tons of *S. torvum* and *S. aculeatissimum* fruits were imported into the Netherlands from regions where *Leucinodes orbonalis* is present (10 tons is a rough estimate; exact import figures are not known). About 50% of the imported fruits (50% is a rough estimate; exact figures are not known) is transited to other European countries. ***Capsicum* fruit** In 2004, 386 tons of *Capsicum annuum* were imported into the Netherlands from countries where *L. orbonalis* is present (Eurostat, 2005).

	5 **Moderately large**	***Lycopersicon* fruit** In 2004, 1.666 tons of tomatoes were imported into the Netherlands from countries where *L. orbonalis* is present (Eurostat, 2005).
	3 **Not large**	***Cucurbita* fruit** In 2004, 63 tons of *Cucurbita pepo* fruits were imported into the Netherlands from countries where *L. orbonalis* is present (Eurostat, 2005).
	1 **Not large**	***Abelmoschus esculentus* fruit** Detailed import figures are lacking. Some okra fruit is imported from countries where *L. orbonalis* is present. The movement along this pathway is estimated to be very small.
1.10 How widely is the commodity to be distributed through the PRA area? *Note: the more scattered the destinations, the more likely it is that the pest might find suitable habitats.* *not widely = 1* *very widely = 9*	**9** **very widely**	**All commodities** All imported host fruits are distributed to stores in the PRA area and used for consumption.
1.11 How widely spread in time is the arrival of different consignments? *Note: introduction at many different times of the year will increase the probability that entry of the pest will occur at a life stage of the pest or the host suitable for establishment.* *not widely = 1*	**9** **Very widely**	**All commodities** All imported host fruits are imported into the Netherlands throughout the whole year.

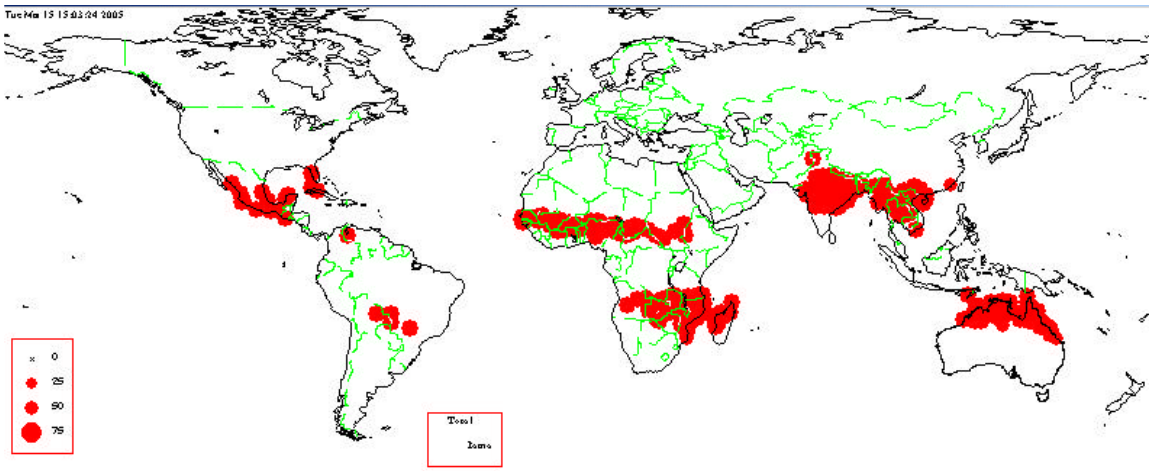
very widely = 9		
1.12a Could the pest transfer from the pathway to a suitable host? *<u>Note:</u> consider innate dispersal mechanisms or the need for vectors, and how close the pathway on arrival is to suitable hosts.* *if yes go to 1.12b* *if no go to 1.2*	**Yes**	See 1.12b
1.12b How likely is the pest to be able to transfer from the pathway to a suitable host? *not likely = 1* *very likely = 9*	**1** **Not likely**	**<u>Generally for all pathways</u>** Fruits are sold in stores and super markets and possibly also on market places, which are usually situated in towns and not near agricultural/horticultural areas. Mature larvae may leave the fruits in the store or, when infested fruits have been discarded, from compost heaps near the store or consumer's places. They may pupate and adult moths appearing from the pupae may find a host plant (e.g. a wild *Solanum* species). *Leucinodes orbonalis* will probably not be able to survive wintertime in the Netherlands. The Dutch climate will probably only be favourable for the pest organism during June, July and August when the average daily temperature is above 15ºC (see also the answer on question 1.13). *L. orbonalis* will probably have to enter a glasshouse with a suitable host plant (*Solanum* pot plants, eggplant, tomato and maybe also sweet pepper) to survive wintertime and establish in glasshouses. It is considered very unlikely that this will happen. *L. orbonalis* was found in *Solanum* fruits in 2004 for the first time and shortly after import inspections of *Solanum melongena* had become obligatory in the EU. Probably, the pest organisms had been brought into the Netherlands with imported fruits many times before 2004. More than 4000 interceptions of *L. orbonalis* in hand baggage of persons entering the U.S.A. have been registrated (Source: Animal and Plant Health Inspection Service (APHIS), U.S. Department of Agriculture (USDA), J.P. Floyd, personal communication to J.W. Lammers, 2005). In the Netherlands, plant products imported by persons (not business) are usually not inspected. Most likely, *L. orbonalis* has entered the Netherlands also with plant products

