

Benefits of insect pollination in cultivated Brassicaceae

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Table S1. Studies reporting on insect pollination and yield parameters in *Brassica carinata*, *Camelina sativa*, *Eruca sativa*, and *Sinapis alba*; n/a = information not available.

Plant	Beneficial effect of insect pollination	No effect of insect pollination	Comparison taken in this review	Country	References
<i>B. carinata</i>	Increase in seed yield (kg/ha) and number of seeds/silique. Cultivar n/a	No significant increase in silique length	Open vs. caged inflorescences	India	(Sihag 1986)
	Increase in seed yield (kg/ha). Cultivar n/a		Added vs. not added honeybee hives	US	(Stiles et al. 2019)
<i>C. sativa</i>	Increase in seed weight/open flower, silique set, number of seeds/silique, and number of seeds/open flower. Cultivars Ligena, Celine, and Calena.		Open pollination vs. bagged for insect exclusion	Germany	(Groeneveld and Klein 2014)

<i>E. sativa</i>	Increase in seed yield (kg/ha), seed weight/plant, number of siliques/plant, number of seeds/silique, and silique length. Cultivar n/a		India	(Sihag 1986)
<i>S. alba</i>	Increase in seed production (number of seeds/branch divided by number of flowers/branch) and seed germination. Wild population	Open vs. bagged plants to exclude pollinators	Israel	(Gibson-Forty et al. 2021)
	Increase in number of seeds/silique and number of seeds/open flower. Cultivar n/a	No significant increase in silique length	India	(Sihag 1986)

Table S2. Studies reporting on insect pollination and yield parameters in *Brassica juncea*; n/a = information not available.

Beneficial effect of insect pollination	No effect of insect pollination	Comparison taken in this review	Country	References
Increase in seed yield (q/ha), number of siliques/plant, number of seeds/silique, and weight of 1,000 seeds. Cultivar n/a		Open vs. caged plants	India	(Mahadik et al. 2019)
Increase in seed yield (t/ha). Cultivar n/a	No effect on seed germination, weight of 1,000 seeds, oil content (%), and protein content (%)	Open vs. covered plants (with net) to exclude pollinators	Bangladesh	(Mandal et al. 2018)

Increase in silique set, number of seeds/silique, and weight of 1,000 seeds. Cultivar n/a	Open vs. caged plants	India	(Devi and Sharma 2018)
Increase in silique set, number of seeds/silique, and weight of 1,000 seeds. Cultivar n/a	Open vs. caged plots	India	(Devi et al. 2017)
Increase in seed yield (q/ha), number of siliques/plant, silique length, silique set, number of seeds/silique, weight of 1,000 seeds, germination, seed vigor, and oil content. Cultivar RH 0749, type n/a	Open vs. caged with honeybees vs. caged without pollinators	India	(Nagpal et al. 2017)
Increase in seed yield/plant (g) with increased honeybee visits.	Honey bee visits/plant	India	(Maity et al. 2014)

Cultivars: parental lines of
hybrid NRCHB506

Increase in numbers of siliques/plant and silique set.		Open vs. caged with honeybees vs. caged without pollinators	India	(Goswami and Khan 2014)
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Average of 7 different cultivars
(Kranti, Varuna, Margold,
Vardan, Vaibhav, EC399312
and EC399313), type n/a

Increase in oil content (%).	No significant	Open natural	India	(Mahindru et al. 1998)
Increase in seeds/silique in intensive pollination compared to natural pollination and caged plants compared to plants under natural pollination. Cultivar RL 1359, type n/a	increase in silique setting, weight of 1,000 seeds, and germination	pollination vs. open with hives of honey bees (intensive pollination) vs. caged without pollinators		

Increase in seed yield (kg/ha).		Open natural	India	(Chand and Singh
Cultivar Pusa Bold, type n/a		pollination vs. open		1995)
		with Indian honey		
		bee colonies vs.		
		caged without		
		pollinators		
Increase in seed yield (kg/ha),	No significant	Open vs. caged	India	(Sihag 1986)
number of siliques/plant, and	increase in silique	inflorescences		
number of seeds/silique.	length			
Cultivar Prakash, type n/a				

Table S3. Studies reporting on insect pollination and yield parameters in *Brassica napus*. Except for Sihag et al., the references are from the year 2000 onwards; n/a = information not available.

