NEW PEST ADVISORY GROUP (NPAG)
Plant Epidemiology and Risk Analysis Laboratory
Center for Plant Health Science & Technology

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NPAG Report

***Chrysodeixis chalcites* (Esper):** Golden twin-spot moth, tomato looper
Lepidoptera: Noctuidae
NPAG Chair Approval Date: July 8, 2013

Adult *C. chalcites* (photo credit: Paolo Mazzei; source: http://www.invasive.org/)

This report is an internal PPQ document, intended to be used as an aid in PPQ decision making. The technical recommendations listed at the end of this document do not necessarily represent PPQ policy.

Initiating Event and Pest Identification: Joel Floyd (PPQ-PHP-NIS) notified NPAG on February 7, 2013 (Floyd, 2013c) of a PestLens notification stating that *Chrysodeixis chalcites* (Lepidoptera: Noctuidae) has been found in Ontario, Canada since 2008 (PPQ, 2013c, citing Murillo et al., 2013). This is the first field report of *C. chalcites* in Canada, where over 900 specimens have been detected in tomato and green bean field crops in southern Ontario (Essex and Chatham-Kent counties) over multiple years (2008-2011), the large majority of which occurred in tomatoes for processing in Essex County (Murillo et al., 2013). This insect was previously detected in and eradicated from greenhouses in British Columbia, Canada in 2006 (Lafontaine and Schmidt, 2013; Murillo et al., 2013). NPAG previously analyzed this pest in 1995 when it was found in multiple greenhouses on imported geranium (*Pelargonium*) cuttings from the Canary Islands (see details below). The NPAG managers decided to re-open the case file for this pest because of the potential pathway for this pest from Canada.

Taxonomy note: While some authors proposed that *C. chalcites* and the closely related *C. eriosoma* might be the same species (e.g., Murillo et al., 2013), the consensus among researchers appears to be that the relationship between these two species needs further clarification and that in the meantime they are treated as separate species (CABI, 2013; Floyd, 2013b; Holloway et al., 1987; Murillo et al., 2013; Passoa, 2006). Although these two species cannot be distinguished from each other morphologically (Murillo et al., 2013; Passoa, 2006), specimens have been distinguished by their geographic origin, pheromones, and more recently by molecular analysis (Lafontaine and Schmidt, 2013). *Chrysodeixis chalcites* occurs in Europe, the Mediterranean, the Middle East, and Africa, whereas *C. eriosoma* occurs in southern and eastern Asia and Oceania (CABI, 2013; Murillo et al., 2013; Passoa, 1995a; Zhang, 1994).

Prior NPAG History: In January 1995, PPQ was first notified of *C. chalcites* being detected in an Ohio greenhouse on geranium (*Pelargonium*) cuttings from the Canary Islands. Follow-up investigations on similar shipments verified infestations in greenhouses in Colorado, Louisiana, North Carolina, and Oregon (Havens, 1995). NPAG recommended a minimum of two pesticide applications with negative surveys and trappings before plants could be moved (Cousins, 1995). The last infested greenhouse was released from quarantine on March 27, 1995 (Havens, 1995). An NPAG Datasheet (NPAG, 1995) and a Pest Alert (Passoa, 1995b) were also prepared. As a consequence of these finds, *C. chalcites* is now regulated under CFR 319.37-5 (u) on *Pelargonium* sp. plants from the Canary Islands (7 CFR § 319.37, 2013).

Synonym(s): *Autographa chalcites* Esper, *Autographa chalcites* Linnaeus, *Chrysodeixis chalcytes* (Esper), *Chrysodeixis chalcytes* (Doubleday), *Noctua chalcites* Esper, *Noctua chalcytes* Esper, *Noctua chalsytis*

David R. Prokrym, Chair
david.r.prokrym@aphis.usda.gov
(919) 855-7578

USDA/APHIS/PPQ/CPHST/PERAL
1730 Varsity Drive, Suite 300
Raleigh, NC 27606-5202

Tara Holtz, Executive Secretary
tara.m.holtz@aphis.usda.gov
(919) 855-7423

Hubner, *Noctua questionis* Fabricius, *Phalaena chalcites* Esper, *Phytometra chalcites* Esper, *Plusia buchholzi* Plotz, *Plusia chalcites* (Esper), *Plusia chalcytes* Saalmuller, *Plusia cohaerens* Schultz (CABI, 2013).

Current PPQ Port Policy: The PestID database lists *Chrysodeixis chalcites* (Esper) (Doubleday) as reportable/actionable (PestID, 2013; queried April 15, 2013).

Pest Situation Overview:

Exotic status: *Chrysodeixis chalcites* occurs in Europe, the Mediterranean, the Middle East, and Africa (CABI, 2013; Murillo et al., 2013; Passoa, 1995a; Zhang, 1994). It is not known to occur in the United States. However, its recent occurrence in Canada represents a new potential pathway of introduction (through natural spread and trade). Additionally, there is a possible find from 2010 of *C. chalcites* in Monroe County, Michigan (collected by Henry Murillo, University of Windsor, Ontario, Canada); NIS tried to obtain the specimens to enable confirmation of this find (Floyd, 2013b), but they were told the specimens were no longer available (NPAG, 2013).

Known pest status: *Chrysodeixis chalcites* is a highly polyphagous pest that causes important damage by feeding on the foliage and fruit of a variety of vegetable and ornamental crops, both in field and greenhouse production (CABI, 2013; De Clercq et al., 1998; Polaszek et al., 2012). It is considered a "major pest" and "one of the most serious lepidopteran pests" in many countries (CABI, 2013; Polaszek et al., 2012). For instance, it causes "serious economic damages" in greenhouse tomato production in Italy (Garzia et al., 2003), is a "major pest" of tomatoes in Israel (Broza and Sneh, 1994), is one of the most damaging pests of banana production in the Canary Islands (Polaszek et al., 2012), is a principal pest of soybean in Italy (Zandigiacomo, 1990), and can cause significant yield loss in soybeans in Zimbabwe (Lapointe et al., 1995). On tomatoes, it can completely defoliate young plants (Harakly and Farag, 1975), and it has caused yield loss of 10-15% in greenhouse production (Daricheva et al., 1983). Damage to banana fruit reduces their commercial value (Anonymous, 2013b). In Italy, heavy infestations to ornamental plants (e.g., *Ficus*, *Aeschynanthus*) caused reduced plant marketability, with an estimated average loss of 10% (Sannino et al., 2005). Crops on which it is reported as a pest also include: clover, alfalfa, corn, artichokes, potato, cucumber, peppers, tobacco, green beans, cruciferous vegetables, and strawberry (Alvarado, 2009; CABI, 2013; Hill, 1987; Passoa, 1995b; Triggiani, 1969). Despite the numerous pest reports, there is a lack of quantitative data measuring damage (CABI, 2013).