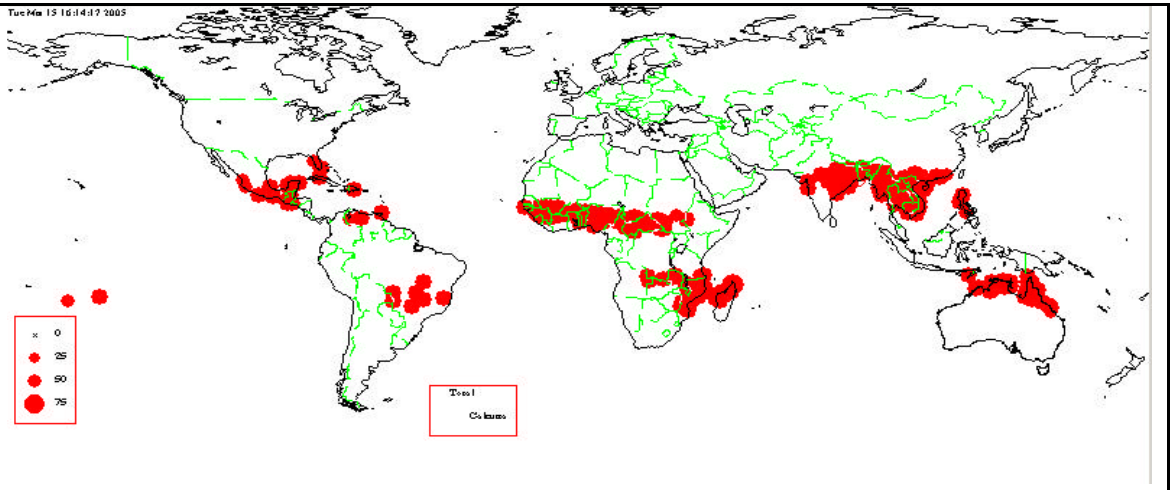
		carried by passengers for many years. As far as we know, *L. orbonalis* has never been reported as a pest organism in the Netherlands and has not been found on tomato, sweet pepper and egg plant production sites during a survey performed by the Dutch Plant Protection Service in 2005.
	2 **Not likely**	**<u>Consignments that are sorted/packed near glasshouse production sites</u>** Imported fruits are sometimes sorted/packed at locations near or in glasshouse production areas where also fruits produced in the PRA area are sorted and packed. These packing/sorting areas are usually not far from glasshouse production sites (e.g. 1 location is known to be about 1 km from a production site). *L. orbonalis* may enter production sites with package material that is returned to the production site or adult moths – if present – may fly to production sites that are close by during summer time.
	7 **Likely**	**<u>Consignments that are sold in a glasshouse</u>** It is known that at least one store in the Netherlands sells tropical fruits, including various *Solanum* fruits, inside a glasshouse. This store has an open connection to an area in which mainly sweet pepper is grown. The glasshouse is located in a glasshouse area. In this particular case the risk on transfer is high. It is not known if more stores are located in or at close range of glasshouses in the PRA area.
1.13 Is the intended use of the commodity (*e.g.* processing, consumption, planting, disposal of waste) likely to aid introduction? *<u>Note:</u> consider whether the intended use of the commodity would destroy the pest or whether the processing, planting or disposal might be done in the vicinity of suitable hosts.*	**2** **not likely**	**<u>All commodities</u>** Imported material is used for consumption. If retailers or consumers will find infested fruit, they will discard it and put it in closed containers or on open compost heaps. On compost heaps, larvae can probably develop to adults during summer time. The adults may fly into glasshouses with a suitable crop and start a new generation. *L. orbonalis* may also develop on outdoor grown *Solanum* spp, (weeds, potato or *Solanum* spp. grown in gardens) during warm weather. Temperatures below 20ºC may already be unfavourable for *L. orbonalis*. Saxena (1966) found that a temperature of 20ºC was already fatal for young larvae. However, Katiyar and Mukharji (1973) did find development of larvae at 15ºC, but few eggs hatched at

not likely = 1 *very likely = 9*		this temperature. In the same study, pupae developed at 15ºC but not at 10ºC. In the Netherlands, the mean daily temperature is below 15ºC from September to May en between 15 and 20ºC from June to August (http://www.knmi.nl/klimatologie/normalen1971-2000/per_station/stn260/4-normalen/260_debilt.pdf, visited in November 2005). Thus, most time of the year, the temperature in the Netherlands will be too low for outdoor development of *L. orbonalis*.
Establishment		
1.14 How many host plant species are present in the PRA area? *one or few = 1* *many = 9*	**4** **several**	Crops grown in protected cultivation: *Solanum melongena* (eggplant, 89 hectares; CBS 2005) *Lycopersicon esculentum* (tomato, 1200 hectares; CBS 2004), *Capsicum annuum* (sweet pepper, 1200 hectares; CBS 2005; small area hot pepper: exact figures not known), *Solanum* spp. (container grown ornamentals; less than 10 ha)* ***Uncertainty*** tomato and sweet pepper are no major host plants in countries where *L. orbonalis* occurs. It is uncertain if *L. orbonalis* could be a serious pest on mono-crops of tomato and sweet pepper in heated glasshouses (see also the answer on question 9). *Cucurbita* spp. may act as a host plant since *L. orbonalis* has been intercepted in/on fruits or other plant products of *Cucurbita* spp. in the U.S.A. No other data have been found on Cucurbita spp. as a host plant of the pest organism. *Cucurbita* spp. are used as rootstocks for cucumber (*Cucumis sativus*) in commercial glasshouse nurseries on a limited scale. *Cucurbita* sp. are also grown outside in private (hobby) gardens and in commercial glasshouse production sites (*C. pepo*) on a small area. Agricultural crops: *Solanum tuberosum* (potato, 164.000 hectares; CBS 2005)

		Pisum sativum (pea 4.860 hectares; CBS 2005) *Solanum sisymbriifolium** (used as an intercrop, acreage not known) ***Uncertainty:*** It is uncertain if pea is a host plant. Weeds (Mennema et al, 1985; Van der Meijden et al, 1989; Van der Meijden, 1996): *Solanum nigrum* (black nightshade) (generally occurring *Solanum dulcamara** (generally occurring) *Solanum lycopersicum** (not general/rare) *Solanum triflorum** (not general/rare) *Solanum physalifolium** (not general/rare) **** Uncertainty:*** Plant species indicated by an asterisk are not mentioned in literature as a host plant but since several *Solanum* spp. are mentioned in literature as a host plant (Anonymous, 1984; CAB international, 2004) and *L. orbonalis* is frequently found in imported fruits *of S. torvum and S. aculeatissimum,* all *Solanum* spp. are considered as potential host plants (See also the question on answer 9).
1.15 How extensive are the host plants in the PRA area? *rare = 1* *widespread = 9*	**9 widespread**	Eggplant, tomato, sweet pepper and *Solanum* pot plants are limited to glasshouse areas (except those grown in hobby gardens) that are located in different parts in the Netherlands. Potato is a major agricultural crop and is grown in several regions in the Netherlands of which Zeeland, Flevoland, Noordoostpolder, Groningen and Drenthe are the main regions. Peas are mainly grown in Zeeland. It is uncertain if pea is a host plant (see also answers on question 9 and 1.14). The weeds *Solanum nigrum* and *S. dulcamare* are widespread in the Netherlands (Van der Meijden *et al*, 1989).
1.16 If an alternate host is needed to complete the life cycle, how extensive are	**Not applicable**	

such host plants in the PRA area? *rare = 1* *widespread= 9*		
**1.17 ***If a vector is needed for dispersal, how likely is the pest to become associated with a suitable vector? <u>Note</u>*: is the vector present in the PRA area, could it be introduced or could another vector be found?* *not likely = 1* *very likely = 9*	**Not applicable**	
1.18 Has the pest been recorded on crops in protected conditions elsewhere? (Answer this question only if protected cultivation is important in the PRA area.) *no = 1* *often = 9*	**No**	No data have been found in literature about damage in protected cultivation.
1.19 How likely are wild plants (*i.e.* plants not under cultivation, including weeds, volunteer plants, feral plants) to be significant in dispersal or maintenance of populations? *not likely = 1* *very likely = 9*	**2** **Not likely**	*Solanum nigrum* and *S. dulcamare* are common weeds in the Netherlands. They may contribute to dispersal of *Leucinodes orbonalis* during summer time but their significance is considered low due to the unfavourable climatic conditions during most time of the year in the PRA area.
**1.20 ***How similar are the climatic conditions that would affect pest establishment in the PRA area and in the area of origin?	**1** **Not similar**	**Outdoor climate** A climate match has been carried out with Climex (Suthurst and Maywald, 1985). Results of this study indicate that no climate match exist with the Netherlands and the regions where

