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Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen

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Executive Summary

The protection of bee pollinators, *e.g.*, honey bees (*Apis mellifera*) and non-*Apis* bees in the United States has grown increasingly important, because declines in their populations have the potential to impact food security due to loss of pollination services. Several key factors have been implicated in overall honey bee colony losses, including pesticides. The U.S. Environmental Protection Agency (EPA) risk assessment process for pesticides includes an evaluation of risk to bee pollinators. This document provides a compilation of information on the attractiveness of crops grown in the United States to pollinating bees as food sources of pollen and nectar, and agronomic practices that are relevant to the interactions between these insects and the crops. The information provides a starting point for the risk assessment process for pollinating bees in terms of determining the potential for exposure to pesticide applications on these crops. In addition, the information contained in this resource will help to inform decisions to pursue further refinements in the risk assessment process as well as options for risk mitigation.

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Introduction

The number of managed honey bee colonies in the U.S. has declined over the past 60 years and there are indications that the number and diversity of insect pollinators in general have also declined in North America[1]. Additionally, populations of some non-*Apis* bee species have declined in recent decades[2,3,4]. Although multiple factors have been associated with declines in *Apis* and non-*Apis* bees (*e.g.*, arthropod pests, disease, poor nutrition, decreases in the diversity of food resources for bees, loss of habitat, lack of genetic diversity and pesticides), no single factor or specific combination of factors has been identified as the principal cause[5]. The U.S. Department of Agriculture (USDA) has been tasked by Congress to identify and to develop means to mitigate the causes of honey bee declines[6]. Although pesticides alone have not been implicated as the principal cause of overall bee pollinator declines, the EPA and USDA have been working collaboratively to understand the potential role that pesticides may be playing, particularly in combination with other identified factors.

In September, 2012, scientists from the EPA Office of Pesticide Program's Environmental Fate and Effects Division, in collaboration with Health Canada's Pest Management Regulatory Agency and the California Department of Pesticide Regulation, presented a White Paper[7] to the Federal Insecticide, Fungicide and Rodenticide Act Scientific Advisory Panel (SAP) on a proposed framework for assessing risks of pesticides to bees in order to protect pollination services, production of hive products, and bee pollinator biodiversity. The proposed process for assessing risks to bees, using honey bees as a surrogate for non-*Apis* bees as well, serves as a

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[1] NAS. 2007. Status of Pollinators in North America. National Research Council of the National Academies. The National Academies Press, Washington DC. ISBN 978-0-309-10289-6.

[2] Grixti, J.C., L.T. Wong, S.A. Cameron, and C. Favret. 2009. Decline of bumble bees (*Bombus*) in the North American Midwest. Biological Conservation 142:75–84.

[3] Cameron, S.A., J.D. Lozior, J.P. Strange, J.B. Koch, N. Cordes, L.F. Solter, and T.L. Griswold. 2011. Patterns of widespread decline in North American bumble bees. Proceedings of the National Academy of Sciences 108:662-667.

[4] Bartomeus, I., J.S. Ascher, J. Gibbs, B.N. Danforth, D.L. Wagner, S.M. Hedtke, and R. Winfree. 2013. Historical changes in northeastern US bee pollinators related to shared ecological traits. Proceedings of the National Academy of Sciences 110(12): 4656 – 4660 doi: 10.1073/pnas.1218503110. http://www.pnas.org/content/110/12/4656.short

[5] USDA. 2013. Report on the National Stakeholders Conference on Honey Bee Health. National Honey Bee Stakeholder Conference Steering Committee. Alexandria, Virginia. October 15 – 17, 2012. http://www.usda.gov/documents/ReportHoneyBeeHealth.pdf

[6] USDA. 2007. Colony Collapse Disorder Action Plan, CCD Steering Committee, June 20, 2007. http://www.ars.usda.gov/is/br/ccd/ccd_actionplan.pdf

[7] http://www.epa.gov/scipoly/sap/meetings/2012/091112meeting.html

means to advance the science and to allow EPA to quantitatively assess the potential risk of pesticides to managed bees (*Apis* and non-*Apis*) and feral non-*Apis* bees.

The proposed framework for assessing risk to bees is similar to the process used by the EPA Office of Pesticide Programs for other taxa[8]; however, the biology of insect pollinators such as honey bees presents special considerations, which warrant a dedicated framework. Bee species can exhibit a wide range of social interaction/structure, with social structure of the various species affecting routes for potential exposure to pesticides. Often, the major commercial bee pollinators are either honey bees or bumble bees, but in some cases certain solitary bee species are also used commercially, *e.g.*, blue orchard bees (*Osmia lignaria*) and alfalfa leafcutter bees (*Megachile rotundata*).

It is also important to note that risk assessors may have to evaluate a wide variety of plant types as a result of pesticide use patterns, from forestry and ornamental uses to use in crops, such as corn (*Zea mays*) and canola (*Brassica napus*). These uses may differ in regards to need and timing of commercial insect pollination services. However, some crops may be pollinator-dependent or pollinator-attractive when in bloom, but they may be typically harvested before flowering (*e.g.*, lettuce) and would not represent a route of exposure based on typical cultivation practices. In other cases, some crop flowers are visited by solitary bees or bumble bees but not by honey bees. All of these pieces of information are essential to the understanding of bee pollinator visitation to a plant/crop of interest and the consequent need to assess the risk to bee pollinators from a pesticide application to this plant/crop.

As the SAP highlighted in the following conceptual model for the tiered approach in risk assessments to *Apis* and non-*Apis* bee pollinators (**Figure 1, Boxes 2a and 2b**), the first step of a risk assessment is to evaluate whether there is the potential for exposure. Therefore, information on the pollination biology of each plant/crop is needed to determine if bees are likely to visit the plants that are identified for pesticide applications. In addition, a risk assessor also needs information on the application rate, timing, method of application, and environmental fate of a pesticide in order to evaluate potential routes of exposure. Together, these pieces of information enable a risk assessor to determine if the proposed application of a pesticide leads to probable routes of exposure that could coincide with the timing of bee pollinator visitation to the plant/crop that is under consideration. In all cases, registrants provide information on the application rate, timing, method of application, and environmental fate of a chemical when a new pesticide use pattern is proposed. However, to complement the use information, a comprehensive and robust source of information on the pollination ecology of the plants to

[8] USEPA. 2004. Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs. U.S. Environmental Protection Agency, Endangered and Threatened Species Effects Determinations. http://www.epa.gov/espp/consultation/ecorisk-overview.pdf . Last accessed 1/6/15.

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which the pesticide is to be applied (*i.e.*, target plant) is needed to evaluate whether proposed uses for pesticide applications represent a potential exposure to either adult or immature (brood) bees.

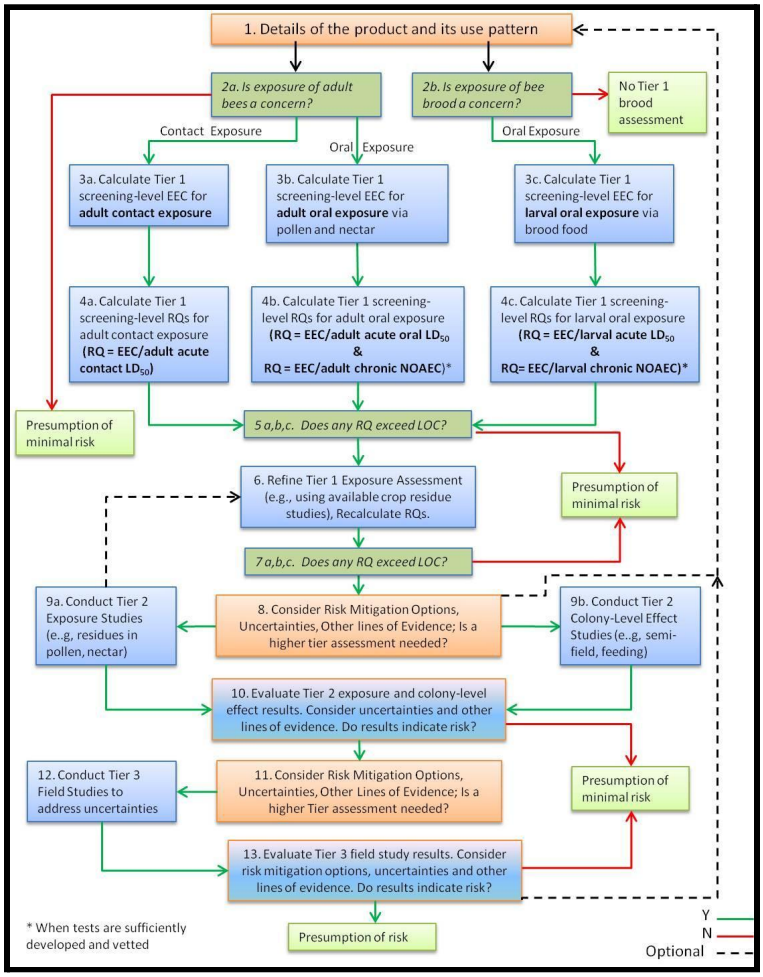

Figure 1. Example tiered approach for assessing risk to honey bees from foliar spray applications.