Biology: *Chrysodeixis chalcites* is a tropical/subtropical species (CABI, 2013). It feeds primarily on the foliage of its hosts (Alvarado, 2009; Juvik et al., 1982), but it can also feed on the fruit, such as tomato (Daricheva et al., 1983; Hächler et al., 1998) and banana fruit (Polaszek et al., 2012) and developing pods of soybeans (Taylor, 1980). They feed externally on fruit, but on legumes they can bore deep into pods sometimes cutting them in two (CABI, 2013). It can cause important damage to banana (Anonymous, 2013b) and tomato (Hächler et al., 1998) fruits. Females deposit eggs, usually one or two at a time, on leaves of its hosts (Harakly and Farag, 1975). The reported mean number of eggs laid per female varies between 149 to 1,060 (Amate et al., 1998; CABI, 2013; Harakly and Farag, 1975). After hatching, the first instar larvae feed on the parenchyma of the lower leaf surface (CABI, 2013). It usually has six instars (Harakly and Farag, 1975). The second and third instars roll the edges of leaves together and spin silken threads on the leaves; the later instars eat through the leaves which makes them appear skeletonized; and the last two instars will usually eat the entire leaf except for maybe the midrib or other large veins (CABI, 2013). The last instar spins a white cocoon and pupates; the cocoon is usually attached on the underside of the leaf within the folded edges, but can also be on any object on the soil (Harakly and Farag, 1975) and on tomato fruit, often in a bunch of ripening tomatoes (Hächler et al., 1998). It has no diapause, continually breeding through the year (CABI, 2013). Despite being a tropical/subtropical species, it can move to more temperate areas during warm weather months through long distance migratory flight borne on strong winds, such as from North Africa and southern Europe to central and northern Europe (CABI, 2013; Palmqvist, 1998; Sparks et al., 2007).

Prevalence and global distribution: Africa - Algeria, Angola, Cameroon, Canary Islands (Spain), Cape Verde, Comoros, Congo Democratic Republic, Côte d'Ivoire, Egypt, Gambia, Guinea, Kenya, Libya, Madagascar, Madeira (Portugal), Malawi, Mauritius, Morocco, Mozambique, Nigeria, Réunion, Saint Helena, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, South Africa, Tunisia, Uganda, Zambia, and Zimbabwe (CABI, 2013); **Asia** - India (Indian Punjab), Iran, Iraq, Israel, Jordan, Lebanon, Syria, Turkey (CABI, 2013); **Europe** - Albania, Austria, Belgium, Bulgaria, Croatia, Cyprus, Denmark, Finland, France (including Corsica), Germany, Greece, Hungary, Italy (including Sicily), Malta, Netherlands, Poland, Portugal (including Azores), Romania, Serbia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, Yugoslavia (Serbia and Montenegro) (CABI, 2013; GBIF, 2013); **North America** – Canada (southern Ontario) (Floyd, 2013b; Lafontaine and Schmidt, 2013; Murillo et al., 2013).

Chrysodeixis chalcites occurs year-round in the tropical/subtropical areas of its distribution (Avidov and Harpaz, 1969; CABI, 2013; Hächler et al., 1998). Although it cannot overwinter outdoors in the temperate areas of the above distribution (CABI, 2013), it can establish itself in greenhouses in those areas (CABI, 2013; Lecheva and Loginova, 1988) and can immigrate from the south to temperate areas during warm season months (CABI, 2013; Hächler et al., 1998; Palmqvist, 1998; Sparks et al., 2007). In the Netherlands, researchers have also suspected that greenhouses could be the source of field populations of this insect (De Vos and Rutten, 1995).

Because of the taxonomic confusion with *C. eriosoma*, there are reports in the literature of *C. chalcites* also occurring in southern and eastern Asia and Oceania, including Hawaii. However, literature referring to *C. chalcites* in those areas is thought to actually refer to *C. eriosoma* (Passoa, 1995a; Zhang, 1994). The contact zone of the geographic ranges of *C. chalcites* and *C. eriosoma* is probably in the Indian subcontinent (Spitzer and Jaros, 2004).

Because of its presence in southern Ontario, Murrilo et al. (2013) suspect that *C. chalcites* may be present in surrounding tomato crop areas in Ohio, Michigan, and New York, and they suggest it might be overwintering further south, with spring migrations into Canada and these northern U.S. states. Although CAPS surveys for this insect have not confirmed its presence in the United States (CPHST, 2013), there was a possible but unconfirmed find of *C. chalcites* from 2010 in Monroe County, Michigan (Floyd, 2013b; NPAG, 2013). It may be that it is present in the United States but has been mistaken for the soybean looper, *Chrysodeixis includens*, which is morphologically very similar to it (Brambila and Passoa, 2013; Passoa, 1995b). Another unknown possibility is that greenhouses are a source of the field populations in Canada; this does seem plausible considering the area of Leamington (Essex County, Ontario), where most *C. chalcites* detections were made (Murillo et al., 2013), has the largest tomato greenhouse production in Canada (AAFC, 2006) with 1,500 acres (Awad, 2013), and that field tomatoes for processing in that area are usually grown from greenhouse-grown transplants (Anonymous, 2013a).

Host range: Amaryllidaceae - *Hippeastrum* hybrids (amaryllis); **Apiaceae** - *Anethum graveolens* (dill); **Asteraceae** - *Cynara cardunculus* var. *scolymus* (globe artichoke), *Flaveria australasica* (yellow twin-stem), *Chrysanthemum indicum* (chrysanthemum), *Chrysanthemum* spp., *Helianthus*, *Lactuca sativa* (lettuce); **Boraginaceae** - *Echium vulgare* (viper's-bugloss); **Brassicaceae** - *Brassica* spp.; **Caryophyllaceae** - *Dianthus* (carnation), **Cucurbitaceae** - *Cucumis sativus* (cucumber), *Cucurbita pepo* (squash), **Fabaceae** - *Cytisus* spp., *Arachis hypogaea* (groundnut), *Glycine max* (soybean), *Medicago sativa* (alfafa), *Phaseolus* (beans), *Phaseolus vulgaris* (common bean), *Pisum sativum* (pea), Trifolium, **Geraniaceae** - *Pelargonium* (geranium), **Gesneriaceae** - *Aeschynanthus*, **Lamiaceae** - *Marrubium* (horehound), *Plectranthus* spp., *Salvia*, **Malvaceae** - *Gossypium herbaceum* (short staple cotton), *Gossypium* spp. (cotton), **Moraceae** - *Ficus*, **Musaceae** - *Musa acuminata* (banana), **Poaceae** - *Zea mays* (corn), **Rosaceae** - *Fragaria* (strawberry), **Solanaceae** - *Capsicum annuum* (bell pepper), *Solanum habrochaites* (a wild tomato), *Solanum lycopersicum* (tomato), *Solanum nigrum* (black nightshade), *Solanum pennellii* (a wild tomato), *Datura stramonium* L. (datura), *Nicotiana tabacum* (tobacco), *Solanum tuberosum* (potato), **Urticaceae** - *Parietaria* spp., *Urtica* spp. (Alvarado, 2009; Avidov and Harpaz, 1969; CABI, 2013; Garzia et al., 2003; Hill, 1983,

1987; Ippolito and Parenzan, 1985; Jatinder and Gurdip, 1998; Juvik et al., 1982; Lecheva and Loginova, 1988; Polaszek et al., 2012; Rabindra et al., 1975; Sannino et al., 1991; Sannino et al., 2005; Sukhpalvir et al., 2003; Taylor, 1980; Taylor and Kunjeku, 1983; Tremblay, 1972; Triggiani, 1969; Urbaneja et al., 2002; Weaving, 1969; Zandigiacomo, 1990; Zhang, 1994; Zümroeglu and Akbulut, 1987).