<u>Note</u>: the climatic conditions in the PRA area to be considered may include those in protected cultivation. *not similar = 1* *very similar= 9*		*Leucinodes orbonalis* presently occurs.  These two maps were generated from a climate match run with Patna and Calcutta (India) as reference locations compared with 2031 locations worldwide. The red areas (dots) on these maps indicate the similarity in climates with the two reference locations where *Leucinodes orbonalis* is known to occur. No similarities were found in climatic conditions between the regions of origin and the PRA area. It should be noted that no Climex study was carried out specifically for *L. orbonalis*. This might alter the overall picture somewhat.

	6 **Rather similar**	 **Protected cultivation** In the Netherlands, *Solanum melongena* is grown in heated glasshouses that meet the climate requirements for development of *Leucinodes orbonalis*. For that reason there is a serious possibility for indoor establishment. See also the answer on question 16.
1.21 How similar are other abiotic factors in the PRA area and in the area of origin? *<u>Note</u>: the major abiotic factor to be considered is soil type; others are, for example, environmental pollution, topography/orography.* *not similar = 1* *very similar= 9*	**7** **Fairly similar**	*Leucinodes orbonalis* is present in large areas in South East Asia and Africa. Several of these areas are not very distinctive in topography with the PRA area. Soil type may affect the life cycle of the pest organism as mature larvae of *L. orbonalis* may pupate in the soil to a depth of 1-3 cm (CAB International, 2004). However, *L. orbonalis* also pupate in decomposed leaves and under withered branches and no records were found on (major) effects of soil type on the life cycle of the pest organism (Yin, 1993).
1.22 How likely is the pest to have competition from existing species in the PRA area for its ecological niche? *very likely =1*	**7** **Not likely**	*Leucinodes orbonalis* might face some competition from other boring caterpillars within its host plant range. However, it is unlikely that the level of competition will play a significant role.

not likely = 9		
1.23 How likely is establishment to be prevented by natural enemies already present in the PRA area? *very likely =1* *not likely = 9*	**8** **Not likely**	As many as sixteen parasitoids, three predators and three species of entomopathogens have been reported as natural enemies of *L. orbonalis* from the known distribution area (Knorsheduzzaman *et al*., 1998). However, they do not seem to play any significant role in keeping *L. orbonalis* damage under reasonable level (Srivastava and Butani, 1998). In the PRA area, no known natural enemies of *L. orbonalis* are present. Establishment of *L.orbonalis* will likely not be prevented by natural enemies in the PRA area.
**1.24 ***If there are differences in the crop environment in the PRA area to that in the area of origin, are they likely to aid establishment? *Note: factors that should be considered include: time of year that the crop is grown, soil preparation, method of planting, irrigation, whether grown under protected conditions, surrounding crops, management during the growing season, time of harvest, method of harvest etc.* *not likely = 1* *very likely = 9*	**1** **Not likely**	Eggplant is grown year round in countries where *Leucinodes orbonalis* is present. In the Netherlands, the eggplant crop is removed in November and often also the substrate on which the crop is grown. New plants are planted about 2-3 weeks later. Tomato and sweet pepper also have a production-free period, usually of about 3 weeks. This practice will cause a large decrease in population size and *L. orbonalis* will mainly survive this period by pupae present on sheltered places in the glasshouse. In the case of *Solanum* pot plants, a host plant will be present during the whole year, which creates a situation, which is more comparable to that of the area of origin.
1.25 Are the control measures which are already used against other pests during the growing of the crop likely to prevent establishment of the pest? *very likely = 1* *not likely = 9*	**8** **Not likely**	Integrated control is common practice in the protected cultivation of eggplant, tomato and sweet pepper in the Netherlands. Selective insecticides are being used to control pests against which no natural enemies are being used. *Bacillus thuringiensis* is being used against caterpillars during the cultivation period. It has to be applied several times and does not always work sufficiently but has no harmful effect on natural enemies. Teflubenzuron and spinosad (the latter only in tomato and sweet and hot pepper) are also being used

		against caterpillars. However, these agents negatively affect natural enemies and are generally used at the end of the cropping period only. Moreover, teflubenzuron may not be very effective since the efficacy of the related compound diflubenzuron against *L. orbonalis* is low (Krishna *et al*, 2002). Methomyl and deltamethrin may also be used in the Netherlands; they are effective against *L. orbonalis* but also kill natural enemies and have a long residual effect which make reintroduction of biocontrol agents not possible during 8 –1 2 weeks (Peter and David, 1989; Patnaik and Singh, 1997; Radhika *et al*, 1997; Sharma and Chhibber, 1999). Since 29 April 2005, a new insecticide against caterpillars is on the Dutch market based on methoxyfenozide. This compound fits well in the integrated control system. It should, however, not be used at high frequencies since it is rather sensitive to development of resistance (Gore and Adamczyk, 2004; Grafton-Cardwell *et al*, 2005). No results have been found on the efficacy of methoxyfenozide against *L. orbonalis*. A major problem in the control of *L. orbonalis* is that the larvae bore inside fruits or stems where they will not be killed by insecticide spraying. The pupae, which are usually formed on sheltered spots, may also be difficult to destroy. Pesticides based on *Bacillus thuringiensis* are effective against *L. orbonalis* (Jat and Pareek, 2001; Krishna *et al*, 2002). However, they probably cannot completely control the pest since larvae bore inside the plant and *Bacillus thuringiensis* based pesticides often do not sufficiently control other Lepidoptera species which are assumed easier to control since they do not bore inside the plant. It is, therefore concluded that control measures already used are likely not sufficient to control *Leucinodes orbonalis* during the cropping period. It has to be emphasized that the above mentioned aspects indicate that *L. orbonalis* is a threat to the integrated and biological- pest- management systems presently being used in glasshouse fruit vegetables. At the end of the cropping period, the crop is removed and eradication of the pest organism in the glasshouse. Outdoor establishment of *L. orbonalis* is not expected in the Netherlands due to the moderate climate. However, the following can be said about the control measures in