Development of the Pollinator Attractiveness Crop List

In order to assess the potential for *Apis* and non-*Apis* bees to be exposed to pesticides applied to various crops, relevant data and agronomic practices connected to the pollination of these plants/crops are needed. These data include a measure of attractiveness to pollinating bees (*i.e*., honey bees, bumble bees, and solitary bees) to each plant and/or crop, the phenology of the bloom period, use/non-use of managed pollinators, and the acreage of the various crop/plant groups in the United States.

The goal of this effort is to compile information on the attractiveness of crops grown in the United States to pollinating *Apis* and non-*Apis* bees as food sources of pollen and nectar. To achieve this goal, the EPA, USDA, and Michigan State University Extension Entomologist

Dr. Rufus Isaacs initiated a project to gather the relevant information to serve as a resource for pesticide risk assessments. The tables described here entitled "*Bee Pollinator Attractive Crops List*" (**Tables 1** and **2**) were developed to provide a relative rating of the degree to which honey bees, bumble bees, and solitary bees utilize the various crops grown in the United States. This list was informed by previous work conducted and recently published by the European Food Safety Authority (EFSA)[9] for assessing pesticide risks to bees and adapted for the specific situations and regulatory data needs for the EPA.

Information for the Bee Pollinator Attractive Crops List (**Tables 1** and **2**) was collected from multiple sources, including peer-reviewed published information, university and agricultural extension resources, and expert opinion based on experience with the pollination of specific crops. The published information included the key texts of McGregor[10], Free[11], and Delaplane and Mayer[12]. Additionally, primary research publications were used where appropriate, and these are listed in **Table 3**. Online or published articles from expert knowledge of specific agricultural crop systems were also used to complete these entries, based on the experience of entomologists that work in crop pollination and bee keeping or from state agricultural extension agencies. When expert opinion was used as the source of information, the source is also identified in **Table 3**. If information could not be identified from publications or expert opinion to

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[9] European Food Safety Authority, 2013. EFSA Guidance Document on the risk assessment of plant protection products on bees (*Apis mellifera*, *Bombus* spp. and solitary bees). Appendix D. EFSA Journal 2013; 11(7):3295, 266 pp., doi: 10.2903/j.efsa.2013.3295.

[10] McGregor SE, 1976. Insect pollination of cultivated crop plants. Agricultural Handbook No. 496. Ed USDA Agricultural Research Service W, D.C, USA.

[11] Free JB. 1993. Insect Pollination of crops, 2nd edn. Academic Press: London, UK.

[12] Delaplane, K. S. & Mayer, D. F. (2000). Crop Pollination by Bees. – New York, Oxon (CABI Publishing).

address a specific aspect of the pollination biology of the plant or its associated typical agronomic practice, the corresponding cells in **Tables 1** and **2** were left blank and this aspect of the crop remains an uncertainty.

There are specific considerations for some of the data listed in **Tables 1** and **2** related to the rating of attractiveness of pollen and/or nectar resources to bees. For each of the crops listed, the degree to which pollen and nectar are attractive and used by honey bees is listed using a scale where "-" = not attractive, "+" = attractive under certain conditions, and "++" = high attractiveness in all cases. The same rating system is used for bumble bees and for solitary bees with the major groups of solitary bees likely to be found at flowers of each crop listed, if known. The ratings for bumble bee and solitary bee taxa do not address pollen and nectar separately, however. The different attractiveness ratings are based on the degree to which information qualitatively indicates that they are used by bees. If the cited information indicates that certain bees frequently visit and extensively use a particular floral resource, then it is given the classification of “++” for the respective type of bee. If, however, information indicates that certain bees only visit a crop infrequently (*e.g.*, only under conditions of few alternative food sources) or few bees are noted to forage on a given crop resource, it is given the classification of “+” for the appropriate taxa of bee. Despite the relatively lower level of attractiveness compared to crops with a “++” rating, it is important to note that crops designated with a “+” may still become a major source of food for bees depending on the environmental conditions. For example, a crop that under normal conditions bees would only minimally use as a forage source, could be extensively used during certain time periods due to the lack of alternative available forage (*e.g.*, drought, flooding, *etc.*). Additionally, nearby competing crops which may be more pollinator attractive may draw away some groups of pollinators due to the ease of obtaining pollen/nectar. Finally, when the various groups of bees are noted to be absent from a particular crop or resource, this crop is noted with a “-” for the appropriate type of bee. When crop specific information was available, attractiveness ratings are based on the inherent attractiveness of the crop to pollinating bees and not based on specific agronomic practices such as harvest prior to bloom. It is assumed that a crop that is harvested prior to bloom would be “unattractive” to pollinating bees as it would not provide flowers for visitation during typical cultivation.

There are also considerations specifically related to **Table 1** given that for most of the crops data were already available in the EFSA guidance document[13]. The first consideration is that if the specific attractiveness rating was not listed in the EFSA guidance document for solitary bees, but rather only the type of bee was listed to denote floral visitation by that bee, then a “+” rating is applied in **Table 1** to denote that solitary bees visit the specific crop. The second consideration is that in many cases data were already available for the various crops in the EFSA document. Where additional data could not be found, the data in **Table 1** show the

[13] *Ibid*. European Food Safety Authority, 2013.

attractiveness ratings simply based on the EFSA guidance document. If other data provided clarification on additional bee taxa not addressed by EFSA and/or simply confirmed the EFSA data, then the EFSA data were combined with the additional data source noted in the reference. In some cases, other data sources modified the ratings provided by EFSA and these citations are provided in the references column.

In some cases, information is lacking for a crop, but another crop is identified as a surrogate for the rating of attractiveness to bees given similarity in plant family or crop group. In these cases, the surrogate is identified in the “Reference” column and serves as a reasonable assumption of attractiveness to bees. It should be noted, however, that there is uncertainty in the use of surrogate plants for the rating, as attractiveness may vary even within plant families.

Whether a crop requires bee pollination or not includes specific considerations related to the agronomic practices of the crop. The entry for 'requires bee pollination' refers to harvestable, productive crop yields rather than any specific level of fruit set. Consequently, if a crop “requires bee pollination” then the specific crop requires either specific bee taxa or bees in general to produce productive and harvestable crop yields. If a crop does not require bee pollination, then the specific crop attains harvestable and productive crop yields via other pollination methods aside from bees, such as through wind, mammal, or other invertebrate (*e.g.*, butterfly) pollination. Whether the crop requires bee pollination is listed based on the information provided in the cited reference, which provides information on whether the crop has a dependence on bee-mediated pollen transfer for the production of seeds, nuts, or fruit. This information is specifically for the production of the edible crop parts that will be harvested and sold. Many crops do not require bees for pollination to produce marketable yields, yet they do require bees for breeding or seed production (*i.e.,* intended for crop propagation), which is typically a very small proportion of the total crop acreage. In these cases the crops are stated as requiring bee pollination and the “Notes” column of **Tables 1 and 2** state if the requirement is only for seed production. Finally, some crops may produce flowers during the typical production of the harvestable part of the crop but does not require bee pollination. In these cases, exposure to bees is assumed and the attractiveness ratings of the crop to bees are specified in **Tables 1**

and **2**.