For all the above listed host plants, we found either multiple reports of them being hosts or reports of *C. chalcites* larvae feeding on or causing damage to them. According to CABI (2013), its main hosts are soybean, short staple cotton, tobacco, beans, common bean, tomato, and potato. It shows a particular preference for tomatoes (Hächler et al., 1998). Banana is a significant host as well (Polaszek et al., 2012).

The above host list is very likely not comprehensive. For instance, CABI (2013) states that its hosts also include plants in the families Acanthaceae, Bignoniaceae, Convolvulaceae, Crassulaceae, Orchidaceae, Scrophulariaceae, and Violaceae. CABI (2013) lists additional plants as hosts [e.g., *Citrus*, *Triticum aestivum* (wheat)], but because we found no other reports of such plants being hosts and CABI provides no original source reference to verify this information, we did not include such plants in the list above. These plants may very well be hosts, but maybe only occasional or poor hosts. Of note, we did find one report of *C. chalcites* attacking wheat, but this information was from the Philippines (Hasan and Cervancia, 1986), and literature referring to *C. chalcites* in southern or eastern Asia or Oceania is thought to actually refer to the closely related species *C. eriosoma* (Zhang, 1994).

Potential pathways of introduction: *Chrysodeixis chalcites* could likely be introduced to the continental United States through natural dispersal from Canada, as there is evidence of adults migrating long distances (i.e., between countries) (CABI, 2013; Palmqvist, 1998; Sparks et al., 2007; Spitzer and Jaros, 2004).

The moth could also be introduced through trade because the larvae of this species can travel easily on host material moved through international trade (CABI, 2013). Based on interception data (see below), its biology, current permitted imports into the United States, and current volumes of those imports (see below), potential pathways into the country include imports of cut flowers and plants for propagation (Q37) of its host genera, and certain fruits and vegetables for consumption (Q56) (e.g., tomato and pepper fruit, green beans, leafy vegetables). Based on interception data (see below) and its biology/host preferences, peppers and especially tomato fruit appear to present more likely pathways compared to other Q56 material. With very few exceptions, these plant products (cut flower, Q37, and Q56) are permitted entry into the United States from countries that have *C. chalcites* without phytosanitary measures beyond inspection that specifically target this species (APHIS, 2013a; PPQ, 2013a, 2013b, 2013d). However, we noted that in 2009 restrictions were put in place to mitigate *Tuta absoluta* (Lepidoptera: Gelechiidae) in tomato imports from many of the Old World countries that have *C. chalcites* (Bech, 2012); since that time, there has only been one interception of *C. chalcites* in tomatoes (PestID, 2013). It is likely that the measures for *T. absoluta* (pest exclusionary structures, etc.) are also mitigating *C. chalcites* in tomatoes from those countries. Also, although the above imports represent potential means of introduction, *C. chalcites* feeds externally on its hosts and can cause obvious damage symptoms (Anonymous, 2013b; CABI, 2013; Hächler et al., 1998), thereby decreasing its likelihood of being in these pathways, some more than others depending on postharvest processing, morphology of the commodity, and other factors.

Tomato imports (fruits and plants for planting) from Canada, especially southern Ontario where *C. chalcites* has been detected in tomato production, may represent an important pathway of introduction. U.S. imports of tomatoes from Canada during the most recent five years (CY2008-12) averaged nearly 100,000 metric tons (FAS, 2013). In 2012, $4.4 million (4,624 tons) worth of field tomatoes, a large proportion of which likely originated from southern Ontario (Arbuckle, 2013), and over $293 million (145,994 tons) worth of greenhouse grown tomatoes (GTIS, 2013) were shipped from Canada to the United States. In the last ten years, over 3 million tomato plants for planting were imported from

Canada (APHIS, 2013c). Other imports from Canada could be pathways as well. There have been shipments of many host commodities in the last ten years, such as cabbage (4,899 shipments), tomatoes (4,458), peppers (3,284), lettuce (3,137), and green beans (1,380); plus cut flowers and plants for propagation of multiple host genera (e.g., *Chrysanthemum*, *Ficus*, *Pelargonium*, *Solanum*) (APHIS, 2013c). The area in Ontario where most *C. chalcites* detections were made (Leamington) is the "tomato capital" of Canada; this area has the largest number of greenhouses in all of North America, with tomatoes being the most important crop, and cucumbers and peppers also significant in the area (Awad, 2013). So far, however, *C. chalcites* has not been intercepted in any products from Canada (PestID, 2013; queried 4/16/2013).

Interception data: At U.S. ports of entry since 1985, *C. chalcites* has been intercepted 316 times, most interceptions being in permit cargo (254) (PestID, 2013; queried 4/16/2013). Of the permit cargo interceptions, there were 160 interceptions with cut flowers of many different genera, 76 with fruit for consumption (mainly tomatoes and peppers), and three interceptions in propagative material (*Solanum lycopersicum* and *Pelargonium* sp.) (PestID, 2013; queried 4/16/2013). Other countries have reported its larvae on *Pelargonium*, *Chrysanthemum*, and banana fruit in trade (CABI, 2013; Carter, 1984), and in 1995 it was found on imported *Pelargonium* cuttings in greenhouses in multiple U.S. states (Havens, 1995). Despite the fact that commodities such as cabbage, lettuce, and green beans are permitted entry from countries that have this pest (APHIS, 2013a), there have been only two interceptions with lettuce and none with other Q56 commodities at U.S. ports of entry (PestID, 2013). This higher interception rate in tomatoes and peppers compared to other Q56 commodities may, in part at least, be a result of the substantially higher import volumes of tomatoes and peppers from countries in the Old World that have *C. chalcites* (APHIS, 2013c).

Potential distribution in the United States and spread: Based on a recently prepared risk map (Christie and Borchert, 2013), the estimated area of the United States at risk of potential permanent (i.e., with overwintering ability) population establishment includes a large majority of the southern half of the country plus a small area of the Pacific Northwest (Figure 1). This map is based on availability of hosts and suitable climate; it includes the exclusion layer of 2.5ºC for 60 days and the climate suitability based on the average output of five generations. Areas excluded from Figure 1 could, however, see the occurrence of temporary populations through migrations (Christie and Borchert, 2013). Therefore, a second Risk map with no temperature exclusions (Figure 2) gives an estimate of risk for both permanent and seasonal migratory populations. This species could also establish in areas with unfavorable climates by establishing in greenhouses as it has done in parts of northern Europe (CABI, 2013; De Vos and Rutten, 1995). In addition to natural spread through flight, the pest could likely spread through domestic trade of its host plants and plant products.