Beneficial effect of insect pollination	No effect and negative effect of insect pollination	Comparison taken	Country	References
Increase in seed yield (kg/ha), number of seeds/m ² , and number of seeds/silique. Cultivar Rivette, open-pollinated	No effect on seed weight (of 100 seeds), number of siliques/m ² , and above-ground biomass	Beehive vs. pollinator-exclusion tents	Uruguay	(Mazzilli et al. 2020)
Increase in seed biomass (g/plant), decrease in number of flower-abscission scars, and shorter growing season in both open-pollinated and hybrid		With vs. without insect pollination (<i>Bombus terrestris</i>)	Canada	(Adamidis et al. 2019)

varieties. Cultivar names not mentioned (8 open-pollinated and 15 hybrid cultivars)

Increase in silique weight and number of seeds/silique.	No effect on weight of 1,000 seeds	Open vs. covered inflorescences	Brazil	(Fuzaro et al. 2018)
Hybrids Hyola 61 and Hyola 433				
Increase in number of seeds/silique.	No effect on yield, number of seeds/plant, number of silique/plant, and weight of 1,000 seeds	Open ambient pollination vs. excluded pollination with polythene mesh	UK	(Garratt et al. 2018)
Increase in seed yield, silique set, and seed mass adjusted to plant biomass. 28 different	Decrease in number of seeds/silique and no	Variable pollinator abundance	France	(Perrot et al. 2018)

cultivars. Cultivar names not mentioned (88.7% restored hybrid cultivars and 11.1% conventional cultivars)	significant effect on seed weight			
Increase in yield (total seed weight/plant), seed weight/vegetative biomass ratio, number of seeds/silique, and silique set. Cultivar type Yangguang 2009, open-pollinated	No effect on number of siliques/plant. Reduction in number of flowers/plant, 1,000-seed weight, and above-ground biomass excluding siliques	Open vs. closed cages	China	(Zou et al. 2017b, a)
Increase in seed yield (t/ha) only in open-pollinated cultivars Galileo, Epure, and Alpaga	No significant increase in seed yield (t/ha) in hybrid cultivars	Open pollination vs. open pollination with addition of	Sweden	(Lindström et al. 2016)

	Excalibur, Compass, and Expower	beehives (extra pollinators)		
Cultivar n/a	No effect on seed weight/seed. No effect on numbers of seeds/silique and seeds/plant	Open vs. bagged (pollinator exclusion)	Ethiopia	(Samnegård et al. 2016)
Increase in yield (total seed weight) and number of flowers/plant. Cultivar Petranova, open-pollinated	No effect on above-ground biomass	Open vs. pollinator-exclusion cover	Netherlands	(van Gils et al. 2016)
Increase in yield (t/ha) and oil content (g/kg). Hybrid variety Visby		Caged plants either with or without <i>B. terrestris</i>	Switzerland	(Sutter and Albrecht 2016)

Increase in seed yield (g/plant and kg/fed), number of siliques/plant, number of seeds/silique, weight of 1,000 seeds, and germination. Cultivar Serw4, open-pollinated		Open vs. caged plants	Egypt	(Kamel et al. 2015)
Increase in yield (g/m ²) only in open-pollinated cultivar Catalina. Increase in oil content, seeds/silique and number of siliques/m ² in open-pollinated (Catalina) and in hybrid cultivars (Excalibur, PR45D01).	No yield increase (g/m ²) in hybrid cultivars (Excalibur, PR45D01)	Open vs. closed cages excluding pollinators	Italy	(Marini et al. 2015)
Increase in silique length, seed mass/silique, and silique set.	Non-significant increase in silique mass	Shade houses with and without	Brazil	(Witter et al. 2015)

Increase in silique mass and number of seeds/silique only with the pollinators <i>A. mellifera</i> and <i>Plebeia emerina</i> . Hybrid Hyola 61.	and number of seeds/silique with the pollinator <i>Tetragonisca fiebrigi</i>	bee colonies of three types (<i>A. mellifera</i> , <i>P. emerina</i> , <i>T. fiebrigi</i>)		
Increase in yield (seed weight/plant). Hybrids Excalibur and Compass		Variable pollinator visitation	Sweden	(Bartomeus et al. 2015)
Increase in seed yield (kg/ha), seed mass/plant, seed mass/silique, and number of seeds/silique. Hybrids Hyola 61 and Hyola 433	Reduction or no effect on weight of 1,000 seeds, depending on sowing date	Open vs. caged with or without beehives	Brazil	(Chambó et al. 2014)
Increase in number of seeds/silique for Hyola 61 in one	No effect on number of seeds/silique in Hyola	Open vs. covered flowers	Brazil	(Blochtein et al. 2014)

location. Increase in total seeds	433 and in Hyola 61			
wegith/silique for Hyola 61 in	(another location); no			
another location. Hybrids Hyola	effect on total seed			
61 and Hyola 420	weight/silique in Hyola			
	433 and in Hyola 61			
	(another location).			
Increase in silique weight,	No significant effect on	Caged plants with	UK	(Garratt et al. 2014)
number of seeds/silique, and	seed weight	pollinators vs.		
silique set (%). Open-pollinated		caged plants		
cultivar Heros		without		
		pollinators		
Increase in seed yield (g/plant),	Decrease in weight of	Open vs. open	Germany	(Hudewenz et al.
silique set, and number of	1,000 seeds	and additional		2014)
seeds/silique. Open-pollinated		hand pollination		
		vs. bagging to		