Many crops in **Tables 1** and **2** employ commercial honey bee colonies (or colonies of other types of bees) that are rented by the grower and provided by a beekeeper to provide pollination services. If that is likely to happen within a cropping system within the United States, based on the information provided in the cited reference, it is listed as "Yes" in the “Uses Managed Pollinators” column. If that does not happen based on the designation of not requiring bee

pollination, then the column has a "No" entry based on inference drawn from the column on bee pollination requirements.

Use of the Pollinator Attractiveness Crop List

As part of its pesticide ecological risk assessments, the EPA intends to consider the information on pollinator attractiveness provided in **Tables 1** and **2** in determining the potential for bees to be exposed to pesticides from the crop itself following application to a specific crop. If a risk assessment is warranted, other information included in **Tables 1** and **2** can assist in refining the scope of the risk assessment. The other information includes the spatial extent of treated crops, the timing of application in relation to likely periods of bee visitation, and agronomic practices that may affect the exposure of the bees (*e.g.,* harvesting prior to bloom). Where necessary, information in this list may be supplemented with additional information on a case-by-case basis (*e.g.*, crop and region-specific information from local agricultural extension experts).

Table 1. Summary of the attractiveness to *Apis* and non-*Apis* bees of crops grown in the U.S., whether crop requires bee pollination and if so, whether managed pollinators are used.

Also summarized is the bearing acreage of the crop, the extent to which the crop is used in seed production and whether the crop is harvested prior to bloom. The degree to which pollen and nectar are attractive is listed using a scale where "-" = not attractive, "+" = attractive under certain conditions, and "++" = high attractiveness; entry “N/AV” specifies when crop-specific data are unavailable; entry “N/AP” specifies when crop-specific data are not applicable.

Crop	Description	HB Poll.[1]	HB Nec.[1]	Bumble Bees	Solitary Bees	Requires Bee Pollination	Uses Managed Pollinators	Ref No.	U.S. Bearing Acreage[2]	Seed Production[7]	H
Alfalfa	*Medicago sativa*	+	++	+	++ Alfalfa leafcutting bee, Alkali bee	For seed production, only	For seed production, only	1	17,763,000	2011: 6600 acres	
Almonds	*Prunus amygdalus*; *P. communis*; *Amygdalus communis*	++	+	+	+*Osmia*	Yes	Yes	1	780,000		
Anise, badian, fennel, corian, juniper berries	anise (*Pimpinella anisum*); badian or star anise (*Illicium verum*); caraway (*Carum carvi*); coriander (*Coriandrum sativum*); cumin (*Cuminum*	+	+	+	+	Yes (not juniper berries)	No	2	N/AV		

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	cyminum); fennel (*Foeniculum vulgare*); juniper berries (*Juniperus communis*)										
Apples	*Malus pumila*; *M. sylvestris*; *M. communis*; *Pyrus malus*	++	+	+	*++Andrena, Anthidium, Halictus, Osmia, Anthophora, Habropoda*	Yes	Yes	1	327,800		
Apricots	*Prunus armeniaca*	++	++	++	*+Osmia*	Yes	Yes	3	12,150		
Artichokes	*Cynara scolymus*	+	+	+	+	Yes	No	3,4, 81	7,000		
Asparagus	*Asparagus officinalis*	+	+	N/AV	N/AV	For seed production, only	For seed production, only	1	24,500		
Avocados	*Persea americana*	+	+	N/AV	+	Yes	Yes	1	59,950		
Bananas	*Musa sapientum*; *M. cavendishii*; *M. nana*	-	+	-	-	No	No	5	1,000		
Barley	*Hordeum* spp.	-	-	-	-	No	No	3	3,000,000		
Beans	*Phaseolus* spp.	+	+	+	N/AV	No	No	3	77,200		
Blueberries	fruits of the genus *Vaccinium*	+	+	++	*++Andrena, Colletes, Osmia, Anthophora, Xylocopa*	Yes	Yes	1	77,700		
Broad beans, horse beans, dry	*Vicia faba*	++	++	++	*+Anthophora, Eucera, Megachile, Xylocopa*	Yes		5	1,311,300		
Buckwheat	*Fagopyrum esculentum*	+	++	+	+	Yes	Yes	5, 73	33,678		
Cabbages and other brassica	Chinese, mustard cabbage, pak-choi (*Brassica chinensis*); white, red, Savoy cabbage, Brussels sprouts, collards, kale and kohlrabi (*Brassica oleracea*	++	++	+	+	For seed production, only	For seed production, only	1	Cabbage 60,180 (Annual); Brussels sprouts 7,569 (Census); Kale 6,256 (Census); Collards 12,542 (Census)		

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	all varieties except *botrytis*)										
Carobs	*Ceratonia siliqua*, Carob tree, locust bean	+	+	+	+	Yes	No	49, 74			
Carrots	*Daucus carota*	+	+	+	+ *Megachile rotundata*	For seed production, only	For seed production, only	1, 3	71,400 Fresh Market; 13,310 Processing	2012: 4941 acres	
Castor oil seed	*Ricinus communis*	+	-	N/AV	N/AV			EFSA	N/AV	Yes	
Cauliflowers and broccoli	*Brassica oleracea* var. *botrytis*, subvarieties *cauliflora* and *cymosa*, includes headed broccoli	++	++	+	+ *Andrenidae, Nomadidae, Megachilidae*	For seed production, only	For seed production, only	5	163,730 Fresh market and processing		
Cherries	Mazzard, sweet cherry (*Prunus avium*; *Cerasus avium*); hard-fleshed cherry (var. *duracina*); heart cherry (var. *juliana*)	++	+	+	++ *Osmia*	Yes	Yes	1	86,790 Sweet; 36,500 Tart		
Chestnuts	*Castanea* spp.: *C. vesca*; *C. vulgaris*; *C. sativa*.	++	++	+	+	Yes	Yes	3	3,784		
Chick peas	Chickpea, Bengal gram, garbanzos (*Cicer arietinum*)	+	++	+	+ *Osmia, Megachile*	No	No	72	213,600; Note: Included in All Dry Bean Acres		
Chicory roots	*Cichorium intybus* subsp. *sativum*	+	+	N/AV	+*Andrena, Anthidium, Halictus, Osmia*	Yes	N/AV	EFSA, 3	N/AV		
Chillies and peppers	Red and cayenne pepper, paprika, chillies (*Capsicum frutescens*; *C. annuum*); allspice,	+	-	++	+	Yes	No	1	71,200 Chile and Bell		

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	Jamaica pepper (*Pimenta officinalis*)										
Clover for forage and silage	*Trifolium* spp. Various species grown for pasture, green fodder or silage	++	++	+	++ *Megachile, Osmia, Andrena, Anthidium*	For seed production, only	For seed production, only	1,5, 89, 102, 103	28,506 White, Red and Crimson		
Coffee, green	*Coffea* spp. (*arabica, robusta*, *liberica*)	+	-	N/AV	+	Yes	No	5	7300	Yes	
Corn	*Zea mays*	+	-	+	+	No	No	3	87,668,000		
Cotton	Upland cotton (*Gossypium hirsutum*) Pima Cotton (*Gossypium barbardense*)	-	+	+	*Halictus, Anthophora, Xylocopa, Megachile, Nomia, Ptilothrix*	No	No	5, 104, 105, 106, 107, 108, 109, 110, 111	7,664,400	Historical use of bees for hybrid seed production; however, hybrid cotton seed production is no longer considered economically viable	
Cow peas	Cowpea, blackeye pea/ bean (*Vigna unguiculata*)	-	+[3]	+	+	Yes	N/AV	11	39,100 Blackeye Peas, Included with All Dry Beans		
Cranberries	American cranberry (*Vaccinium macrocarpon*)	+	+	++	++*Andrena, Agapostemon, Melitta, Megachile*	Yes	Yes	1	40,300		
Cucumbers and gherkins	*Cucumis sativus*	+	+	+	+ *Melissodes Andrena*	Yes	Yes	1	40,060 Fresh; 82,100 for Pickles	Yes	
Currants	Black (*Ribes nigrum*); red and white (*R. rubrum*)	-	+	++	+ *Anthophora*	Yes	No	5	580 Total		
Dates	*Phoenix dactylifera*	+	+	N/AV	N/AV	No	No	3	8,400		