		(potential) host plant crops grown in the open: Potatoes are sprayed with pyrethroid insecticides (deltamethrin, esfenvalerate and/or lambda-cyhalothrin) to control aphids during the growing season In the PRA area, (DLV, 2002; H. Boesveld, Dutch Plant Protection Service, personal communication to D.J. van der Gaag, 2005). These insecticide sprays may also be effective against *Leucinodes orbonalis.* However, due to exuberant use in the area of origin, a potential insecticide resistance should be taken into account. In the countries of origin, it appears very difficult to control *L. orbonalis* In Bangladesh, farmers may spray every day or on alternate days during rainy seasons and in winter farmers spray weekly (Rashid *et al*, 2003). Control is expected to be less difficult in outdoor crops the Netherlands due to the moderate climate. Pyrethroid insecticides are used against the pea weevil (*Sitona lineatus*) in peas. Sprays against the pea weevil may also control *Leucinodes orbonalis.* The insecticidal sprays in potato and pea are not expected to eradicate *L. orbonalis*, but the climate in the PRA area will probably be too cool for outdoor establishment of L. orbonalis, as already mentioned above.
**1.26 ***Is the reproductive strategy of the pest and duration of life cycle likely to aid establishment? *<u>Note</u>: consider characteristics which would enable the pest to reproduce effectively in a new environment, such as parthenogenesis/self-crossing, duration of the life cycle, number of generations per year, resting stage etc.*	**8** **Likely**	Under indoor circumstances (heated glasshouses), the species may develop year-round without diapause. Based on this information the species can have several generations a year. In India, *L. orbonalis* can complete 8 generations a year (Alam *et al*., 2003). Females can lay up to 250 eggs (average 170) (Singh and Singh, 2001).

not likely = 1 *very likely = 9*		
1.27 How likely are relatively low populations of the pest to become established? *not likely = 1* *very likely = 9*	**1** **Not likely**	In general, low densities in populations are subject to the Allee-effect, which may reduce the rate at which invaders move into a new environment (Lewis and Kareiva, 1993). **In case infested consignments are directly transported to auctions /stores** Normally, only larvae and/or eggs of *L. orbonalis* are imported with fruit. First, these larvae or eggs have to develop into adult moths. Moths of the opposite sex will have to find each other for mating and will have to find a spot with a suitable climate for establishment. It is not likely that these events occur successively in the Netherlands. **In case infested consignments are packed/sorted near glasshouse production sites** The above described events are not likely to occur in this case as well. **In case infested consignments are sold in a glasshouse** The above described events are much more likely to occur if infested fruit is sold in a glasshouse production site where host plants are present.
	2 **Not likely** **6** **Likely**	
1.28 How probable is it that the pest could be eradicated from the PRA area? *very likely = 1* *not likely = 9*	**7** **Likely**	*Leucinodes orbonalis* can probably not survive outdoors in the Netherlands. It may, however, survive in heated glasshouses. Eradication in glasshouses is expected to be possible since windows may be closed and the whole crop, plant debris, artificial substrate, plastic cover etc can be removed and destroyed.
1.29 How genetically adaptable is the pest? *<u>Note</u>: is the species polymorphic, with, for example, subspecies, pathotypes? Is it known to have a high mutation rate? This genotypic (and phenotypic) variability*	**Not known**	No data have been found.

facilitates the pest's ability to withstand environmental fluctuations, to adapt to a wider range of habitats, to develop pesticide resistance and to overcome host resistance. *not adaptable =1* *very adaptable = 9*		
**1.30 ***How often has the pest been introduced into new areas outside its original range? *Note: if this has happened even once before, it is important proof that the pest has the ability to pass through most of the steps in this section (ie association with the pathway at origin, survival in transit, transfer to the host at arrival and successful establishment). If it has occurred often, it suggests an aptitude for transfer and establishment.* *never = 1* *often = 9*	**Not known**	No date have been found.

2. Economic Impact Assessment		
Identify the potential hosts in the PRA area, noting whether wild or cultivated, field or glasshouse. Consider these in answering the following questions. When performing a PRA on a pest that is transmitted by a vector, consider also any possible damage that the vector may cause. *According to the pest and host(s) concerned, it may be appropriate to consider all hosts together in answering the questions once, or else to answer the questions separately for specific hosts.* *Note that, for most pest/crop/area combinations, precise economic evaluations are lackiing. In this section, therefore, expert opinion is asked to provide an evaluation of the likely scale of impact. Both long-term and short-term effects should be considered for all aspects of economic impact.*		
**2.1 ***How important is economic loss caused by the pest within its existing geographic range? *little importance = 1* *very important = 9*	**9** **Very important**	**Egg plants (*Solanum melongena*)** *Leucinodes orbonalis* is a major pest of eggplant in South-East Asia. The larvae bore into the shoots and preferably into the fruits. The prices of such damaged fruits are much lower and heavily damaged fruits are unmarketable (Rashid *et al*, 2003). In an experiment in India, percentages of damaged fruits ranged from 12 to 95 in the period December to June (Naresh *et al*, 1986). In another experiment performed in another region in India, percentages of damaged fruits varied from 0 to 67% from October to December (Singh *et al*, 2000). No control measures were taken in these treatments. In a survey performed in Gujarat (India), percentages damaged fruits varied from 0 to 60% on commercial farms during the year. The use of pesticides was limited to 5 –6 sprays per year on these farms (Alam *et al*, 2003). In Bangladesh, spraying frequencies may be much higher and yield losses possibly lower. In the rainy seasons of 2000 – 2002, most farmers sprayed every day or on alternate days against *Leucinodes orbonalis* in the Jessore district of Bangladesh (Rashid *et al*, 2003). Losses caused by *Leucinodes orbonalis* were not mentioned in that study. However, costs for pesticides constituted 32% of total costs (Rashid *et al*, 2003).
	4 **Moderately important**	***Solanum* spp. other than *S. melongena*** Damage to *Solanum tuberosum* (potato) may be considerable with up to 42% of shoots damaged by *L. orbonalis* reported in one article (Mishra and Chand, 1975). The potato yield was 15% lower in the field than under caged conditions In an experiment conducted in

	1 **Little importance**	India, (Murthy and Nandihalli, 2003). No other reports on damage of *Solanum tuberosum* by *L. orbonalis* have been found. *L. orbonalis* has frequently been found in *S. torvum* fruits imported into the Netherlands suggesting that the pest organism may cause considerable damage to this crop. The economic damage to *Solanum* crops other than *Solanum melongena* is estimated to be of moderate importance. However, it has to be emphasized that damage to certain *Solanum* crops (e.g. *S. torvum*) may be much more important but information is lacking. **<u>Host plants other than *Solanum* spp.</u>** In the USA, *L. orbonalis* has been intercepted on host plant fruits other than *Solanum* spp. (Table 1). However, as far as we know *L. orbonalis* is not an important pest on crops other than *Solanum* spp. in its current area of distribution. For example, in the Philippines, *L. orbonalis* does not cause any serious damage in tomato and has not been observed on sweet pepper in the open field (B. van Haperen, East-West Seed Company Ltd., personal communication to H. Stigter, 2005).
2.2 How important is environmental damage caused by the pest within its existing geographic range? *<u>Note</u>: environmental damage may be impact on ecosystem health, such as effects on endangered/threatened species, keystone species or biodiversity.* *little importance = 1* *very important = 9*	**2** **Probably of litte importance**	It may damage several wild plants like *Solanum nigrum*. No information is, however, available on environmental damage caused by the pest organism in literature.
2.3 How important is social damage caused by the pest within its existing geographic	**5** **Fairly**	Rashid *et al* (2003) performed a socio-economic analysis of eggplant pest control in the major eggplant production area of Bangladesh. Some of the results of that study are briefly