cultivar Sherlock and hybrids		preven insect or		
Traviata, Treffer, and Visby		wind pollination		
Increase in the number of	No effect on weight of	Open next to bee	Serbia	(Nedić et al. 2013)
siliques/plant and number of	1,000 seeds	hives vs. caged		
seeds/silique. Cultivar KWC				
“Triangle”, type n/a				
Increase in number of		Open vs. covered	Pakistan	(Shakeel and
siliques/plant, number of		with nylon cloth		Inayatullah 2013)
seeds/silique, and weight of 100				
seeds. Cultivars Ganyou and				
Oscar, type n/a				
Increase in number of		Open vs.	Ireland	(Stanley et al. 2013)
seeds/silique and seed		exclusion cover		
weight/silique. Cultivars				

Castille (open-pollinated) and
Excalibur (hybrid)

Increase in seed weight/plant, weight of 1,000 seeds, number of seeds/plant, oil content (%), and market value (Euro cents/plant). Cultivar SW Stratos™, open-pollinated	No effect on the number of flowers/plant and number of seeds/plant; reduction of chlorophyll content in seeds	Open vs. pollinator- exclusion cover	Sweden	(Bommarco et al. 2012)
Increase in seed yield (g/m ²), number of seeds/silique, and silique set in MSL 501 C line (male sterile). MSL 501 B (male fertile) line in cage with MSL 501 C	No effect on weight of 1,000 seeds	Caged with <i>Osmia rufa</i> , <i>Eristalis tenax</i> , and <i>Episyrphus</i> <i>balteatus</i> and without pollinators	Germany	(Jauker et al. 2012)

Increase in seed weight/silique and number of seeds/silique. Hybrid Hyola 432	No effect on the number of flowers/plant and number of siliques/plant	Open vs. pollinator exclusion cover	Brazil	(De Souza Rosa et al. 2011)
Increase in silique weight, number of seeds/silique, and silique length. Cultivar Bulbul, open-pollinated		Open vs. caged	Pakistan	(Ali et al. 2011)
Increase in yield (t/ha), number of seeds/silique, and number of siliques/plant. Hybrid Artus	Decrease in weight of 1,000 seeds	Open vs. partial pollinator exclusion (without pollinators of size \geq honeybees) vs.	Chile	(Araneda Durán et al. 2010)

		total pollinator exclusion		
Increase in number of seeds/silique. Cultivar Licosmos, open-pollinated	No differences in weight of individual seeds.	Caged, no hoverflies vs. hoverflies	Germany	(Jauker and Wolters 2008)
Increase in weight of seeds/m ² , number of seeds/m ² , silique set, number of siliques/plant, number of seeds/silique, weight of seeds/silique, and weight of seeds/plant. Open-pollinated cultivar LG3235RR and hybrids Hyola 357RR and Invigor 247LL	No differences or decrease in weight of 1,000 seeds	Addition of beehives vs. caged (or in the field with no addition of beehives or caged)	Canada	(Sabbahi et al. 2005)

<p>Increase in seed yield (g/m²), number of siliques/m², and yield of oil (g/m²) in the treatment closer (<100 m) to apiaries compared to those further away (≥300 m). Cultivar Karoo, type n/a</p>		<p>Plost located at different distances from apiaries</p>	<p>Australia</p>	<p>(Manning and Wallis 2005)</p>
<p>Increase in the number of seeds/silique, number of seeds/plant dry weight, and seed weight/plant dry weight in both lines Male-sterile line Express (MSL) and Male-fertile line Express (MFL). Increase in number of seeds/plant, seed</p>	<p>Decrease in weight of 1,000 seeds in both lines MSL and MFL. Decrease in plant dry weight in MSL. No effect on number of seeds/plant, seed weight/plant, number of</p>	<p>No pollinator vs. high pollinator density (caged)</p>	<p>Germany</p>	<p>(Steffan-Dewenter 2003)</p>

weight/plant, and number of	siliques/plant, and plant			
siliques/plant only in MSL line	dry weight in MFL			
Cultivar CTC-4, open-pollinated	No significant effect on	Open vs. bagged	Brazil	(Mussury and
	silique length, seeds	inflorescences		Fernandes 2000)
	size, number of			
	seeds/plant, weight of			
	10 seeds, and			
	germination			
Increase in number of		Open vs. caged	India	(Sihag 1986)
seeds/silique and silique length.		inflorescences		
Cultivar type n/a				

Table S4. Studies reporting on insect pollination and yield parameters in *Brassica oleracea*; n/a = information not available.