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Eggplants	*Solanum melongena*	-	-	++	+	For seed production, only	No	5	5,004		
Elder	*Sambucus nigra*	+	+	+	+	No	No	6	N/AV		
Figs	*Ficus carica*	-	-	-	-	No	No	5	8,600		
Garlic	*Allium sativum*	+	+	N/AV	*+Halictus, Osmia*	For seed production, only	No	3	23,900		
Gooseberry	*Ribes grossularia*	-	+	++	+	Yes	No	5	N/AV		
Grapefruit (inc. pomelos)	*Citrus maxima; C. grandis; C. paradisi*	++	++	+	N/AV	No	No	3, 9	73,300 (no pomelos)		
Grapes	*Vitis vinifera*	+	-	-	-	No	No	5	962,100		
Grasses for forage; Sil	Including inter alia: bent, redtop, fiorin grass (*Agrostis* spp.); bluegrass (*Poa* spp.); Columbus grass (*Sorghum almum*); fescue (*Festuca* spp.); Napier, elephant grass (*Pennisetum purpureum*); orchard grass (*Dactylis glomerata*); Rhodes grass (*Chloris gayana*); *Phleum, Agropyron, Elymus, Phalaris, Koeleria, Stipa, Danthonia, Deschampsia, Bromus, Trisetum, Calamagrostis, Carex and Juncus*	+	-	-	-	No	No	5	35,328,000		
Groundnuts, with shell, peanuts	*Arachis hypogaea*	+	N/AV	+	*+ Lasioglossum, Megachile, Anthidium, Nomia*	N/AV	N/AV	EFSA	1,042,000		

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Hazelnuts, with shell (filberts)	*Corylus avellana*	+	-	-	-	No	No	50	29,000		
Hemp	*Cannabis sativa*	+	-	+	N/AV	No	No	51	N/AV		
Hops	*Humulus lupulus*	+	-	-	-	No	No	7, 82	35,224		
Kiwi fruit	*Actinidia chinensis*	+	+	+	+	Yes	Yes	1	4,200		
Leeks, other alliaceous vegetables	Leeks (*Allium porrum*); chives (*A. schoenoprasum*); other alliac	+	++	+	+ *Osmia, Hoplitis*	For seed production, only	No	3, 5	N/AV		
Leguminous for silage	Including inter alia: birdsfoot trefoil (*Lotus corniculatus*); lespedeza (*Lespedeza* spp.); kudzu (*Pueraria lobata*); sesbania (*Sesbania* spp.); sainfoin, esparcette (*Onobrychis sativa*); sulla (*Hedysarum coronarium*)	+	++	++	++ *Anthidium, Anthophora, Lasioglossum, Megachile, Osmia, Xylocopa*	Yes	Yes	3, 8, 102, 103	Birdsfoot - Not Published; 3,219 Lespedeza		
Leguminous vegetables	*Vicia faba*	++	++	++	+ *Anthophora, Eucra, Megachile*	Yes	No	1	N/AV		
Lemons/ limes	Lemon (*Citrus limon*); sour lime (*C. aurantifolia*); sweet lime (*C. limetta*)	++	++	N/AV	+	No	No	5	55,000 Lemons (Annual) 820 Limes (Census)		
Lentils	*Lens esculenta*; *Ervum lens*	+	+[3]	-	+ *Megachile*	No	No	52	347,000		
Lettuce	*Lactuca sativa*	+	+	+	+	No	No	3, 5	259,100 Head, Leaf and Romaine		
Linseed	*Linum usitatissimum* Flaxseed.	-	-	-	-	No	Yes	90	N/AV		

Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen, **2017**

Lupins	*Lupinus alba*, *L. angustifolia*, *L. luteus*.	+	-	++	+	For seed production, only	No	91	N/AV		
Melonseed	*Cucumis melo*, includes seeds of other Cucurbitaceae	+	+	+	+ *Ceratina, Peponapis, Melissodes, Agapostemon*	Yes	Yes	5	N/AV		
Mushrooms and truffles	Edible mushrooms	N/AP	N/AP	N/AP	N/AP	No	No	40			
Mustard seed	White mustard (*Brassica alba; B. hirta*; *Sinapis alba*); black mustard (*Brassica nigra*; *Sinapis nigra*) *Brassica juncea*	++	++	+	+	Yes	N/AV	5		43,400	
Oat	*Avena* spp., mainly *Avena sativa*	-	-	-	-	No	No	3	1,030,000		
Okra	*Abelmoschus esculentus*; *Hibiscus esculentus*	+	+	+	+	Yes	No	5	2,377		
Olives	*Olea europaea*	+	-	N/AV	N/AV	No	No	3	44,000		
Onions	*Allium cepa*	+	+	-	+ *Halictus, Nomia*	For seed production, only	For seed production, only	5	143,340	dry bulb: 2010: 73213 acres	
Oranges	Common, sweet orange (*Citrus sinensis*); bitter orange (*C. aurantium*)	++	++	+	+ *Andrena, Xylocopa*	No	Yes	9	613,000		
Peaches/ nectarines	*Prunus persica*; *Amygdalus persica*; *Persica laevis*	+	+	+	+ *Osmia*	Yes	Yes	1	112,880 Peaches; 26,400 Nectarines		
Pears	*Pyrus communis*	+	+	+	+ *Osmia, Andrena*	Yes	Yes	1	54,400		
Peas	Garden pea (*Pisum sativum*);	+	+	+	+ *Eucera, Xylocopa*	No	No	7	797,000	2013; 406 acres	

Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen, **2017**

	field pea (*P. arvense*)										
Peppermint	*Mentha* spp.: *M. piperita*	+	++	++	+	No	No	39	68,800		
Persimmons	*Diospyros kaki*; *D. virginiana*	+	+	+	+	Yes	No	5	4,968		
Pistachios	*Pistacia vera*	-	-	-	-	No	No	53	178,000		
Plums and sloes	Greengage, mirabelle, damson (*Prunus domestica*); sloe (*P. spinosa*)	+	+	+	+ *Osmia, Anthophora*	Yes	Yes	1	82,780		
Poppy seed	*Papaver somniferum*	++	-	N/AV	N/AV	No	N/AV	EFSA, 92	N/AV		
Potatoes	*Solanum tuberosum* Irish potato	-	-	+	+*Andrena*	For breeding, only	No	3	1,052,000		
Pumpkins, squash and gourds	*Cucurbita* spp., includes marrows	+	+	++	+ *Agapostemon, Melissodes, Peponapis*	Yes	Yes	5	91,700 Pumpkins and Squash		
Pyrethrum, dried	*Chrysanthemum cinerariifolium*	+	+	+	+	No	No	3, 81	N/AV		
Quinces	*Cydonia oblonga*; *C. vulgaris*; *C. japonica*	+	+	N/AV	N/AV	N/AV	N/AV	EFSA	N/AV		
Rapeseed (including canola)	*Brassica napus* var. *oleifera*	++	++	+	++ *Megachile*	Yes	Yes	1,3,5	1,264,500 Canola; 1,700 Rapeseed	2013: 1,500 acres	
Raspberries	*Rubus idaeus*	+	+	++	+*Osmia, Anderna, Coletes, Halictus*	Yes	Yes	1	17,300		
Rice, paddy	*Oryza* spp., mainly *Oryza sativa*.	-	-	-	-	No	No	3	2,468,000		

Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen, **2017**

Rye	*Secale cereale*	-	-	-	-	No	No	3	278,000		
Rye grass for forage and silage	Italian ryegrass (*Lolium multiflorum);* English, perennial ryegrass (*L. perenne*).	-	-	-	-	No	No	3	N/AV		
Safflower seed	*Carthamus tinctorius*	+	+	N/AV	+	Yes	Yes	EFSA, 93	170,000		
Serradella/ birdsfoot	*Ornithopus sativus*	+	++	N/AV	+ *Megachile*	Yes	N/AV	EFSA	N/AV		
Sesame seed	*Sesamum indicum*	+	++	N/AV	+	Yes	No	5	17,501		
Sorghum	*Sorghum bicolor, spp. bicolor*	+	-	N/AV	+	No	No	3, 83	6,910,000 Grain and Silage		
Soybeans	*Glycine soja*	+	+	+	+	No	No	1	75,869,000		
Spices	Including inter alia: bay leaves (*Laurus nobilis*); dill seed (*Anethum graveolens*); fenugreek seed (*Trigonella foenum-graecum*); saffron (*Crocus sativus*); thyme (*Thymus vulgaris*); turmeric (*Curcuma longa*)	+	+	+	+	No	No	5	N/AV		
Spinach	*Spinacia oleracea*	-	-	-	-	No	N/AV	EFSA	31,440		
Strawberries	*Fragaria* spp.	+	+	+	+*Andrena*, Halictids, *Osmia*	No	Yes	3	58,190		

Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen, **2017**

Sugar beet	*Beta vulgaris* var. *altissima*	-	+	N/AV	+	For breeding, only	No	3	1,154,200		
Sugar cane	*Saccharum officinarum*	-	-	-	-	No	No	3	905,600	2013: 907 acres	
Sunflower seed	*Helianthus annuus*	++	++	++	*++Halictus, Dieunomia, Megachile, Melissodes, Svastra, Xylocopa*	Yes	Yes	1	1,474,600	2013: 1,502,000 acres	
Sweet potatoes	*Ipomoea batatas*	+	+	+	+	For breeding, only	No	5, 41, 78, 79	113,200		
Tangerines, mandarins, clementines	Mandarin, tangerine (*Citrus reticulata*); clementine, satsuma (*C. unshiu*)	++	++	+	*+Andrena, Xylocopa*	Yes	Yes	9	52100 Tangerines and Mandarins		
Tobacco[5]	*Nicotiana tabacum*	+	-	+	+	No	No	44, 84	355,700		
Tomatoes	*Lycopersicon esculentum*	-	-	+	+	Yes	Yes	1	93,600 Fresh; 277,000 Processing		
Triticale	*Triticum x Secale*	-	-	-	-	No	No	N/AV[6]	61,428		
Turnips for fodder	*Brassica rapa* var. *rapifera*.	++	++	+	+	For breeding, only	For breeding, only	3	N/AV		
Vetches	Spring/common vetch (*Vicia sativa*).	++	+	++	++	Yes	No	42	3,441		
Viper's grass	*Scorzonera hispanica*	+	+	+	+	Yes	No	43	N/AV		
Walnuts with shell	*Juglans* spp.: *J. regia*.	+	-	-	-	No	No	EFSA, 45	245,000		

Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen, **2017**

Watermelons	*Citrullus vulgaris*	+	+	+	+ *Agapostemon, Floridegus, Halictus, Hoplitus, Melissodes*	Yes	Yes	1	123,330		
Wheat	*Triticum* spp.: common (*T. aestivum*), durum (*T. durum*), spelt (*T. spelta*).	-	-	-	-	No	No	3	45,157,000		

† Major crops based on Appendix D in the EFSA bee risk assessment guidance document and their attractiveness to pollinating bees. The table also contains relevant agronomic information associated with each crop. The entry "N/AV" specifies when crop-specific data are unavailable. Where "EFSA" is listed as the reference for a specific crop in this table, the data from Appendix D in the EFSA bee risk assessment guidance are used as the sole source of information on attractiveness ratings as no additional data were identified.

[1] HB= honey bee; Pol = Pollen; Nec = Nectar

[2] Estimates from the Census of Agriculture have a 2012 harvested acreage date. NASS fruit estimates have a 2012 reference date and vegetables refer to 2013. Fruit estimates are in bearing acres. Field crops and specialty crops are reported in harvested acres. All Census estimates are reported in harvested acreage. N/AV = not available. Please refer to reference 48 in **Table 3** for the citation related to these data.

[3] Extra-floral nectaries

[4] Mainly on extra-floral nectaries

[5] Unmanufactured tobacco

[6] Extrapolation based on wheat and rye

[7] Seed production refers to crops grown to produce seeds intended for crop propagation rather than for human or livestock consumption

Table 2. Additional crops identified in the 40 CFR crop groupings and their attractiveness to *Apis* and non-*Apis* bees, whether crop requires bee pollination and if so, whether managed pollinators are used.

The degree to which pollen and nectar are attractive is listed using a scale where "-" = not attractive, "+" = attractive under certain conditions, and "++" = high attractiveness; entry “N/AV” specifies when crop-specific data are unavailable. The table also contains relevant agronomic information associated with each crop.

Crop	EPA Crop Group	HB Poll[1]	HB Nec[1]	Bumble Bees	Solitary Bees	Requires Bee Pollination	Uses Managed Pollinators	Refe Nu
Arracha (PR) *Arracacia xanthorrhiza* (Apiaceae)	Roots and tuber vegetables	+	+	+	+	Yes	No	Extrapol carrot in
Arrowroot *Maranta arundinacea* (Marantaceae)	Roots and tuber vegetables						*Uncertainty*[a]	
Chinese artichoke *Stachys affinis* (Lamiaceae)	Roots and tuber vegetables						*Uncertainty*[a]	
Jerusalem artichoke (Asteraceae)	Roots and tuber vegetables	+	+	+	+	No	No	
Edible burdock (Asteraceae)	Roots and tuber vegetables	+	+	+	+	No	No	Extrapo Jerusale artichok
Edible canna (Cannaceae)	Roots and tuber vegetables						*Uncertainty*[a]	
Cassava (Euphorbiaceae)	Roots and tuber vegetables	-	-	-	-	No	No	
Turnip-rooted chervil (Apiaceae)	Roots and tuber vegetables	+	+	+	+	For seed production, only	No	Extrapo coriande **Table 1**

Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen, **2017**

Chufa (Cyperaceae)	Roots and tuber vegetables	*Uncertainty*[a]						
Dasheen (Araceae)	Roots and tuber vegetables	+	+	N/AV	N/AV	No	No	46
Ginger (PR) (Zingiberaceae)	Roots and tuber vegetables	*Uncertainty*[a]						
Ginseng (Araliaceae)	Roots and tuber vegetables	N/AV	N/AV	N/AV	+	No	No	
Horseradish (Brassicaceae)	Roots and tuber vegetables	+	+	+	+	No	No	Attracti extrapol radish b
Leren (PR) (Marantaceae)	Roots and tuber vegetables	*Uncertainty*[a]						
Turnip rooted parsley (Apiaceae)	Roots and tuber vegetables	+	+	+	+	No	No	Extrapo parsley
Parsnip (Apiaceae)	Roots and tuber vegetables	+	+	+	+	For seed production, only	No	
Radish (Brassicaceae)	Roots and tuber vegetables	+	+	+	+ *Megachile*	For seed production, only	For seed production, only	
Rutabaga and turnip (Brassicaceae)	Roots and tuber vegetables	++	++	+	+	For seed production, only	For seed production, only	
Salsify, (oyster plant) (Asteraceae)	Roots and tuber vegetables	*Uncertainty*[a]						
Salsify, spanish (Asteraceae)	Roots and tuber vegetables	*Uncertainty*[a]						