range? *<u>Note</u>: social effects could be, for example, damaging the livelihood of a proportion of the human population, or changing the habits of a proportion of the population (eg limiting the supply of a socially important food).* *little importance = 1* *very important = 9*	**important**	discussed below: Eggplant, *Solanum melongena*, is the most popular and economically important vegetable in Bangladesh. *Leucinodes orbonalis* is a major pest of *Solanum melongena* (eggplant) and potential losses are high (more than 65%). Therefore, farmers spray pesticides almost every day during the hot and humid season. Very few farmers use protective clothing and, as a consequence, almost all farmers face health problems. Yield losses by the pest organism are still substantial despite the high costs for plant protection measures. However, it was concluded that the farmers still earned substantial profits from eggplant cultivation.
**2.4 ***How extensive is the part of the PRA area likely to suffer damage from the pest? *<u>Note</u>: the part of the PRA area likely to suffer damage is the <u>endangered area</u>, which can be defined eco-climatically, geographically, by crop or by production system (e.g. protected cultivation).* *very limited = 1* *whole PRA area = 9*	**1** **Very limited** **3** **Limited** **3** **Limited**	It is **uncertain** to which extent *Leucinodes. orbonalis* will cause damage in mono-croppings of tomato, sweet pepper and *Solanum* pot plants in Dutch glasshouses. Therefore, it is presently impossible to give a reliable answer this question. Therefore, the answer is divided into sub answers, each sub answer referring to a possible situation, if *L. orbonalis* would establish in the NL. **Outdoor crops** *Leucinodes orbonalis* may cause considerable damage to potato shoots in the area of origin and may also lead to yield losses (Murthy and Nandihali, 2003). In the PRA area, little damage is expected in outdoor crops because of the unfavourable climatic conditions for *L. orbonalis* (relatively cool climate). Pea is possibly not an important host plant of *L. orbonalis* as no literature could be found on damage caused by the pest organism. **Eggplant – glasshouse production sites** *L. orbonalis* is expected to be able to cause serious damage in eggplant (*Solanum melongena*). Eggplant is a relatively small crop in the Netherlands with a total area of 89 ha (CBS, 2005). **Eggplant + *Solanum* pot plants – glasshouse production sites**

	7 **Extensive**	If besides eggplants, *Solanum* pot plants would also suffer damage from *L. orbonalis*, the part of the PRA area that could suffer damage would increase slightly. *Solanum* pot plants are grown on less than 10 ha (F. van Noort, Applied Plant Research, Aalsmeer, personal communication to D.J. van der Gaag, 2005). **Eggplant + *Solanum* pot plants + tomato + sweet pepper – glasshouse production sites** Tomato and sweet pepper may also be attacked by the pest organism (Das and Patnaik, 1970; Anonymous, 1984; CAB international, 2004). These crops are major glasshouse vegetables in the Netherlands covering 20 - 25% of the total glasshouse area in the PRA-area. *L. orbonalis* is no major pest of tomato or sweet pepper in the countries where it occurs. In an experiment performed in India major losses were reported in eggplant caused by *Leucinodes orbonalis* while other pest organisms caused important losses in tomato (Pareek and Bhargava, 2003). *L. orbonalis* always cause damage in eggplant on research farms of East-West Seed Company in the Bulacan and Batangas regions in the Philippines, while no damage has ever been observed in tomato plants grown on the same farms at the same time and no serious damage have been observed on commercial tomato farms in the Philippines (B. van Haperen, East-West Seed Company Ltd., personal communication to H. Stigter, 2005). B. van Haperen has never observed *L. orbonalis* on sweet pepper in the Philippines. In heated glasshouses with mono-crops of tomato or sweet pepper, the situation might be different as *L. orbonalis* will not be able to choose for preferred *Solanum* host plants. Therefore, *L. orbonalis* may cause damage in mono-crops of tomato and sweet pepper under protected conditions.
Spread potential is an important element in determining how fast economic impact is expressed and how readily a pest can be contained		
2.5 How rapidly is the pest liable to spread in the PRA area by natural means? *very slowly = 1* *very rapidly = 9*	**3** **(Probably) slowly**	Little is known about the speed of natural spreading in the countries of origin.
2.6 How rapidly is the pest liable to	**3**	Larvae of *L. orbonalis* present in imported fruits are distributed to stores in the Netherlands.

spread in the PRA area by human assistance? *very slowly =1* *very rapidly= 9*	**Slowly**	However, fruits are used for consumption and, therefore, the risk of spread to glasshouse production sites is assumed to be low. If it establishes in glasshouses, the species may be spread with (*Solanum*) planting material.
2.7 How likely is it that the spread of the pest could be contained within the PRA area? *<u>Note</u>: consider the biological characteristics of the pest that might allow it to be contained in part of the PRA area; consider the practicality and costs of possible containment measures.* *very likely = 1* *not likely = 9*	**5** **Moderate**	The adult stage of *Leucinodes orbonalis* (the adults) can fly and move through the air by itself. However, the climatic conditions in North Western Europe are not favourable to the pest organism. It will probably only be able to survive and establish in heated glasshouses. Spread to other areas may occur with young planting material but natural spread is not very likely to occur.
**2.8 ***Considering the ecological conditions in the PRA area, how serious is the direct effect of the pest on crop yield and/or quality likely to be? *<u>Note</u>: the ecological conditions in the PRA area may be adequate for pest survival but may not be suitable for significant damage on the host plant(s). Consider also effects on non-commercial crops, e.g. private gardens, amenity plantings.* *not serious= 1* *very serious= 9*	**7** **Serious for host plants grown under protected conditions**	See 2.4 Serious for eggplant and possibly also for container grown *Solanum* spp, tomato and sweet pepper grown in heated glasshouses. No effect of *L. orbonalis* on outdoor crops in the Netherlands is expected.