Beneficial effect of insect pollination	No effect of insect pollination	Comparison taken	Country	References
Increase in yield (quintal/ha), number of siliques/plant, number of seeds/silique, and weight of 1,000 seeds. Var. <i>botrytis</i> , cultivar Sel-1, type n/a		Open vs. caged plants	India	(Sharma et al. 2013)
Increase in silique set (%), number of seeds/silique, weight of 100 seeds, and seed germination. Var. <i>botrytis</i> , cultivar Kathmandu Local, open-pollinated		Open/caged with beehive vs. bagged inflorescences	Nepal	(Verma and Partap 1994)

Increase in silique set (%), number of seeds/silique, weight of 100 seeds, and germination. Var. <i>capitata</i> , cultivar Pride of India, open- pollinated		Open/caged with beehive vs. bagged inflorescences	Nepal	(Verma and Partap 1994)
Increase in number of seeds/silique and weight of 100 seeds. Var. <i>botrytis</i> , cultivars Snowball-16, K-1, Sel-1, Sel-12, and Sel-25, type n/a	No significant increase in silique set (%)	Open vs. bagged/caged floral buds	India	(Kumar et al. 1988)
Increase in seed yield (kg/ha), number of siliques/plant, number of		Open vs. caged inflorescences	India	(Sihag 1986)

seeds/silique, seed

weight/plant, and silique

length. Var. *botrytis*,

cultivar n/a

Increase in seed yield (g/5

plants), silique set (%),

silique length, number of

seeds/silique, weight of

1,000 seeds, and

germination. Var. *botrytis*

cultivar Hissar-1, type n/a

Increase in silique set (%),

number of seeds/silique, and

weight of 1 seed. Var.

botrytis cultivar n/a

Shorter (12.5 m) to

longer (200 m) distances

from bee hives

India

(Tewari and Singh 1983)

Open vs. bagged

inflorescences

India

(Varma and Joshi 1983)

Table S5. Studies reporting on insect pollination and yield parameters in *Brassica rapa* (synonymous of *Brassica campestris*); n/a = information not available.

Beneficial effect of insect pollination	No effect of insect pollination	Comparison	Country	References
Increase in yield (weight of seeds/plant). Variety Toria, cultivar n/a, open-pollinated		Open vs. bagged to exclude pollinators	Nepal	(Devkota et al. 2021)
Increase in number of siliques/plant, silique set, seeds/silique, seed diameter, and weight of 100 seeds. Variety Toria, cultivar and type n/a	No significant effect on silique length	Open vs. enclosed plants with netting	Nepal	(Subedi and Subedi 2019)
Increase in yield (g/plant), seeds/silique, and siliques/raceme. Cultivar n/a	No effect on weight of 100 seeds. Decrease in	Open vs. bagged to exclude pollinators	Finland	(Toivonen et al. 2019)

	number of racemes/plant			
Increase in seed yield (g/m ²), number of siliques/raceme, and number of seeds/silique. Variety Toria, open-pollinated	In one of the two sites the increase in seed yield (g/m ²) and number of seeds/silique were not significant	Honeybee hives close to the field (≤ 100 m) vs. no honeybee hives close to the field (1 km)	India	(Stanley et al. 2017)
Increase in seed yield (kg/ha), weight of 1,000 seeds, number of siliques/plant, seeds/silique, and silique length. Variety Toria, cultivar RSPT-1, type n/a		Open/honeybee colonies vs. pollinators excluded with insect-proof nets over plants	India	(Sharma and Abrol 2014)

Increase in seed yield (t/ha), number of siliques/plant, number of seeds/silique, silique length, and harvest index (seed weight/aboveground plant biomass weight). Variety Toria, cultivar Pragati open-pollinated	Decrease in plant height and number of branches/plant	Open vs. caged (with pollinators <i>A. cerana</i> and <i>A. mellifera</i> and without pollinators)	Nepal	(Pudasaini and Thapa 2014)
Increase in weight of 1,000 seeds and germination. Variety Toria, cultivar Pragati, open- pollinated	Increase in oil content not significant	Open vs. caged (with pollinators <i>A. cerana</i> and <i>A. mellifera</i> and without pollinators)	Nepal	(Pudasaini et al. 2014)
Increase in weight of 100 seeds, number of seeds/silique, and silique set		Open vs. enclosed with insect mesh net	India	(Tara and Sharma 2010)

Increase in seed weight/plant, number of siliques/plant, number of seeds/silique, seeds/plant, and germination.	No changes in plant height	Open vs. caged to exclude pollinators	Indonesia	(Atmowidi et al. 2007)
Cultivar n/a				
Increase in seed weight/plant and number of siliques/plant.		Open vs. caged to exclude pollinators	Pakistan	(Khan and Chaudhry 1995)
Var. Sarson, open-pollinated				
Increase in seed yield (g/plant), number of siliques/plant, silique weight, number of seeds/silique, and number of seeds/plant. Var.	No effect on number of flowers/plant	Open vs. bagged plants	India	(Singh and Singh 1992)
Toria, open-pollinated				

Increase in silique set, seeds/silique, percentage of healthy seeds, and oil yield (mg/silique). Var. Sarson, cultivar BSH-1, open-pollinated	Decrease in weight of 100 seeds and oil content (%)	Open vs. bagged/netted plants	India	(Mishra et al. 1988)
Increase in seed yield (kg/ha), number of siliques/plant, number of seeds/silique, seed weight/plant, and silique length. Var. Toria, open-pollinated		Open vs. caged inflorescences	India	(Sihag 1986)

Table S6. Studies reporting on insect pollination and yield parameters in *Raphanus sativus*; n/a = information not available.