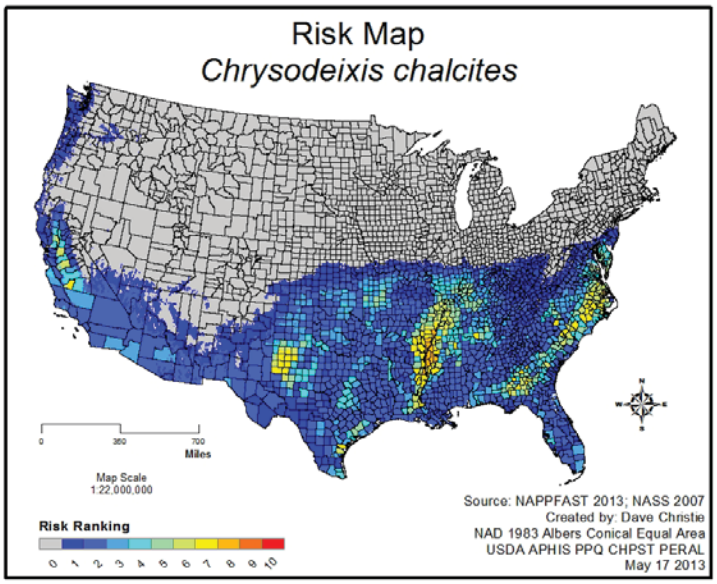

Figure 1. Risk map showing the overall risk of permanent (i.e., with overwintering ability) population establishment of *Chrysodeixis chalcites* in the continental United States based on availability of hosts and suitable climate (using an exclusion layer of 2.5ºC for 60 days). Note: Excluded areas could see the occurrence of temporary populations through migrations (source: Christie and Borchert, 2013).

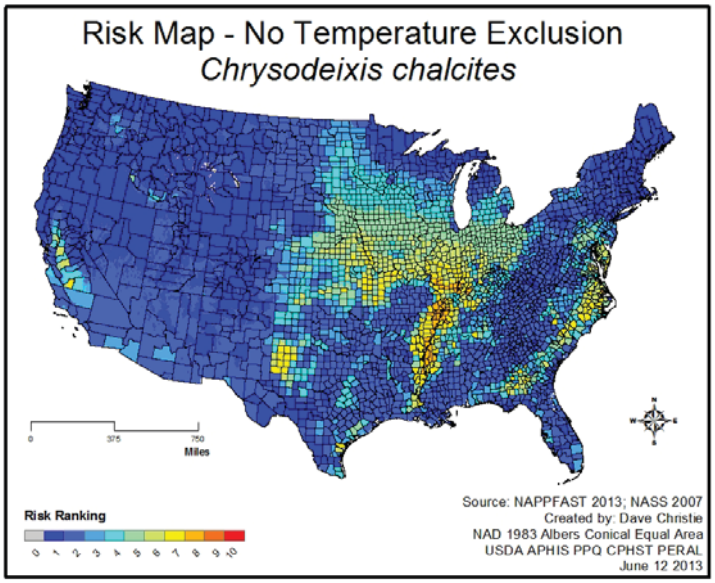

Figure 2. Risk map showing the overall risk of both permanent (i.e., with overwintering ability) and seasonal migratory populations of *Chrysodeixis chalcites* in the continental United States based on availability of hosts and suitable climate (no temperature exclusion included) (source: Christie and Borchert, 2013).

Detection and control: The CAPS datasheet on this species, available online, provides detailed descriptions and photos of the different life stages (CPHST, 2013). Signs and symptoms of the pest's presence include: skeletonized leaves, rolled or folded leaves, webbing, frass, presence of larvae on upper or lower surfaces of leaves, and damaged fruit/pods (CABI, 2013). The first-instar larvae can be difficult to detect compared to the other signs/symptoms (CABI, 2013). The CAPS-approved survey method is a trap and lure combination using the product "*Chrysodeixis chalcites* Lure"; details on the

lure, survey site selection, trap placement etc. are provided in the CAPS datasheet (CPHST, 2013). This lure contains 1 mg of Z-7-dodecenyl acetate and 0.2 mg each of Z-9-tetradecenyl acetate and Z-9-dodecenyl acetate (Lance, 2013). In Ontario, Canada, adults of this species were collected from universal moth traps baited with pheromone lures for *Trichoplusia ni*, but the large majority of detections were of larvae collected from host plants and reared in a growth chamber to the adult stage (Murillo et al., 2013). *Chrysodeixis chalcites* (both adult and immature stages) cannot be distinguished morphologically from the closely related species *C. eriosoma*; molecular analysis is needed to distinguish these two species (CPHST, 2013). *Chrysodeixis chalcites* could be confused with the soybean looper, *Chrysodeixis includens* (Brambila and Passoa, 2013; Passoa, 1995b), which is widely distributed in the United States and has many of the same hosts as *C. chalcites* (CABI, 2013). Also, the CAPS-approved lure can attract both *C. includens* and *C. eriosoma* (Mastro, 2013). However, adults of *C. chalcites/eriosoma* can be distinguished from *C. includens* morphologically using differences in the male genitalia (Brambila and Passoa, 2013; Floyd, 2013b); therefore, suspect larvae can be reared to adulthood to confirm their identity as either *C. chalcites/eriosoma* or *C. includens*.

Control measures for *C. chalcites* have included use of chemical pesticides (e.g., pyrethroids, indoxacarb, endosulfan, cyromazine) (CABI, 2013) and the biopesticide *Bacillus thuringiensis* (Daricheva et al., 1983; Taylor, 1980; Vacante et al., 2001), field monitoring and use of economic thresholds to determine efficient spray programs (Lapointe et al., 1995), preserving natural enemies (as part of an IPM program) (Garzia et al., 2003), use of naturally occurring nuclear polyhedrosis virus (Taylor, 1980), and keeping greenhouses free of weeds (Daricheva et al., 1983). Such pest management practices are already used in the United States for noctuid loopers (e.g., *C. includens* and *Trichoplusia ni*) and other Lepidoptera pests in the crops of concern in the United States (e.g., Capinera, 2001, 2005; CIPM, 2013; Zalom, 2012). *Bacillus thuringiensis* gave 100% control of *C. chalcites* in greenhouse tomatoes (Vacante et al., 2001) and reduction of larval populations to below the economic threshold in field tomatoes (Broza and Sneh, 1994). In Canada, *C. chalcites* was eradicated from a greenhouse using *B. thuringiensis* in 2006 (Arbuckle, 2013). Biocontrol using natural enemies (parasitoids, predators) has been investigated, but is not yet commercially available (Polaszek et al., 2012). For instance, a study with *Trichogramma evanescens* in greenhouse tomato resulted in 82% parasitism of eggs (Pizzol et al., 1997). The predatory stinkbugs *Podisus maculiventris* and *Podisus nigrispinus* show high potential for control in greenhouses (De Clercq et al., 1998). In Israel, research to develop resistant tomato cultivars found three tomato accessions with significant reduction in pest survival (Juvik et al., 1982). Resistance to some pesticides has been recorded (De Clercq et al., 1998; Polaszek et al., 2012).