2.9 How likely is the pest to have a significant effect on producer profits due to changes in production costs, yields *etc.* in the PRA area? *not likely = 1* *very likely = 9*	**7** **Likely**	*Leucinodes orbonalis* will not likely have a significant effect on the profits of outdoor grown crops (see also the answer on question 2.4). However, production costs of crops grown under protected conditions (eggplant, and possibly also container grown *Solanum* spp., tomato and sweet pepper) will probably increase due to an increase in chemical pesticide applications and a disruption of the integrated control strategies. Yields may be lower due to damage caused by the pest organism and labour costs may increase, as damaged fruits will have to be removed. Moreover, growers may not harvest fruits during 3 days after pesticides based on deltamethrin, methomyl or spinosad have been applied. Companies that grow young planting material will also have serious economical damage since growers of fruit vegetables will avoid buying young plants from infested companies.
2.10 How likely is the pest to have a significant effect on consumer demand in the PRA area? *Note: consumer demand could be af-fected by loss in quality and/or increased prices.* *not likely = 1* *very likely = 9*	**2** **Not very likely**	Presently, the supply of eggplant, tomato and sweet pepper fruits is large in the PRA-area. *Leucinodes orbonalis* can cause large yield reductions in the area of origin during hot and humid weather (Alam *et al*, 2003). Fruits of eggplant, tomato and sweet pepper are also being imported. Therefore, the pest will probably not (or to a limited extent only) affect the supply and prices of the products. Growers will have to spray more frequently and there are more side effects on biological control used against other pests which, consequently, have to be controlled chemically in addition. This is unwanted by growers and consumers. However, the price of the product, which will not or be affected to a limited extent only, is most important for most consumers.
2.11 How likely is the presence of the pest in the PRA area to affect export markets? *Note: consider the extent of any phytosanitary measures likely to be imposed by trading partners.* *not likely = 1* *very likely= 9*	**6** **Likely**	The EU is the main export market of the Netherlands for fruit vegetables. Exact production and export figures are presented on www.tuinbouw.nl for 2001 – 2004. Most fruit vegetables produced are being exported. Fruits of tomato and sweet pepper are major agricultural export products in the Netherlands with export values of 867 and 620 million euro, respectively, in 2003 (Anonymous, 2003). Eggplant is a much smaller crop with an export value of 55 million dollar in 2003 according to the database of FAOSTAS (http://apps.fao.org/faostat/).

		If *Leucinodes orbonalis* would be present in the PRA area, the export market of fruit vegetables with a total value of more than a billion euro could be seriously affected, especially when *L.orbonalis* would become a quarantine organism in the EU and/or when import countries do not tolerate any damaged fruits. Production costs will increase due to control measures related to infestations of this pest, which could weaken the export market position of the Netherlands. Young planting material of tomato and sweet pepper are also exported (about 30-50% of the total production is exported; exact figures are not known). Export of young planting material of eggplant is probably limited (J. den Dekker, Plantum NL, personal communicaton to D.J. van der Gaag, 2005). If *L. orbonalis* is able to infest tomato and/or sweet pepper, the export of young planting material of these crops could be affected.
2.12 How important would other costs resulting from introduction be? <u>Note</u>*: costs to the government, such as research, advice, publicity, certification schemes; costs (or benefits) to the crop protection industry.* *little importance = 1* *very important = 9*	**5 Moderately important**	Glasshouse growers will have to apply more chemical pesticides. The producers of these pesticides will benefit whereas producers of natural enemies may loose turnover. Costs for inspection will increase.
2.13 How important is the environmental damage likely to be in the PRA area? *little importance = 1* *very important = 9*	**2 (Probably) of little importance**	The climatic conditions in the PRA area are relatively unfavourable for development for the pest organism and, therefore, environmental damage will probably be of little importance.
2.14 How important is the social damage likely to be in the PRA area? *little importance = 1*	**3 Not very important**	Presently, no indications are known that *Leucinodes orbonalis* would cause important social damage in the PRA-area except that eggplant, tomato and sweet pepper may have to be sprayed more frequently by chemical pesticides which is unwanted by many consumers.

very important = 9		
2.15 How probable is it that natural enemies, already present in the PRA area, will affect populations of the pest if introduced? *very likely = 1* *not likely = 9*	**9** **Not likely**	See 1.23
2.16 How easily can the pest be controlled? *<u>Note</u>: difficulty of control can result from such factors as lack of effective plant protection products against this pest, occurrence of the pest in natural habitats or amenity land, simultaneous presence of more than one stage in the life cycle, absence of resistant cultivars.* *easily = 1* *with difficulty= 9*	**7** **With some difficulty**	*Leucinodes orbonalis* is difficult to control in eggplant in tropical regions where farmers may use pesticides daily during the hot and rainy season (Rashid *et al*, 2003). In the PRA area, the climatic conditions outdoor are not favourable for *L. orbonalis.* It is, therefore, expected that *Leucinodes orbonalis* will not survive and does not need to be controlled in the open field. In Gujarat (India), percentages damaged fruits were much lower in November and December when temperatures dropped to 10-15°C during night than in July and August (rainy season) when both maximum and minimum temperatures were above 20°C (Alam *et al*, 2003). In glasshouses in the PRA area, temperatures will be much more favourable for *L. orbonalis* than in the open field and control may be difficult, especially during summer time. Control of larvae of *L. orbonalis* (the caterpillars) is expected to be more difficult than control of caterpillar species already present in the PRA area since the larvae of *L. orbonalis* bore inside the plant and are only vulnerable to insecticides a short time after hatching. Eggplant, and also tomato and green pepper are annual crops and growers may eradicate the pest from their glasshouse if they use strict hygienic measures and remove the substrate and all plant debris at the end of the growing season. During the growing season, *L. orbonalis* may, however, move between glasshouses and enter a glasshouse that was free of the pest. In the production of *Solanum* pot plants, plants are present throughout the whole year and control may be even more difficult than in eggplant.
2.17 How likely are control measures to disrupt existing biological or integrated	**8** **Very likely**	Integrated control of pests is common practice in eggplant, tomato and sweet pepper (J. Pijnakker, Applied Plant Research, Naaldwijk, personal communication to D.J. van der Gaag,

systems for control of other pests? *not likely = 1* *very likely = 9*		2005). Non-selective pesticides, which negatively affect natural enemies, will probably have to be used since control by the selective agent *Bacillus thuringiensis* will probably be insufficient to control *Leucinodes orbonalis*. The recently registered pesticide methoxyfenozide fits probably well into an integrated control system but this compound should not be used in high frequencies because of risks of resistance development by the pest organism (Gore and Adamczyk, 2004; Grafton-Cardwell *et al*, 2005). No data have been found on the efficacy of methoxyfenozide against *L. orbonalis*.
2.18 How likely are control measures to have other undesirable side-effects (for example, on human health or the environment)? *not likely = 1* *very likely = 9*	**5** **Moderate**	The pesticides teflubenzuron, deltamethrin, esfenvalerate and methomyl negatively affect aquatic organisms and have a relatively high environmental impact (www.library.wur.nl/milieumeetlat). The use of these pesticides is limited in the cultivation of eggplant, tomato and sweet pepper since most pests are controlled with natural enemies. Frequent use of the above mentioned pesticides would lead to a higher impact on the environment. The impact on human health will be negligible as long as precautions are taken as indicated on the pesticide label.
2.19 Is the pest likely to develop resistance to plant protection products? *not likely = 1* *very likely =9*	**5** **Moderately likely**	In Asia, pesticides belonging to different groups, carbamate, organophosphate and pyrethroid insecticides, are sprayed in very high frequencies to control the pest (Rashid *et al*, 2003). Such an intensive chemical control strategy increases the chance on resistance development by the pest organism and some data suggest indeed that the pest organism has developed some resistance to the pyrethroid insecticides (Ali, 1994; Kabir *et al*., 1994). In the PRA-area however, spraying frequency will be lower due to less favourable climatic conditions, which results in an a lower risks on resistance development.
After completing this section, the assessor should comment on whether sufficient information exists to trust the answers given; or if he/she knows of other relevant factors that have not been considered in this evaluation.		
Most information in this PRA is reliable and sufficient to answer many of the questions. The main uncertainty is whether or not other crops are at risk under protected conditions in the Netherlands, besides eggplant.		