Beneficial effect of insect pollination	No effect of insect pollination	Comparison	Country	References
Increase in weight of 1,000 seeds, number of siliques/plant, number of seeds/silique, silique length, germination, and seed vigor. Cultivar n/a		Open vs. bagged plants	India	(Jakhar et al. 2014)
Increase in seed yield (q/ha), number of siliques/plant, number of seeds/silique,		Caged with bees vs. caged without bees	India	(Chandrashekhara and Sattigi 2009)

weight of 1,000 seeds, seed
filling, and seed germination.

Cultivar n/a

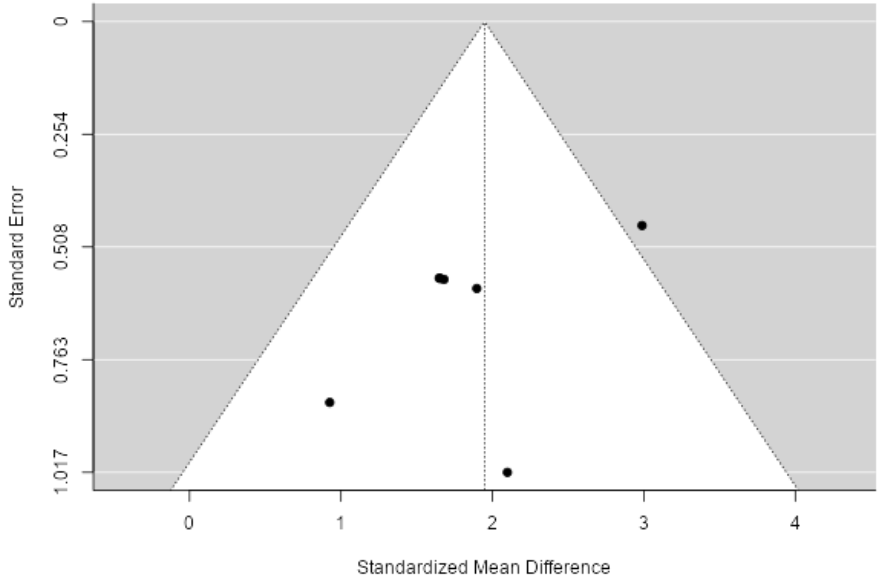
Increase in seed yield (g/plant), weight of 100 seeds, and number of seeds/silique. Cultivar Japanese White	No significant increase in number of siliques/plant, silique length, and germination	Open vs.caged plants	India	(Kapila et al. 2002)
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Increase in weight of 100 seeds, number of seeds/silique, silique set, and germination. Cultivar Mino Early		Caged with one beehive vs. uncaged in open field without beehives	Nepal	(Partap and Verma 1994)
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Increase in number of seeds/silique and silique set.	No significant increase in weight of 100 seeds	Open vs. bagged plants	India	(Verma and Phogat 1994)
Cultivar Japanese Long White				
Increase in seed yield (kg/ha), number of siliques/plant, number of seeds/silique, seed weight/plant, and silique length.			India	(Sihag 1986)
Cultivar n/a				

Fig. S1. Funnel plots corresponding to the meta-analyses of the effect of insect pollination on seed yield in self-compatible (A) and self-incompatible (B) Brassicaceae crops.