Potential economic impacts: The crops/production systems on which *C. chalcites* is a pest (see evidence under "known pest status") are economically significant in the continental United States, including those on which it is reported as a major pest: tomatoes (field and greenhouse), soybeans, and bananas. Except for bananas, economic hosts have wide cultivation in the continental United States (CIPM, 2013; Geisler, 2011; NASS, 2009). Greenhouse tomatoes account for close to 40% of U.S. fresh tomatoes (Cook and Calvin, 2005). This insect could have impact by affecting the yield and/or cost of production of these hosts, although the extent of those impacts are unknown. These impacts will likely be mitigated by the fact that viable management options exist and are used in the United States for similar pests on potential hosts.

Trade implications: *Chrysodeixis chalcites* is a regulated pest for Costa Rica, Japan, the Republic of Korea (APHIS, 2013b), and South Africa (EPPO, 2013). The United States exports commodities that could potentially be a pathway for *C. chalcites* to these countries [e.g., tomatoes to Japan and Korea, cabbage lettuce to Japan and Korea, cut flowers to Japan and Costa Rica (GTIS, 2013)]. However, we did not find evidence that any foreign countries restrict commodities or require specific phytosanitary measures because of the presence of *C. chalcites* or other species of *Chrysodeixis*. Therefore, impacts on exports might be minimal.

Potential environmental impacts: Species currently listed as threatened or endangered in the continental United States that may be affected by presence of *C. chalcites* include: *Cucurbita*

okeechobeensis ssp. *okeechobeensis* (FL), *Helianthus paradoxus* (NM, TX), *H. schweinitzii* (NC, SC), *Trifolium trichocalyx* and *T. amoenum* (CA), and *T. stoloniferum* (many states) (USFWS, 2012). However, we found no evidence of *C. chalcites* causing environmental impacts where it occurs. Some reported natural enemies of *C. chalcites* occur already in the United States [e.g., *Copidosoma truncatellum* (Encyrtidae), *Cotesia marginiventris* (Braconidae) (CABI, 2013; Tingle et al., 1994)]. Generalist predators (lady beetles, etc.) would likely contribute to its control as well. Although chemical pesticides are part of the typical ways to control this pest in crops, pesticide practices currently used for other Lepidoptera pests are likely to be effective against this species, thereby decreasing additional environmental impacts that may occur from its introduction.

NPAG teleconferences: NPAG held a teleconference on June 24, 2013 regarding the recommendation relating to molecular identification (NPAG, 2013). Participants were: Robert Bailey (PPQ-FO), Norman Barr (PPQ-CPHST-Mission Lab), Philip Berger (PPQ-CPHST Director Office), Julieta Brambila (PPQ-FO), Russ Bulluck (PPQ- CPHST Director Office), Joel Floyd (PPQ-NIS), Tara Holtz (PPQ-CPHST-PERAL), Deborah McPartlan (PPQ-PHP-PDEM) , Leah Millar (PPQ-CPHST-PERAL), Talitha Molet (CPHST Director Office), Steven Passoa (PPQ-NIS), David Prokrym (NPAG), and Esther Spaltenstein (NCSU-CIPM).

Current regulatory response and activities: Since 1995, *C. chalcites* has been a CAPS survey pest with active survey in multiple U.S. states (i.e., AR, CT, DE, GA, IN, KS, KY, MA, NH, NJ, NY, ND, OH, OR, SC, SD, WV, WI, WY), but it has not recently been surveyed in NY and never in MI (Floyd, 2013a). It has mostly been surveyed on soybeans and a little in other crops (e.g., corn, greenhouse geraniums), but only once in tomato (Jackson, 2013). It has been a CAPS priority pest and has been offered for survey as part of the Soybean Commodity-based Survey Guidelines (for years 2008 through 2014) and the Solanaceous Crops Commodity-based Survey Guidelines (for 2014) (CAPS, 2013). For the 2013 season, PPQ encouraged states (in particular NY, MI, and OH) to survey for this pest in one or more of its host crops through surveys funded by both the CAPS program and the Farm Bill (Jackson, 2013). IN, KY, MD, MN, TN, and PA will survey for *C. chalcites* during the 2013 survey season. As of May 24, 2013, we do not yet have finalized information for NY and OH (Jackson, 2013). Michigan is planning to survey Wayne and Monroe counties in 2013 (Floyd, 2013b). NIS tried to obtain the specimens from the possible find in 2010 of *C. chalcites* in Monroe County, MI to enable confirmation of this find, but they were told that the specimens were no longer available (NPAG, 2013); NIS notified Michigan State University extension of this find and recommended to the Michigan SPHD that this area be surveyed in 2013 (Floyd, 2013b). NIS has submitted Hawaiian *C. eriosoma* material to Canada (Chris Schmidt, Canadian Food Inspection Agency) to help with their molecular work on distinguishing *C. chalcites* versus *C. eriosoma* (Floyd, 2013b). NIS has prepared a CAPS field screening/diagnostic aid document (Brambila and Passoa, 2013).

Need for new technology or knowledge:

- Molecular method to identify *Chrysodeixis* (*chalcites* or *eriosoma*) specimens to the species level. Canadian researchers state that they have *C. chalcites* in Canada based on molecular work (Lafontaine and Schmidt, 2013; Murillo et al., 2013), but no evidence was found that their molecular data has been published (Barr, 2013).
- Determination of the presence (and distribution, if present) of *C. chalcites* in the United States
- Knowledge of whether *C. chalcites* is in the pathway of host material imports from Canada
- Knowledge of whether greenhouse production can be a source of field populations

National Plant Board consultation: None

The following technical recommendations are based on the best available science at the time of the report completion and are intended to be used as an aid in PPQ decision-making.

NPAG Recommended PPQ Port Policy: NPAG recommends no change in PPQ port policy regarding *Chrysodeixis chalcites*, retain as reportable/actionable.

Recommendations:

1. NPAG recommends no change in PPQ port policy regarding *Chrysodeixis chalcites*, retain as reportable/actionable because this insect is not known to occur in the United States and it is an important pest of multiple economically significant U.S. crops and ornamental plants. **Action Leader: Joe Cavey (PPQ-PHP-NIS)**
2. NPAG recommends that the CPHST Mission Laboratory collaborate with the Canadian researchers to verify molecular work developed to distinguish *C. chalcites* from *C. eriosoma*. NPAG also recommends that the Mission Laboratory prepare for the ability to confirm, via molecular analysis, the species identity of the first suspect *C. chalcites*/*eriosoma* specimen(s) that may be detected in the United States. **Action Leaders: Matt Ciomperlik and Norman Barr (PPQ-CPHST Mission Lab)**
3. NPAG recommends that PPQ-NIS add the cabbage looper (*Trichoplusia ni*) and soybean looper (*Chrysodeixis includens*) as non-targets (i.e., moths that are very similar to *C. chalcites*) to the CAPS field screening/diagnostic aid document for *Chrysodeixis chalcites* to allow for more accurate sorting of suspect samples. **Action Leader: Joel Floyd (PPQ-PHP-NIS)**
4. NPAG recommends that PPQ prepare an NPAG Notice on *Chrysodeixis chalcites* for distribution to U.S. states. **Action Leaders: Tara Holtz (PPQ-CPHST-PERAL) and Robert Bailey (PPQ-FO)**
5. NPAG recommends that PPQ work with Canada to gather and share information about this pest, particularly about the presence in both countries. In particular, PPQ should inquire if Canada has implemented trapping programs, and if so, what specific lures are being used for *Chrysodeixis chalcites*, and if they have collected any *C. chalcites* from greenhouses. **Action Leader: Terri Dunahay (PPQ-PIM)**
6. NPAG recommends a re-evaluation of PPQ policy and activities for *Chrysodeixis chalcites* in one to three years based on any new interception and detection data, or lack thereof, at that time. **Action Leader: David Prokrym (PPQ-CPHST-PERAL)**