Skirret (Apiaceae)	Roots and tuber vegetables	+	+	+	+	Yes	No	Extrapo carrot o
Tanier (Araceae)	Roots and tuber vegetables	*Uncertainty*[a]						
Yam bean (Fabaceae)	Roots and tuber vegetables	+	+	+	+	No	No	Extrapo Bean (lu below
True yam (Dioscoreaceae)	Roots and tuber vegetables	*Uncertainty*[a]						
Chive, Chinese (Liliaceae)	Bulb vegetables	+	++	+	+	For seed production, only	No	Extrapo chive ab
Daylily, bulb (Liliaceae)	Bulb vegetables	-	-	-	-	No	No	
Elegans hosta (Liliaceae)	Bulb vegetables	+	-	+	+	No	No	
Fritillaria (Liliaceae)	Bulb vegetables	+	+	+	+	No	No	
Garlic, great headed (Liliaceae)	Bulb vegetables	+	+	+	+	No	No	3
Garlic, serpent (Liliaceae)	Bulb vegetables	+	+	+	+	No	No	Extrapo great he garlic ab
Kurrat (Liliaceae)	Bulb vegetables	+	++	N/AV	+ *Osmia, Hoplitis*	Yes	No	Extrapo leek in T 5
Lily (Liliaceae)	Bulb vegetables	-	-	-	-	No	No	
Onion (various varieties except green onion) (Liliaceae)	Bulb vegetables	+	+	+	+	For seed production, only	No	3, 14, 8 Attractiv extrapol green o **Table 1**
Shallot (Liliaceae)	Bulb vegetables	+	+	+	+	For seed production, only	No	3, 14, 8 Attractiv extrapol

Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen, **2017**

								green o **Table 1**
Amaranth (Amaranthaceae)	Leafy Vegetables	+	+	+	+	Yes		
Arugula (Brassicaceae)	Leafy Vegetables	++	++	+	+	No	No	Extrapo mustard cabbage **Table 1**
Cardoon (Asteraceae)	Leafy Vegetables	+	+	+	+	Yes	No	81, Attra extrapol artichok **1**
Celery (Apiaceae)	Leafy Vegetables	+	+	+	+	Yes	No	3, Attrac to wild b extrapol parsley
Celtuce (Asteraceae)	Leafy Vegetables	+	+	+	+	No	No	Extrapo lettuce i
Chervil (Apiaceae)	Leafy Vegetables	+	+	+	+	No	No	
Chrysanthemum (Asteraceae)	Leafy Vegetables	+	+	+	+	No	No	81, extra from pyr referenc
Corn salad (Valerianaceae)	Leafy Vegetables	*Uncertainty*[a]						
Cress, garden (Brassicaceae)	Leafy Vegetables	++	++	+	+	No	No	Extrapo mustard cabbage **Table 1**
Cress, upland (Brassicaceae)	Leafy Vegetables	++	++	+	+	No	No	Extrapo mustard cabbage **Table 1**
Dandelion (Asteraceae)	Leafy Vegetables	++	++	++	++	No	No	80, Attra extrapol lettuce i

Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen, **2017**

Dock/sorrel (Polygonaceae)	Leafy Vegetables	*Uncertainty*[a]						
Endive (Asteraceae)	Leafy Vegetables	+	+	+	+	No	No	3, attrac extrapol lettuce i
Fennel (Apiaceae)	Leafy Vegetables	++	++	+	+	Yes	No	3, Attrac to wild b extrapol chervil a
Orach (Chenopodiaceae)	Leafy Vegetables	*Uncertainty*[a]						
Parsley (Apiaceae)	Leafy Vegetables	+	+	+	+	No	No	3, attrac ratings extrapol chervil a
Purslane, garden (Apiaceae)	Leafy Vegetables	+	+	+	+	No	No	Extrapo chervil a
Winter purslane (Portulaceae)	Leafy Vegetables	*Uncertainty*[a]						
Radicchio (Asteraceae)	Leafy Vegetables	+	+	N/AV	*+Andrena, Anthidium, Halictus, Osmia*	Yes	N/AV	Attractiv extrapol chicory
Rhubarb (Polygonaceae)	Leafy Vegetables	Open pollinated, rarely self-pollinated						

Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen, **2017**

New Zealand spinach (Aizoaceae)	Leafy Vegetables	*Uncertainty*[a]						
Swiss chard (Chenopodiaceae)	Leafy Vegetables	-	+	N/AV	+	Yes	No	Extrapo sugar b **Table 1**
Vine spinach (Basellaceae)	Leafy Vegetables	*Uncertainty*[a]						
Brussels sprouts (Brassicaceae)	Brassica leafy vegetables	++	++	+	+	No	No	Extrapo mustard cabbage **1**
Cavalo broccolo (Brassicaceae)	Brassica leafy vegetables	++	++	+	+	No	No	Extrapo mustard cabbage **1**
Collards (Brassicaceae)	Brassica leafy vegetables	++	++	+	+	No	No	Extrapo mustard cabbage **1**
Kale (Brassicaceae)	Brassica leafy vegetables	++	++	+	+	No	No	Extrapo mustard cabbage **1**
Kohlrabi (Brassicaceae)	Brassica leafy vegetables	++	++	+	+	No	No	Extrapo mustard cabbage **1**
Mizuna (Brassicaceae)	Brassica leafy vegetables	++	++	+	+	No	No	Extrapo mustard cabbage **1**

Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen, **2017**

Mustard greens (Brassicaceae)	Brassica leafy vegetables	++	++	+	+	No	No	Extrapo mustard cabbage **1**
Mustard spinach (Brassicaceae)	Brassica leafy vegetables	++	++	+	+	No	No	Extrapo mustard cabbage **1**
Rape greens (Brassicaceae)	Brassica leafy vegetables	++	++	+	+	No	No	Extrapo mustard cabbage **1**
Bean (lupinus) (Fabaceae)	Legume vegetable	++	+	+	+	No	No	1,
Bean (vigna) (Fabaceae)	Legume vegetable	+	+	+	+	No	No	
Guar (Fabaceae)	Legume vegetable	+	+	+	+	No	No	Extrapo Bean (lu above
Jackbean (Fabaceae)	Legume vegetable	+	+	+	+	No	No	Extrapo Bean (lu above
Lablab bean (Fabaceae)	Legume vegetable	+	+	+	+	No	No	Extrapo Bean (lu above
Pigeon pea (Fabaceae)	Legume vegetable	+	+	+	+	No	No	Extrapo Bean (lu above
Sword bean (Fabaceae)	Legume vegetable	+	+	+	+	No	No	Extrapo Bean (lu above
African eggplant (Solanaceae)	Fruiting vegetable	-	-	++	+	No	No	Extrapo entry fo in **Table**
Bush tomato (Solanaceae)	Fruiting vegetable	-	-	++	+	No	No	Extrapo entry fo in **Table**
Cocona (Solanaceae)	Fruiting vegetable	-	-	++	+	No	No	Extrapo entry fo in **Table**

Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen, **2017**

Currant tomato (Solanaceae)	Fruiting vegetable	-	-	++	+	No	No	Extrapo entry fo in **Table**
Garden huckleberry (Solanaceae)	Fruiting vegetable	-	-	++	+	No	No	Extrapo entry fo in **Table**
Goji berry (Solanaceae)	Fruiting vegetable	-	-	++	+	No	No	Extrapo entry fo in **Table**
Groundcherry (Solanaceae)	Fruiting vegetable	-	-	++	+	No	No	Extrapo entry fo in **Table**
Martynia (Pedaliaceae)	Fruiting vegetable	*Uncertainty*[a]						
Naranjilla (Solanaceae)	Fruiting vegetable	-	-	++	+	No	No	Extrapo entry fo in **Table**
Pea eggplant (Solanaceae)	Fruiting vegetable	-	-	++	+	No	No	Extrapo entry fo in **Table**
Pepino (Solanaceae)	Fruiting vegetable	-	-	++	+	No	No	Extrapo entry fo in **Table**
Bell pepper (Solanaceae)	Fruiting vegetable	-	-	++	+	No	No	Extrapo entry fo in **Table**
Roselle (Malvaceae)	Fruiting vegetable	+	+	N/AV	N/AV	Yes	No	
Scarlet eggplant (Solanaceae)	Fruiting vegetable	-	-	++	+	No	No	Extrapo entry fo in **Table**
Sunberry (Solanaceae)	Fruiting vegetable	-	-	++	+	No	No	Extrapo entry fo in **Table**
Tomatillo (Solanaceae)	Fruiting vegetable	-	-	++	+	No	No	Extrapo entry fo in **Table**
Tree tomato (Solanaceae)	Fruiting vegetable	-	-	++	+	No	No	Extrapo entry fo in **Table**