A



B

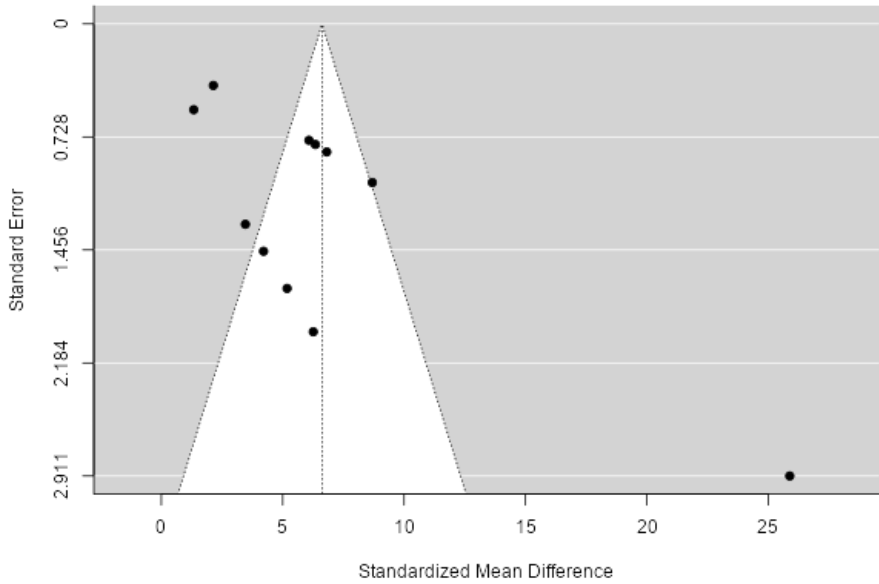
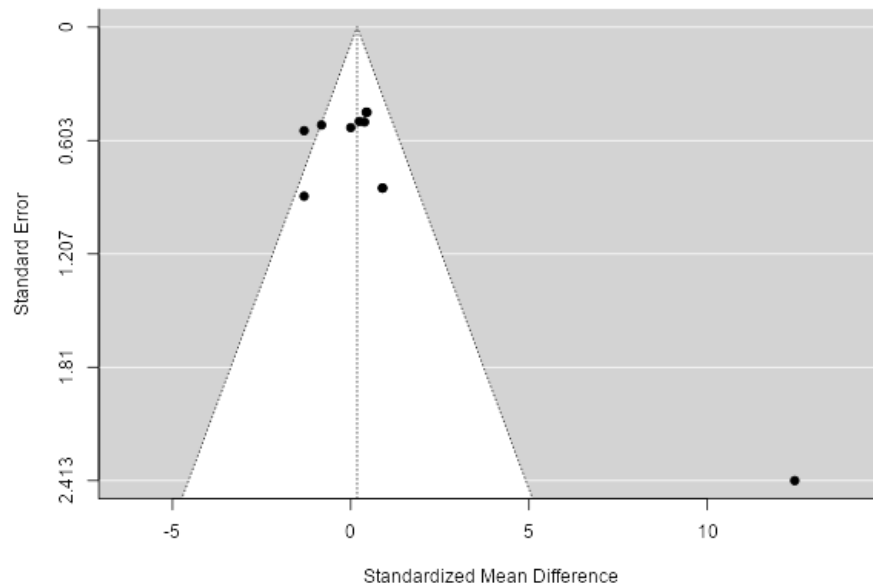


Fig. S2. Funnel plots corresponding to the meta-analyses of the effect of insect pollination on weight of seeds in self-compatible (A) and self-incompatible (B) Brassicaceae crops.

A



B

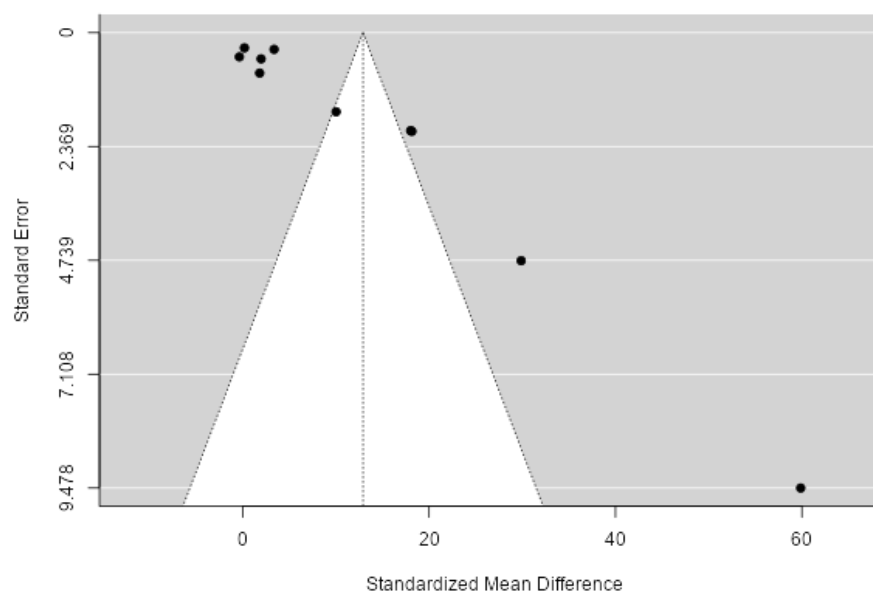
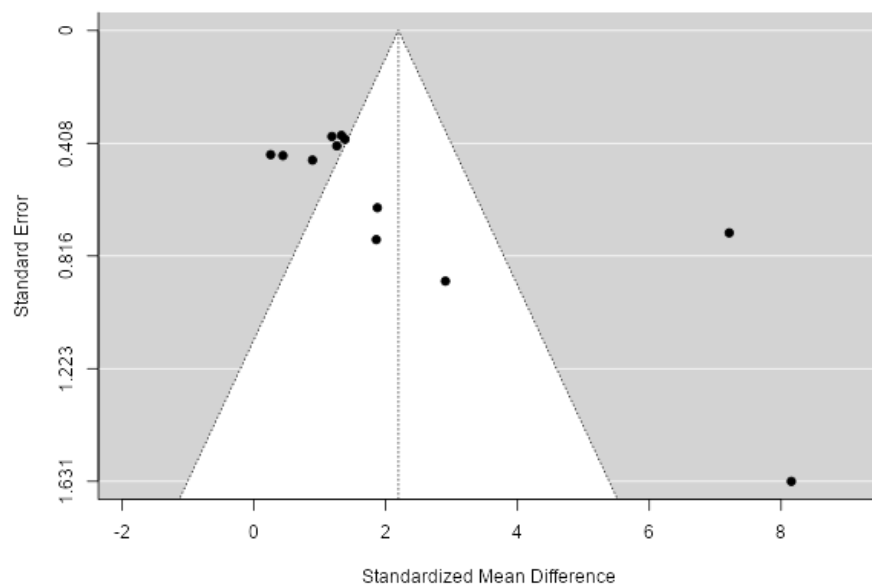