Direct referral to: Joe Cavey (PPQ-PHP-NIS), Matt Ciomperlik (PPQ-CPHST Mission Lab), Norman Barr (PPQ-CPHST Mission Lab), Joel Floyd (PPQ-PHP-NIS), Tara Holtz (PPQ-CPHST-PERAL), Robert Bailey (PPQ-FO), Terri Dunahay (PPQ-PIM), David Prokrym (PPQ-CPHST-PERAL).

References:

7 CFR § 319.37. 2013. U.S. Code of Federal Regulations, Title 7, Part 319 (7 CFR § 319.37 - Plants for Planting).

AAFC. 2006. Crop Profile for Greenhouse Tomato in Canada. Agriculture and Agri-Food Canada (AAFC), Pesticide Risk Reduction Program, Pest Management Centre, Ottawa. 46 pp.

Alvarado, A. P. 2009. Contribution to the knowledge of Lepidoptera that can affect strawberry cultivation. Description, behaviour and relative importance. Agricola Vergel: Fruticultura, Horticultura, Floricultura 28(324):28-36.

Amate, J., P. Barranco, and T. Cabello. 1998. Ciclo vital de *Chrysodeixis chalcites* (Esper) (Lepidoptera: Noctuidae) en condiciones controladas. Bol. San. Veg. Plagas 24:425-428.

Anonymous. 2013a. Growing Tomatoes 101. Thomas Canning (Maidstone) Ltd., Maidstone, Ontario, Canda. Last accessed May 31, 2013, http://www.thomascanning.com/sus_production.html.

Anonymous. 2013b. Lagarta de la plantenera (*Chrysodeixis chalcites*). Phtyoma: La Revista Profesional de Sanidad Vegetal. Last accessed May 21, 2013, http://www.phytoma.com/detalles_aviso.php?id=228&referer=avisos&FiltroAnyo=&FiltroMes=&FiltroCultivo=&FiltroPalabras=Chrysodeixis.

APHIS. 2013a. Fruits and Vegetables Import Requirements (FAVIR) Database. United States Department of Agriculture, Animal and Plant Health Inspection Service (APHIS). https://epermits.aphis.usda.gov/manual/index.cfm?ACTION=pubHome. (Archived at PERAL).

APHIS. 2013b. Phytosanitary Certificate Issuance and Tracking System (PCIT). United States Department of Agriculture, Animal and Plant Health Inspection Service (APHIS). https://pcit.aphis.usda.gov/pcit/faces/index.jsp. (Archived at PERAL).

APHIS. 2013c. PPQ280 (cargo shipments) database. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (APHIS). https://mokcs14.aphis.usda.gov/aqas/login.jsp. (Archived at PERAL).

Arbuckle, H. 2013. *Chrysodeixis chalcites*. Personal communication to Terri Dunahay (Plant Health Trade Director - USDA APHIS PPQ PIM) on March 12, 2013, from Heather Arbuckle (National Manager, Horticultural Commodities, Canadian Food Inspection Agency). Archived at the PERAL Library, Raleigh, NC.

Avidov, Z., and I. Harpaz. 1969. Plant pests of Israel. Israel Universities Press, Jerusalem. 549 pp.

Awad, S. 2013. Where is the Greenhouse Capital of North America? GreenhouseGab.com. Last accessed June 3, 2013, http://greenhousegab.com/2013/01/08/where-is-the-greenhouse-capital-of-north-america/.

Barr, N. 2013. Email regarding *Chrysodeixis chalcites*. Personal communication to Leah Millar on June 19, 2013, from N. Barr (Molecular Biologist, USDA APHIS PPQ CPHST Mission Laboratory). Archived at the PERAL Library, Raleigh, NC.

Bech, R. A. 2012. Federal Import Quarantine Order for Host Materials of Tomato Leafminer, *Tuta absoluta* (DA-2012-21). United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine. Last accessed May 22, 2013, http://www.aphis.usda.gov/import_export/plants/plant_imports/federal_order/downloads/2012/DA-2012-21.pdf.

Brambila, J., and S. Passoa. 2013. *Chrysodeixis chalcites*, Golden Twin Spot Moth: Field Screening Aid. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine. Last accessed June 12, 2013, http://caps.ceris.purdue.edu/webfm_send/2126.

Broza, M., and B. Sneh. 1994. *Bacillus thuringiensis* spp. *kurstaki* as an effective control agent of lepidopteran pests in tomato fields in Israel. Journal of Economic Entomology 87(4):923-928.

CABI. 2013. Crop Protection Compendium. Commonwealth Agricultural Bureau International (CABI). http://www.cabi.org/cpc/. (Archived at PERAL).

Capinera, J. L. 2001. Handbook of Vegetable Pests. Academic Press, San Diego. xviii+729 pp.

Capinera, J. L. 2005. Featured Creatures: *Trichoplusia ni*. University of Florida, Institute of Food and Agricultural Sciences. Last accessed May 30, 2013, http://entnemdept.ufl.edu/creatures/veg/leaf/cabbage_looper.htm.

CAPS. 2013. Priority Pest List for 2014: Commodity and Taxonomic Surveys (Appendix G-1). Cooperative Agricultural Pest Survey (CAPS). Last accessed May 23, 2013, http://caps.ceris.purdue.edu/guidelines/2014/apdx_g1.

Carter, D. J. 1984. Pest Lepidoptera of Europe with Special Reference to the British Isles. Dr. W. Junk Publishers, Dordrecht, and the Trustees of the British Museum (Natural History), London. 431 pp.

Christie, D., and D. M. Borchert. 2013. *Chrysodeixis chalcites* risk map (internal report). Version 1. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Center for Plant Health Science and Technology, Plant Epidemiology and Risk Analysis Laboratory Raleigh, NC. 8 pp.

CIPM. 2013. USDA Crop Profiles. North Carolina State University, Center for Integrated Pest Management (CIPM). http://www.ipmcenters.org/cropprofiles/CP_form.cfm. (Archived at PERAL).

Cook, R., and L. Calvin. 2005. Greenhouse Tomatoes Change the Dynamics of the North American Fresh Tomato Industry (Economic Research Report Number 2). United States Department of Agriculture, Economic Research Service. 86 pp.