Chayote (Cucurbitaceae)	Cucurbit vegetable	+	+	+	+	No	No	
Citron melon (Cucurbitaceae) = watermelon	Cucurbit vegetable	+	+	+	+	Yes	Yes	
Momordica spp. (Cucurbitaceae)	Cucurbit vegetable	+	+	+	+	Yes	Yes	Extrapo entry ab
Calamondin (Rutaceae)	Citrus fruit	++	++	+	+	No	No	
Citron (Rutaceae)	Citrus fruit	++	++	+	+	No	No	Extrapo entry ab
Citrus hybrids (Rutaceae)	Citrus fruit	++	++	+	+	No	No	Extrapo entry ab
Kumquat (Rutaceae)	Citrus fruit	++	++	+	+	No	No	Extrapo entry ab
Mediterranean mandarin (Rutaceae)	Citrus fruit	++	++	+	+	No	No	Extrapo entry ab
Mount white lime (Rutaceae)	Citrus fruit	++	++	+	+	No	No	Extrapo entry ab
New guinea wild lime (Rutaceae)	Citrus fruit	++	++	+	+	No	No	Extrapo entry ab
Tangelo (Rutaceae)	Citrus fruit	++	++	+	+	No	No	Extrapo entry ab
Tangor (Rutaceae)	Citrus fruit	++	++	+	+	No	No	Extrapo entry ab
Uniq fruit (Rutaceae)	Citrus fruit	++	++	+	+	No	No	Extrapo entry ab
Azarole (Rosaceae)	Pome fruit	++	+	+	++*Andrena, Anthidium, Halictus, Osmia, Anthophora, Habropoda*	Yes	No	Extrapo apple in
Crabapple (Rosaceae)	Pome fruit	++	+	+	++*Andrena, Anthidium, Halictus, Osmia, Anthophora, Habropoda*	Yes	Yes	95, Extr from ap **Table 1**
Loquat (Rosaceae)	Pome fruit	++	+	+	++*Andrena, Anthidium, Halictus, Osmia, Anthophora, Habropoda*	Yes	No	Extrapo apple in
Mayhaw (Rosaceae)	Pome fruit	++	+	+	++*Andrena, Anthidium, Halictus, Osmia,*	Yes	No	Extrapo apple in

Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen, 2017

					Anthophora, Habropoda			
Medlar (Rosaceae)	Pome fruit	++	+	+	*++Andrena, Anthidium, Halictus, Osmia, Anthophora, Habropoda*	Yes	No	Extrapo apple in
Asian pear (Rosaceae)	Pome fruit	++	+	+	*++Andrena, Anthidium, Halictus, Osmia, Anthophora, Habropoda*	Yes	Yes	Extrapo apple in
Pseudocydonia sinensis (Rosaceae)	Pome fruit	++	+	+	*++Andrena, Anthidium, Halictus, Osmia, Anthophora, Habropoda*	Yes	No	Extrapo apple in
Tejocote (Rosaceae)	Pome fruit	++	+	+	*++Andrena, Anthidium, Halictus, Osmia, Anthophora, Habropoda*	Yes	No	Extrapo apple in
Capulin (Rosaceae)	Stone fruit	++	+	+	*++Andrena, Anthidium, Halictus, Osmia, Anthophora, Habropoda*	Yes	No	Extrapo apple in
Jujube (Rhamnaceae)	Stone fruit	++	+	+	+	Yes	No	
Nectarine (Rosaceae)	Stone fruit	++	+	+	+	Yes	Yes	
Peach (Rosaceae)	Stone fruit	++	+	+	+	Yes	Yes	
Plum (various) (Rosaceae)	Stone fruit	++	+	+	+	Yes	Yes	
Plumcot (Rosaceae)	Stone fruit	++	+	+	+	Yes	No	Extrapo entry fo
Sloe (Rosaceae)	Stone fruit	++	+	+	+	Yes	No	Extrapo entry fo
Aronia berry (Rosaceae)	Berry and small fruit	+	+	+	+	Yes	No	
Bayberry (Myricaceae)	Berry and small fruit	*Uncertainty*[a]						
Bearberry (Ericaceae)	Berry and small fruit	+	+	++	*++Andrena, Colletes, Osmia, Anthophora, Xylocopa*	Yes	No	Extrapo blueber **Table 1** flower

Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen, **2017**

Bilberry (Ericaceae)	Berry and small fruit	+	+	++	*++Andrena, Colletes, Osmia, Anthophora, Xylocopa*	Yes	No	Extrapo blueberr **Table 1** flower
Blackberry (Rosaceae)	Berry and small fruit	+	+	++	++	Yes	Yes	1
Buffaloberry (Elaeagnaceae)	Berry and small fruit	*Uncertainty*[a]						
Che (Moraceae)	Berry and small fruit	*Uncertainty*[a]						
Chokecherry (Rosaceae)	Berry and small fruit	+	+	N/AV	N/AV	Yes	No	58
Cloudberry (Rosaceae)	Berry and small fruit	+	+	+	+	Yes	No	60
European barberry (Berberidaceae)	Berry and small fruit	*Uncertainty*[a]						
Highbush cranberry (Caprifoliaceae)	Berry and small fruit	*Uncertainty*[a]						
Edible honeysuckle (Caprifoliaceae)	Berry and small fruit	+	+	+	+	Yes	No	62
Huckleberry (Ericaceae)	Berry and small fruit	+	+	++	*++Andrena, Colletes, Osmia, Anthophora, Xylocopa*	Yes	No	Extrapol blueberr **1**, simila
Jostaberry (Grossulariaceae)	Berry and small fruit	-	+	+	+	Yes	No	63, Extr from Cu **Table 1**
Juneberry (Rosaceae)	Berry and small fruit	+	+	+	+	Yes	No	7
Lingonberry (Ericaceae)	Berry and small fruit	+	+	+	+	Yes	No	65
Maypop (Passifloraceae)	Berry and small fruit	-	-	-	+ *Xylocopa*	Yes	No	
Mulberry (Moraceae)	Berry and small fruit	-	-	-	-	No	No	
Partridgeberry (Rubiaceae)	Berry and small fruit	-	-	+	-	Yes	No	
Phalsa (Tiliaceae)	Berry and small fruit	+	+	+	+	Yes	No	
Pin cherry (Rosaceae)	Berry and small fruit	++	+	+	++ *Osmia*	Yes	No	Extrapo cherry t

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Salal (Ericaceae)	Berry and small fruit	+	+	++	*++Andrena, Colletes, Osmia, Anthophora, Xylocopa*	Yes	No	Extrapo blueber **1**, simil
Schisandra berry (Schisandraceae)	Berry and small fruit	*Uncertainty*[a]						
Beechnut (Fagaceae)	Tree nut	-	-	-	-	No	No	
Brazil nut (Lecythidaceae)	Tree nut	+	+	++	+	No	No	
Bur oak (Fagaceae)	Tree nut	+	-	-	-	No	No	
Butternut (Juglandaceae)	Tree nut	+	-	-	-	No	No	
Cashew (PR)(Anacardiaceae)	Tree nut	+	+	N/AV	N/AV	Yes	No	
Candlenut (Euphorbiaceae)	Tree nut	*Uncertainty*[a]						
Chinquapin (Fagaceae)	Tree nut	++	+	+	+	No	No	
Coconut (Arecaceae)	Tree nut	+	+	+	+	Yes	No	
Ginkgo (Ginkgoaceae)	Tree nut	-	-	-	-	No	No	
Guiana chestnut (PR) (Bombacaceae)	Tree nut	*Uncertainty*[a]						
Heartnut (Juglandaceae)	Tree nut	+	-	-	-	No	No	Similar t butternu informat transfer above
Hickory (Juglandaceae)	Tree nut	*Uncertainty*[a]						
Macadamia nut (PR) (Proteaceae)	Tree nut	+	+	N/AV	N/AV	Yes	No	
Pachira (Bombacaceae)	Tree nut	*Uncertainty*[a]						
Peach palm nut (Arecaceae)	Tree nut	-	-	-	-	No	No	
Pecan (Juglandaceae)	Tree nut	-	-	-	-	No	No	
Pine nut (Pinaceae)	Tree nut	*Uncertainty*[a]						
Tropical almond (Combretaceae)	Tree nut	+	+	N/AV	N/AV	No	No	