Fig. S3. Funnel plots corresponding to the meta-analyses of the effect of insect pollination on silique set in self-compatible (A) and self-incompatible (B) Brassicaceae crops.

A



B

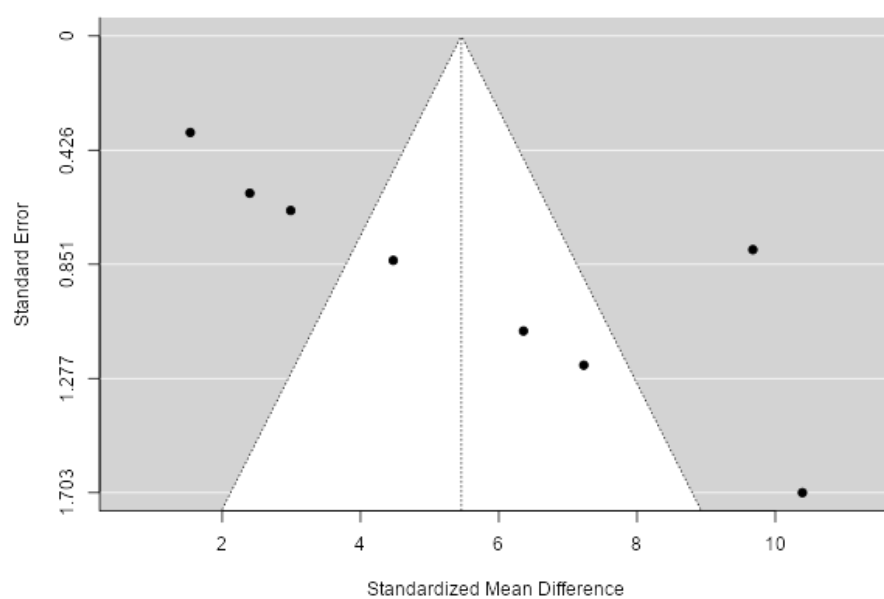
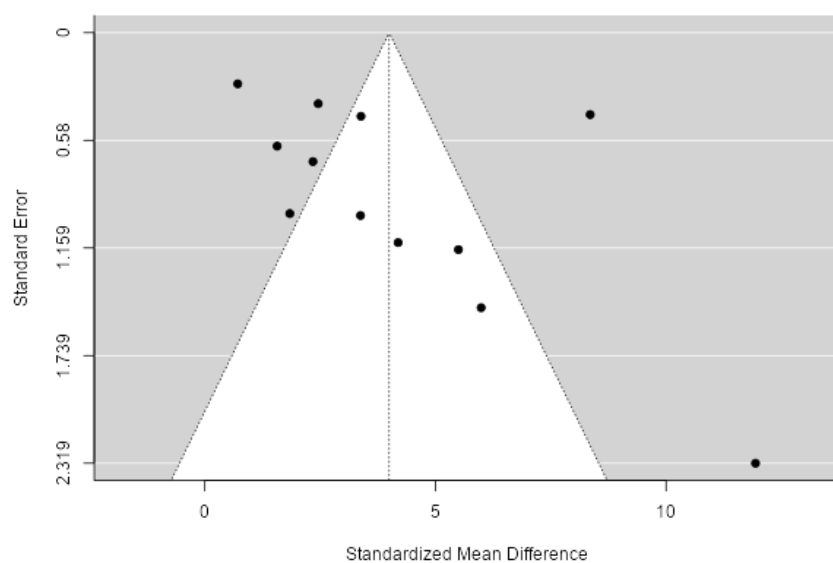


Fig. S4. Funnel plots corresponding to the meta-analyses of the effect of insect pollination on the number of siliques per plant or area in self-compatible (A) and self-incompatible (B) Brassicaceae crops.