3. FINAL EVALUATION OF ASSESSMENT

Entry

Leucinodes orbonalis is able to enter the Netherlands, mainly via a rather low volume of imported consignments of *Solanum* fruits, but also via fruits brought along by passengers travelling from infested areas to the Netherlands. The pest organism is frequently found in imported fruit consignments from regions where it is present. The vast majority of these imported fruits are directly transported to stores and sold for consumption. In order to transfer to a glasshouse production site, imported larvae would have to survive, develop and find a glasshouse with host plants. These successive events are very unlikely to happen, also because the outdoor climate in the Netherlands, besides perhaps the summer months, is not suitable for *L. orbonalis*. Therefore, the overall entry risk is rated very low. The entry risk may be somewhat higher if imported fruits are packed at the same location where also nationally produced fruits are being packed. If package material is returned to the production site, *L. orbonalis* might enter production sites.

REGULAR ENTRY RISK: VERY LOW

One particular case is known of a store that sell tropical fruits, including various *Solanum* fruits, which is located inside a glasshouse with an open connection to an area in which sweet pepper is grown. In this case, the risk of entry is moderate to high.

ENTRY RISK IN CASE(S) FRUIT IS SOLD IN A GLASSHOUSE PRODUCTION SITE: MODERATE - HIGH

Establishment

It is very unlikely that *L. orbonalis* can establish outdoors in the Netherlands since temperatures during winter are probably too low (for a too long period) for survival. It will probably be able to establish in heated glasshouses, although females would first need to find opportunities to mate in order to establish an initial population.

ESTABLISHMENT RISK IN GLASSHOUSES: MODERATE

Economic impact

L. orbonalis is a major pest of eggplant and it is very likely that eggplants grown in Dutch glasshouses would suffer comparable damage if the species became established. It would cause yield losses but also yield problems in eggplant because no fruits may be harvested and sold during 3 days after chemical pesticides, which are presently allowed to use, have been applied (except for the pesticide based on methoxyfenozide for which this period is one day only). Production costs would increase.

L. orbonalis is a minor pest of tomato in countries of origin. It could possibly cause damage in mono-crops of tomato and sweet pepper or *Solanum* pot plants under protected conditions, but it is uncertain how serious damage would be in these cropping systems.

ECONOMIC IMPACT: HIGH

Control

Leucinodes orbonalis is difficult to control during the growing season since the larvae are only vulnerable for pesticides a short time between hatching and before they bore into host tissue. Control measures needed to control *L. orbonalis* will probably disrupt existing integrated systems for control of pests in fruit vegetables in glasshouses.

Conclusion Pest Risk Assessment

Leucinodes orbonalis enters Netherlands with imported fruits from infested tropical areas. It is very unlikely that this species can establish outdoors in the Netherlands. The risk that it will transfer to a suitable host in glasshouses is very low, except for a particular situation in which imported fruits are sold in glasshouse production sites with host plants. If *L. orbonalis* would establish in Dutch glasshouses, it could cause serious damage in eggplant. *Solanum* pot plants, tomato and sweet pepper may also act as host plants and suffer damage. It is, however, uncertain how serious damage will be in these crops.

In the USA, *L. orbonalis* has been intercepted from 1984 onwards in host plant fruits in baggage of passengers entering the country. These import checks are not on a 100%-level, but there are no records of *L. orbonalis* outbreaks in the USA. It must be noted that (commercial) import of host plant fruit from infested areas is forbidden in the USA. Also in the Netherlands or elsewhere in the EU, no records of *L. orbonalis* outbreaks are know, despite the fact that eggplant fruits were not regularly inspected before 2004 and many entries of the pest must have occurred in the past in the Netherlands and other EU member states.

Because of this very low risk of entry and successful establishment in glasshouse production sites in the Netherlands, *L. orbonalis* does not qualify as a quarantine organism.

Literature

Alam, S.N., Rashid, M.A., Rouf, F.M.A., Jhala, R.C., Patel, J.R., Satpathy, S., Shivalingaswamy, T.M., Rai, S., Wahundeniya. I., Cork, A., Ammaranan, C., and Talekar, N.S., 2003. Development of an integrated control strategy for eggplant fruit and shoot borer in South Asia. Shanhua, Taiwan: AVRDC-the World Vegetable Center. Technical Bulletin No. 28. AVRDC Publication No. 03-548. 56 pp.

Ali, M.I., 1994. Circumstantial evidence supports insect resistance in Bangladesh. Resistant Pest Management 6: 5.

Anonymous, 1984. Action plan Eggplant fruit borer *Leucinodes orbonalis* Guenee. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Cooperating State Departments of Agriculture.

Anonymous, 2003. Duurzaam en gedurfd. Maatschappelijk jaarverslag glastuinbouw 2003. LTO Nederland.

CAB International, 2004. Crop Protection Compendium. Wallingford, UK: CAB International. Avaliable on-line at: http://www.cabicompendium.org/cpc

CBS, 2004. Centraal Bureau voor de Statistiek on http://www.cbs.nl/nl/publicaties/artikelen/algemeen/webmagazine/artikelen/archive/artikel.asp?jr=2004&id=1494k&dt=19-07-2004. Last accessed: February 2005.

CBS, 2005. Centraal Bureau voor de Statistiek on http://www.cbs.nl/nl/cijfers/themapagina/landbouw/1-cijfers.htm. Last accessed: February 2005.

Cork, A., Alam, S.N., Rouf, F.M.A., and Talekar, N.S., 2003. Female sex pheromone of brinjal fruit and shoot borer, Leucinodes orbonalis (Lepidoptera: Pyralidae): trap optimization and application in IPM trials. Bulletin of Entomological Research, 93 (2): 107-113.

Das, M.S., and Patnaik, B.H., 1971. A new host of the brinjal shoot and fruit borer *Leucinodes orbonalis* Guen. Journal of the Bombay Natural History Society, 67: 601 – 603.