Cousins, S. 1995. New Pest Advisory Group (NPAG) - Recommendations on a new pest, *Chrysodeixis chalcites* (tomato looper). Personal communication to PPQ Regional Directors and State Plant

Health Directors on January 27, 1995, from Sidney Cousins (USDA-APHIS-PPQ-NPAG). Archived at the PERAL Library, Raleigh, NC.
CPHST. 2013. Pest Datasheet for the Cooperative Agriculture Pest Survey (CAPS): *Chrysodeixis chalcites*. USDA-APHIS Plant Protection and Quarantine, Center for Plant Health Science and Technology, Raleigh, NC. Last accessed July 1, 2013, http://caps.ceris.purdue.edu/webfm_send/2046.
Daricheva, M. A., Z. F. Klyuchko, and A. Sakchiev. 1983. A pest of tomatoes. Zashchita-Rasteni (7):44-45.
De Clercq, P., F. Merlevede, I. Mestdagh, K. Vandendurpel, J. Mohaghegh, and D. Degheele. 1998. Predation on the tomato looper *Chrysodeixis chalcites* (Esper) (Lep., Noctuidae) by *Podisus maculiventris* (Say) and *Podisus nigrispinus* (Dallas) (Het., Pentatomidae). Journal of Applied Entomology 122(2-3):93-98.
De Vos, R., and A. L. Rutten. 1995. Migrating Lepidoptera in 1992 (fifty-third report). Entomologische berichten (amsterdam) 55(3):37-46.
EPPO. 2013. PQR - EPPO's Plant Quarantine Data Retrieval System Version 5.0. European and Mediterranean Plant Protection Organization (EPPO), Paris, France.
FAS. 2013. Global Agricultural Trade System (GATS). United States Department of Agriculture, Foreign Agricultural Service (FAS). http://www.fas.usda.gov/gats/default.aspx. (Archived at PERAL).
Floyd, J. 2013a. Email regarding *Chrysodeixis chalcites*. Personal communication to T. Dunahay on May 13, 2013, from J. Floyd (Domestic Diagnostics Coordinator, USDA APHIS PPQ National Identification Services). Archived at the PERAL Library, Raleigh, NC.
Floyd, J. 2013b. Emails regarding *Chrysodeixis chalcites*. Personal communication to Leah Millar on May 10, 2013, from J. Floyd (Domestic Diagnostics Coordinator, USDA APHIS PPQ National Identification Services). Archived at the PERAL Library, Raleigh, NC.
Floyd, J. 2013c. RE: *Chrysodeixis chalcites* in Canada. Personal communication to Christie Bertone on February 7, 2013, from J. Floyd (Domestic Diagnostics Coordinator, USDA APHIS PPQ National Identification Services). Archived at the PERAL Library, Raleigh, NC.
Garzia, G. T., G. Siscaro, G. L. Malfa, V. Lipari, G. Noto, and C. Leonardi. 2003. Notes on natural enemies of armyworms infesting tomato protected crops in South-Eastern Sicily. Acta Horticulturae (614(Vol 2)):837-841.
GBIF. 2013. GBIF, Online Database. Global Biodiversity Information Facility (GBIF). http://data.gbif.org/welcome.htm. (Archived at PERAL).
Geisler, M. 2011. Floriculture Profile. Iowa State University, Agricultural Marketing Resource Center.
GTIS. 2013. Global Trade Atlas. Global Trade Information Services, Inc. http://www.gtis.com/gta/. (Archived at PERAL).
Hächler, M., M. Jermini, and R. Brunetti. 1998. Two new harmful noctuids on tomatoes in glasshouse in South and Western Switzerland. Revue suisse de viticulture, d'arboriculture et d'horticulture 30(5):281-285.
Harakly, F. A., and S. S. Farag. 1975. Biological studies on the tomato looper *Chrysodeixis chalcytes* (Esper) in Egypt. Bulletin de la Societe Entomologique d'Egypte 59:295-299.
Hasan, N., and C. R. Cervancia. 1986. Insect pest colonization and succession in wheat, *Triticum aestivum* L. Philippine Entomologist 6(6):581-587.
Havens, C. 1995. Update on *Helicoverpa armigera* and *Chrysodeixis chalcites* activities (DA#95-07). Personal communication to State and Territory Agricultural Regulatory Officials on April 26, 1995, from Chuck Havens (USDA-APHIS-PPQ). Archived at the PERAL Library, Raleigh, NC.
Hill, D. S. 1983. Agricultural insect pests of the tropics and their control. Cambridge University Press, New York, NY. xii+ 746 pp.
Hill, D. S. 1987. Agricultural insect pests of temperate regions and their control. Cambridge University Press, New York, NY. 659 pp.
Holloway, J. D., J. D. Bradley, and D. J. Carter. 1987. CIE Guides to Insects of Importance to Man: 1 Lepidoptera. CAB International Oxon, UK. 262 pp.
Ippolito, R., and P. Parenzan. 1985. *Hoplodrina ambigua* D. & S. (Lepidoptera - Noctuidae) and other noctuids on artichoke in Apulia. Entomologica 20:147-158.
Jackson, L. 2013. Emails regarding *Chrysodeixis chalcites*. Personal communication to Leah Millar on March 14 and 26, and May 24, 2013, from L. Jackson (Biological Scientist, USDA APHIS PPQ CPHST). Archived at the PERAL Library, Raleigh, NC.

Jatinder, S., and S. Gurdip. 1998. First record of *Chrysodeixis chalcites* (Esper) on sunflower in Punjab [Abstract]. Insect Environment 3(4):104-105.

Juvik, J. A., T. Ben-David, J. Rudich, and M. J. Berlinger. 1982. Resistance among accessions of the genera *Lycopersicon* and *Solanum* to four of the main insect pests of tomato in Israel. Phytoparasitica 10(3):145-156.

Lafontaine, J. D., and C. Schmidt. 2013. Additions and corrections to the check list of the Noctuoidea (Insecta, Lepidoptera) of North America north of Mexico. ZooKeys 264:227-236.

Lance, D. 2013. FW: *Chrysodeixis chalcites* follow up from NPAG teleconference. Personal communication to Russ Bulluck on June 28, 2013, from D. Lance (USDA APHIS PPQ CPHST Otis Lab). Archived at the PERAL Library, Raleigh, NC.

Lapointe, R., D. P. Giga, R. K. Stewart, and J. Ganhao. 1995. Determination of economic thresholds for semiloopers (Lepidoptera: Noctuidae) on four soyabean cultivars in Zimbabwe. African Entomology 3(1):13-22.

Lecheva, I., and E. Loginova. 1988. *Plusia chalcites* - a pest of glasshouse crops in Bulgaria. Rasteniev"dni nauki 25(10):87-94.

Mastro, V. 2013. FW: *Chrysodeixis chalcites* follow up from NPAG teleconference. Personal communication to Russ Bulluck on June 28, 2013, from V. Mastro (USDA APHIS PPQ CPHST Otis Lab). Archived at the PERAL Library, Raleigh, NC.

Murillo, H., D. W. A. Hunt, and S. L. VanLaerhoven. 2013. First records of *Chrysodeixis chalcites* (Lepidoptera: Noctuidae: Plusiinae) for east-central Canada (DOI:10.4039/tce.2012.106.). The Canadian Entomologist / FirstView Articles 145:1-5.