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Millet (Poaceae)	Cereal grains	+	-	-	-	No	No	Similar t Grasses informat transfer **Table 1**
Popcorn (Poaceae)	Cereal grains	+	-	-	-	No	No	Similar t Grasses informat transfer **Table 1**
Teosinte (Poaceae)	Cereal grains	+	-	-	-	No	No	Similar t Grasses informat transfer **Table 1**
Wild rice (Poaceae)	Cereal grains	+	-	-	-	No	No	Similar t Grasses informat transfer **Table 1**
Velvet bean (Fabaceae)	nongrass animal feeds	*Uncertainty*[a]						
Lupin (Fabaceae)	nongrass animal feeds	+	+	+	+	For seed production, only	For seed production, only	
Crown vetch (Fabaceae)	nongrass animal feeds	+	+	++	++ *Megachile, Osmia*	For seed production, only	For seed production, only	Extrapo entry be
Vetch (Fabaceae)	nongrass animal feeds	+	+	++	+ *Megachile, Osmia*	For seed production, only	For seed production, only	
Milk vetch (Fabaceae) *Astragalus* spp.	nongrass animal feeds	+	+	++	+ *Megachile*	For seed production, only	For seed production, only	96
Angelica (Apiaceae)	Herbs and spices	*Uncertainty*[a]						

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Annatto (Bixaceae)	Herbs and spices	+	-	N/AV	N/AV	No	No	
Lemon balm (Lamiaceae)	Herbs and spices	+	+	+	+	No	No	
Basil (Lamiaceae)	Herbs and spices	+	+	+	+	For seed production, only	For seed production, only	
Borage (Boraginaceae)	Herbs and spices	+	++	+	+	For seed production, only	For seed production, only	25,
Burnet (Rosaceae)	Herbs and spices	+	+	+	+	No	No	
Camomille (Asteraceae)	Herbs and spices	+	+	N/AV	+	No	No	27, Extr to poten experien
Black caraway (Ranunculaceae)	Herbs and spices	+	+	+	+	No	No	28, Extr to poten experien
Caper buds (Capparaceae)	Herbs and spices	+	++	N/AV	+	For seed production, only	For seed production, only	29, Extr to poten experien
Catnip (Lamiaceae)	Herbs and spices	+	++	++	++	For seed production, only	For seed production, only	7
Celery seed (Apiaceae)	Herbs and spices	+	+	+	+	For seed production, only	For seed production, only	
Chinese chives (Liliaceae)	Herbs and spices	+	++	+	+	For seed production, only	For seed production, only	Extrapo chive, 3
Cinnamon (Lauraceae)	Herbs and spices	+	+	N/AV	N/AV	For seed production, only	For seed production, only	
Clary (Lamiaceae)	Herbs and spices	+	+	+	+	For seed production, only	For seed production, only	
Costmary (Asteraceae)	Herbs and spices	+	+	+	+	For seed production, only	For seed production, only	Extrapo chamom
Culantro (Apiaceae)	Herbs and spices	*Uncertainty*[a]						
Horehound (Lamiaceae)	Herbs and spices	+	+	+	+	For seed production, only	For seed production, only	Extrapo 24
Hyssop (Lamiaceae)	Herbs and spices	+	+	++	++	For seed production, only	For seed production, only	
Lavendar (Lamiaceae)	Herbs and spices	+	++	++	++	For seed production, only	For seed production, only	3
Lemongrass (Graminae)	Herbs and spices	-	-	-	-	No	No	

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Lovage (Apiaceae)	Herbs and spices						*Uncertainty*[a]	
Mace (Myristicaceae)	Herbs and spices	-	-	-	-	No	No	
Marigold (Asteraceae)	Herbs and spices	+	+	-	+	No	No	
Marjoram (Lamiaceae)	Herbs and spices	+	+	+	+	No	No	
Nasturtium (Tropaeolaceae)	Herbs and spices	+	+	++	+	No	No	
Nutmeg (Myristicaceae)	Herbs and spices	-	-	-	-	No	No	
Parsley (Apiaceae)	Herbs and spices	+	+	+	+	No	No	
Rue (Rutaceae)	Herbs and spices	+	+	+	+	Yes	No	
Rosemary (Lamiaceae)	Herbs and spices	++	++	+	+	No	No	
Sage (Lamiaceae)	Herbs and spices						*Uncertainty*[a]	
Savory (Lamiaceae)	Herbs and spices	+	+	+	+	Yes	No	
Tansy (Asteraceae)	Herbs and spices	+	+	+	+	No	No	
Tarragon (Asteraceae)	Herbs and spices	+	+	+	+	No	No	
Vanilla (Orchidaceae)	Herbs and spices	+	+	+	+	No	No	
Wintergreen (Ericaceae)	Herbs and spices	-	-	+	-	No	No	
Wormwood (Asteraceae)	Herbs and spices						*Uncertainty*[a]	
Woodruff (Rubiaceae)	Herbs and spices						*Uncertainty*[a]	
Borage (Boraginaceae)	Oilseed	++	+	+	+	Yes	No	3
Calendula (Asteraceae)	Oilseed	+	+	+	+	Yes	No	
Chinese tallow (Euphorbiaceae)	Oilseed	+	+	+	+	Yes	No	

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Crambe (Brassicaceae)	Oilseed	+	+	+	+	Yes	No	
Cuphea (Lythraceae)	Oilseed	+	+	+	+	Yes	No	3
Echium (Boraginaceae)	Oilseed	+	+	+	+	Yes	No	
Euphorbia (Euphorbiaceae)	Oilseed	+	+	+	+	Yes	No	
Evening primrose (Onagraceae)	Oilseed	+	+	+	+	Yes	No	
Flax seed (Linaceae)	Oilseed	+	+	+	+	No	No	
Gold of pleasure (Brassicaceae)	Oilseed	+	+	+	+	Yes	No	
Hare's ear mustard (Brassicaceae)	Oilseed	+	+	+	+	Yes	No	
Jojoba (Simmondsiaceae)	Oilseed	+	+	+	+	Yes	No	
Lesquerella (Brassicaceae)	Oilseed	+	+	+	+	Yes	No	100
Lunaria (Brassicaceae)	Oilseed	+	+	+	+	Yes	No	
Meadowfoam (Limnanthaceae)	Oilseed	+	+	+	+ *Osmia*	Yes	No	
Milkweed (Asclepiadaceae)	Oilseed	+	+	+	+	Yes	No	
Niger seed (Asteraceae)	Oilseed	+	+	+	+	Yes	No	
Oil radish (Brassicaceae)	Oilseed	+	+	+	+	Yes	No	
Rose hip (Rosaceae)	Oilseed	+	+	+	+	Yes	No	
Stokes aster (Asteraceae)	Oilseed	+	+	+	+	Yes	No	
Stokes aster (sweet rocket) (Brassicaceae)	Oilseed	+	+	+	+	Yes	No	
Tallowwood (Olacaceae)	Oilseed	+	+	+	+	Yes	No	
Veronia (Asteraceae)	Oilseed	+	+	+	+	Yes	No	
Tea oil plant (Theaceae)	Oilseed	+	+	+	+	Yes	No	

[a]Where no data are identified for a given crop, there is uncertainty regarding its attractiveness to pollinating bees, and "*Uncertainty*" is listed in the row

[1] HB= honey bee; Poll = Pollen; Nec = Nectar

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