DLV, 2002. DLV-gids: Gewasbescherming in 2002 in de Akkerbouw en Veehouderij. DLV Akkerbouw, Assen.

Ghosh, S.K., Laskar, N., and Senapati, S.K., 2003. Estimation of loss in yield of Brinjal due to pest complex under Terai Region of West Bengal. Environment and Ecology 21(4): 764-769.

Gore, J., and Adamczyk, J.J., 2004. Laboratory selection for beet armyworm (Lepidoptera: noctuidae) resistance to methoxyfenozide. Florida Entomologist 87 (4): 450 – 453.

Grafton-Cardwell, E.E., Godfrey, L.D., Chaney, W.E., and Bentley, W.J., 2005. Various novel insecticides are less toxic to humans more specific to key pests. http://CaliforniaAgriculture.ucop.edu.

Ishahaque, N.M.M. and Chaudhiri, R.P., 1985. A new alternate host plant of brinjal shoot and fruit borer *Leucinodes orbonalis* Guen. In Assam. Journal of Research, Assam Agricultural University 4: 83-85.

Jat, K.L., and Pareek, B.L., 2001. Field evaluation of ecofriendly insecticides against brinjal shoot and fruit borer, Leucinodes orbonalis Guen. Indian Journal of Plant Protection 29: 53-56.

Kabir, K.H., Roul, F.M.A., Islam, M.N., and Malaker, P.K., 1994. Efficacy of different insecticides in controlling brinjal shoot and fruit borer, Leucinodes orbonalis Guen. University Journal of Zoology, Rajshahi University 13: 1-8.

Katiyar, O.P., and Mukharji, S.P., 1973. Development of Leucinodes orbonalis Guenée at certain temperatures. Indian Journal of Horticulture : pp. 291 - 294.

Krishna, T.M., Lal, O.P., Srivastata, Y.N.S., and Handa, S.K., 2002. Field efficacy of different insecticides, *Bacillus thuringiensis* var. kurstaki (B.t.), neem and diblubenzuron for the control of shoot and fruit borer, *Leucinodes orbonalis* Guen. on egg plant.

Lal, O.P., 1975. Zur Uberwinterung von Leucinodes orbonalis Guen. (Lep., Pyralidae), eines Schadlings der Aubergine, *Solanum melongena* L., im Kulu-Tal, West-Himalaya, Indien. Anzeiger für Schadlingskunde, Planzenschutz, Umweltschutz 48: 181-182.

Mehto, D.N., Singh, K.M., and Singh, R.N., 1980. Dispersion of *Leucinodes orbonalis* Guen. During different seasons. Indian Journal of Entomology 42: 539-540.

Mennema, J., Quené-Boterenbrood, A.J., and Plate, C.L., 1985. Atlas van de Nederlands flora 2: Zeldzame en vrij zeldzame planten. Rijksherbarium Leiden, Centraal Bureau voor de Statistiek, Voorburg; Scheltema & Holkema BV, Utrecht. The Netherlands.

Murthy, P.N., and Nandihalli, B.S., 2003. Crop loss estimation caused by *Leucinodes orbonalis* Guenee in potato. Pest Management in Horticultural Ecosystems 9: 59-62.

Naresh, J.S., Malik, V.S., and Balan, J.S., 1986. Estimation of fruit damage and larval populations of brinjal fruit borer, *Leucinodes orbonalis* Guenee and its parasitism by Trathala sp. on brinjal. Bulletin of Entomology (New Delhi) 27: 44-47.

Pareek, B.L., and Bhargava, M.C., 2003. Estimation of avoidable losses in vegetable crops caused by borers under semi-arid conditions of Rajasthan. Insect Environment 9: 59-60.

Patnaik, H.P., and Singh, K.M., 1997. Efficacy of *Bacillus thuringiensis* Berliner and conventional insecticides against brinjal shoot and fruit borer under different spraying schedules. Orissa Journal of Horticulture

Peter, C., David, B.V., 1989. Evaluation of certain pesticides for the control of brinjal and bhendi fruit borers. Pestology 13: 29-31.

Pareek, B.L., Bhargava, M.C., 2003. Estimation of avoidable losses in vegetable crops caused by borers under semi-arid conditions of Rajasthan. Insect Environment 9 (2): 59-60.

Radhika, S., Reddy, K.D., and Subbarathnam, G.V., 1997. Management of brinjal shoot and fruit borer *Leucinodes orbonalis* (Guenee) with insecticides. Journal of Research ANGRAU 25: 10-14.

Rashid, M.A., Alam, S.N., Rouf, F.M.A., and Talekar, N.S., 2003. Socioeconomic parameters of eggplant pest control in Jessore District of Bangladesh. Technical Bulletin AVRDC No. 29.

Reddy, N.A., and Kumar, C.T.A., 2004. Insect pests of tomato, Lycopersicon esculentum Mill. in eastern dry zone of Karnataka. Insect Environment 10: 40-42.

Saxena, P.N., 1966. Effect of low temperature on moult and metamorphosis of the post-embryonic stages of Leucinodes orbonalis Guen. (Lepidoptera: Pyralidae). Proc. Zool. Soc., Calcutta 19: 145 – 151.

Sharma, A.K., Chhibber, R.C., 1999. Effect of exposure periods and insecticides on *Leucinodes orbonalis* in brinjal. Indian Journal of Entomology 61: 242-251.

Singh, Y.P. and Singh, P.P., 2001. Lab biology of shoot and fruit borer (Leucinodes orbonalis) of egg plant at medium high altitude hills of Meghalaya. Indian Journal of Entomology 63 (4): 373-376.

Singh, S.V. and Singh, K.S., and Malik, Y.P., 2000. Seasonal abundance and economic losses of shoot and fruit borer, Leucinodes orbonalis on brinjal. Indian Journal of Entomology 62: 247-252.

Suthurst, R.W., and G.F. Maywald, 1985. A computerized system for matching climates in ecology. Agriculture, Ecosystems and Environment, 13: 218 –299.

Srinivasan, G. and Babu, P.C.S., 1998. Life table studies on shoot and fruit borer Leucinodes orbonalis Guenee (Lepidoptera: Pyriallidae) on brinjal, tomato and potato. Advances in IPM for horticultural

crops. Proceedings of the First National Symposium on Pest Management in Horticultural Crops: environmental implications and thrusts, Bangalore, India 15-17 October, 1997.

Van der Meijden, R., 1996. Heukel's Flora van Nederland. Wolters-Noordhoff b.v., Groningen, the Netherlands.

Van der Meijden, Plate, C.L., Weeda, E.J., 1989. Atlas van Nederland 3: Minder zeldzame en algemene soorten. Onderzoeksinstituut Rijksherbarium/Hortus Botanicus, Leiden; Centraal Bureau voor de Statistiek, Voorburg/Heerlen. The Netherlands.