A



B

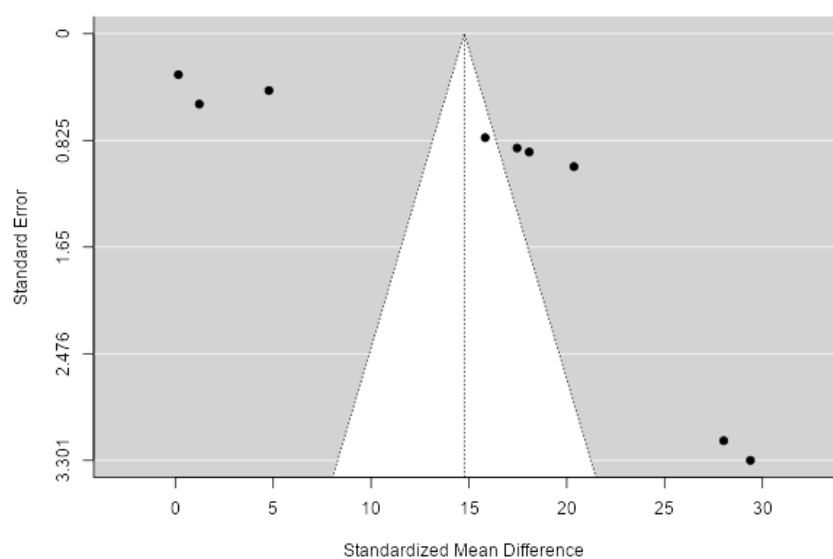
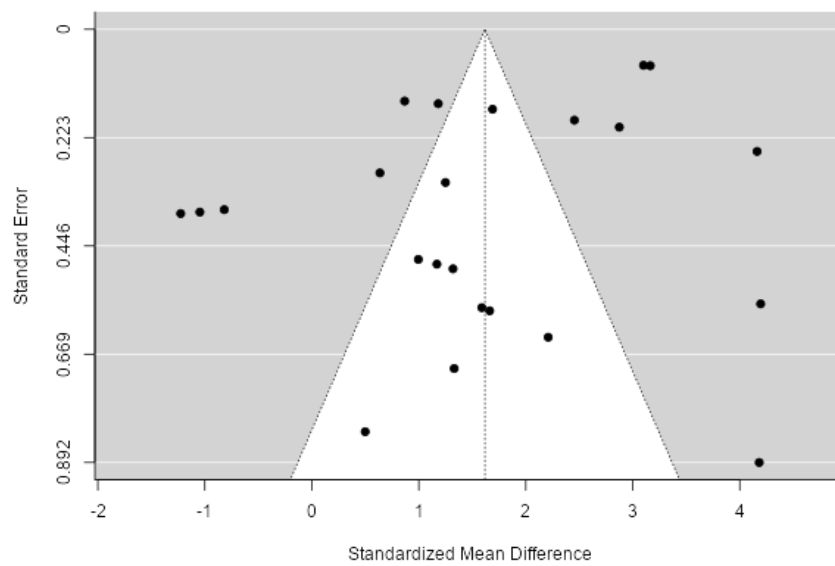
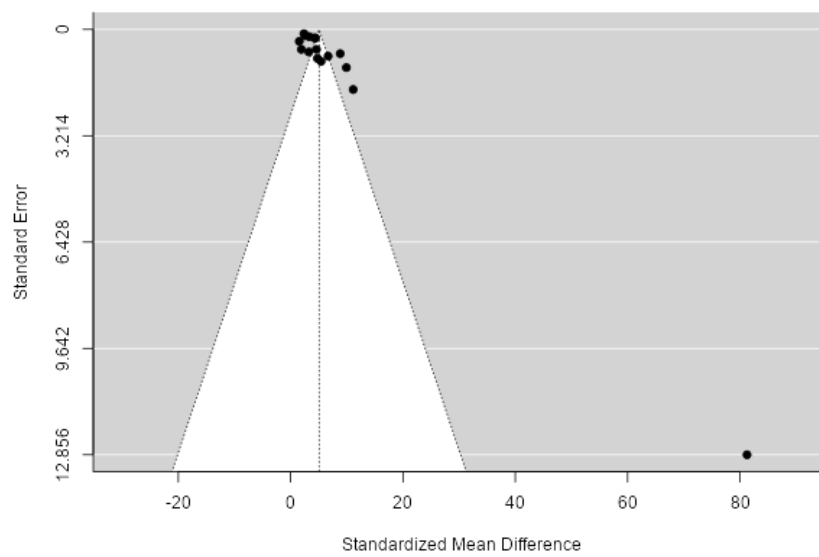


Fig. S5. Funnel plots corresponding to the meta-analyses of the effect of insect pollination on the number of seeds per silique or area in self-compatible (A) and self-incompatible (B) Brassicaceae crops.

A



B



References

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