NASS. 2009. 2007 Census of Agriculture: United States Summary and State Data, Volume 1, Geographic Area Series, Part 51 (AC-07-A-51). United States Department of Agriculture, National Agricultural Statistics Service (NASS), Washington, D.C. 739 pp.

NPAG. 1995. NPAG Data: *Chrysodeixis chalcites*, Golden Twin Spot. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, New Pest Advisory Group (NPAG). 7 pp.

NPAG. 2013. NPAG Teleconference Minutes June 24, 2013: *Chrysodeixis chalcites* (Esper). United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, New Pest Advisory Group (NPAG). 3 pp.

Palmqvist, G. 1998. Remarkable records of Macrolepidoptera in Sweden 1997. Entomologisk tidskrift 119(1):13-27.

Passoa, S. 1995a. *Chrysodeixis chalcites* (Esper). PPQ Fact Sheet 35. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (PPQ).

Passoa, S. 1995b. Pest Alert: *Chrysodeixis chalcites* (Esper). United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine.

Passoa, S. C. 2006. RE: *Chrysodeixis chalcites* - Golden Twin Spot. Personal communication to J. Cavey on November 27, 2006, from S. Passoa (USDA APHIS PPQ National Identification Services). Archived at the PERAL Library, Raleigh, NC.

PestID. 2013. Pest Identification Database (PestID). United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine. https://aqas.aphis.usda.gov/aqas/. (Archived at PERAL).

Pizzol, J., J. Voegele, and A. Marconi. 1997. Efficiency of *Trichogramma evanescens* against *Chrysodeixis chalcites* (Lep., Noctuidae) in greenhouses on tomato crops [Abstract]. International conference on pests in agriculture, 6-8 january 1997, at le corum, montpellier, france. volume 3:751-757.

Polaszek, A., P. F. Rugman-Jones, R. Stouthamer, E. Hernandez-Suarez, M. del Pino Pérez, and T. Cabello. 2012. Molecular and morphological diagnoses of five species of *Trichogramma*: Biological control agents of *Chrysodeixis chalcites* (Lepidoptera: Noctuidae) and *Tuta absoluta* (Lepidoptera: Gelechiidae) in the Canary Islands. BioControl 57(1):21-35.

PPQ. 2013a. Canadian Border Agricultural Clearance Manual. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (PPQ). 164 pp.

PPQ. 2013b. Cut flowers and greenery import manual. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (PPQ). 166 pp.

PPQ. 2013c. PestLens Notification: First report of the golden twin spot moth, *Chrysodeixis chalcites* (Lepidoptera: Noctuidae), in Ontario, Canada. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (PPQ).

PPQ. 2013d. Plants for Planting Manual. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (PPQ). 628 pp.

Rabindra, R. J., A. V. Paul, B. V. David, and T. R. Subramaniam. 1975. On the nuclear polyhedrosis of *Plusia chalcytes* Esp. (Lepidoptera: Noctuidae). Current Science 44(8):273-274.

Sannino, L., A. Balbiani, and B. Espinosa. 1991. Comparative morphological study on the immature stages of the Lepidoptera tobacco pests: 1. Cocoons and pupae (Second Part: Pupae) [Abstract]. Memorie della societa entomologica italiana 70(2):251-266.

Sannino, L., B. Espinosa, S. Vicidomini, F. Rotellini, and G. Caricato. 2005. *Chrysodeixis chalcites* (Esper) harmful to greenhouse ornamental plants. Informatore Fitopatologico 55(9):34-37.

Sparks, T. H., R. L. H. Dennis, P. J. Croxton, and M. Cade. 2007. Increased migration of Lepidoptera linked to climate change. European journal of entomology 104(1):139-143.

Spitzer, K., and J. Jaros. 2004. Mass migration of *Chrysodeixis chalcites* (Esper, 1789) in Tenerife, Canary Islands (Lepidoptera: Noctuidae). Revista de lepidopterologyst 32(125):19-22.

Sukhpalvir, S., S. Gurdip, and R. K. Bajaj. 2003. Incidence of semilooper, *Chrysodeixis chalcites* (Esper) on different hybrids of sunflower at Ludhiana [Abstract]. Insect Environment 9(4):188-190.

Taylor, D. E. 1980. Soyabean semi-loopers. Zimbabwe agricultural journal 77(3):111-112.

Taylor, D. E., and E. Kunjeku. 1983. Development of an economic threshold for semi-loopers (Lepidoptera: Noctuidae) on soya-beans in Zimbabwe [Abstract]. Zimbabwe journal of agricultural research 21(1):89-100.

Tingle, F. C., E. R. Mitchell, and J. R. McLaughlin. 1994. Lepidopterous pests of cotton and their parasitoids in a double-cropping environment. Florida Entomologist 77(3):334-341.

Tremblay, E. 1972. Notes on the overwintering of several species of Noctuid and Tortricid moths [Abstract]. Bollettino del laboratorio di entomologia agraria 'filippo silvestri' portici 30:117-130.

Triggiani, O. 1969. Infestation of *P. chalcites* on French beans grown in the greenhouse [Abstract]. Entomologica 5:69-77.

Urbaneja, A., J. van der Blom, L. Lara, R. Timmer, and K. Blockmans. 2002. Use of *Cotesia marginiventris* (Cresson) (Hym.: Braconidae) for the biological control of noctuids (Lep.: Noctuidae) in integrated pest management of protected sweet pepper [Abstract]. Boletin de sanidad vegetal plagas 28(2):239-250.

USFWS. 2012. Threatened and endangered species system (TESS). United States Fish and Wildlife Service (USFWS). http://ecos.fws.gov/tess_public/pub/listedPlants.jsp. (Archived at PERAL).

Vacante, V., M. Benuzzi, V. Palmeri, and G. Brafa. 2001. Experimental trials of microbiological control of the Turkey moth (*Chrysodeixis chalcites* (Esper) in Sicilian greenhouse crops [Abstract]. Informatore Fitopatologico 51(7/8):73-76.

Weaving, A. J. 1969. The cotton looper - *Plusia* spp. Rhodesia Agricultural Journal 66(6):144-145.

Zalom, F. G. 2012. Management of Arthropod Pests. Pages 49-64 *in* R. M. Davis, K. Pernezny, and J. C. Broome, (eds.). Tomato Health Management. APS Press, St. Paul, Minnesota.

Zandigiacomo, P. 1990. The principal pests of soyabean in north-eastern Italy in 1989 [Abstract]. Informatore Fitopatologico 40(8):55-58.

Zhang, B. C. 1994. Index of economically important Lepidoptera. CAB International, Wallingford, U.K. 599 pp.

Zümroeglu, S., and N. Akbulut. 1987. Studies on the pests appearing in second-crop plantings of soyabean in the Aegean Region [Abstract]. Türkiye entomoloji dergisi 11(4):215-225.

Author: Leah Millar

Chair's Approval: *David R Prokrym*

Signature Date: **July 8, 2013**

Digitally signed by
david.r.prokrym@usda.gov
DN: cn=david.r.prokrym@usda.gov
Date: 2013.07.08 14:09:20 -04'00'