Review

SCI

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Wheat (*Triticum aestivum* L.)-based intercropping systems for biological pest control

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Abstract

Wheat (*Triticum aestivum* L.) is one of the most cultivated crops in temperate climates. As its pests are mainly controlled with insecticides that are harmful to the environment and human health, alternative practices such as intercropping have been studied for their potential to promote biological control. Based on the published literature, this study aimed to review the effect of wheat-based intercropping systems on insect pests and their natural enemies. Fifty original research papers were obtained from a systematic search of the peer-reviewed literature. Results from a vote-counting analysis indicated that, in the majority of studies, pest abundance was significantly reduced in intercropping systems compared with pure stands. However, the occurrence of their natural enemies as well as predation and parasitism rates were not significantly increased. The country where the studies took place, the type of intercropping and the crop that was studied in the association had significant effects on these results. These findings show that intercropping is a viable practice to reduce insecticide use in wheat production systems. Nevertheless, other practices could be combined with intercropping to favour natural enemies and enhance pest control.

Supporting information may be found in the online version of this article.

Keywords: sustainable agriculture; crop diversity; conservation biological control; predators; parasitoids; yield

1 INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important crops worldwide (ranked fifth in terms of production according to FAOSTAT, http://faostat3.fao.org/browse/Q/QC/E). Therefore, finding alternative methods to improve its sustainable production is a major challenge for today's agriculture. Conventional farming practices contributed to increase yields during the twentieth century, but are today contested for their negative impact on the environment[1,2] and human health.[3] Industrialised monoculture systems, which are highly dependent on the use of external inputs such as agrochemicals (i.e. synthesised fertilisers, chemical pesticides, growth regulators), favoured the simplification of agroecosystems.[4,5]

In contrast, promoting functional biodiversity, which supports ecological processes, may allow agricultural systems to benefit from various ecosystem services, including nutrient cycling, soil structuration and pest control.[6,7] One of the 'agrobiodiversity strategies' to improve the sustainability of wheat production (reviewed by Costanzo and Barberi[8]) is to increase plant species diversity at the field scale through intercropping designs.[9–11] Intercropping is defined as the cultivation of at least two plant species simultaneously in the same field,[12–14] without necessarily being sown and/or harvested at the same time.[15]

Andrews and Kassam[13] categorised intercropping into four principle types based on the spatial and temporal overlap of plant species: (1) mixed intercropping – two or more crops mixed with no distinct row arrangement; (2) row intercropping – two or more crops grown in separate alternate rows (when plant species are alternated within the same row, it is considered to be within-row intercropping); (3) strip intercropping – several rows of a crop (strip) alternated with several rows of one or more other crops; (4) relay intercropping – two or more crops grown in relay, but with the growth cycles overlapping to some degree. Choosing a type of intercropping may depend on the associated crops and their valuation after harvest, in addition to the knowledge of the farmer and the level of mechanisation used.

Intercropping systems tend to produce higher yields compared with monocultures and reduce the impact of agriculture on the environment. Specifically, intercropping may improve soil conservation, fertility and crop quality, while possibly reducing the

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Writing a review like a research paper

The methodology used to collect the data and write this paper

By Séverin Hatt

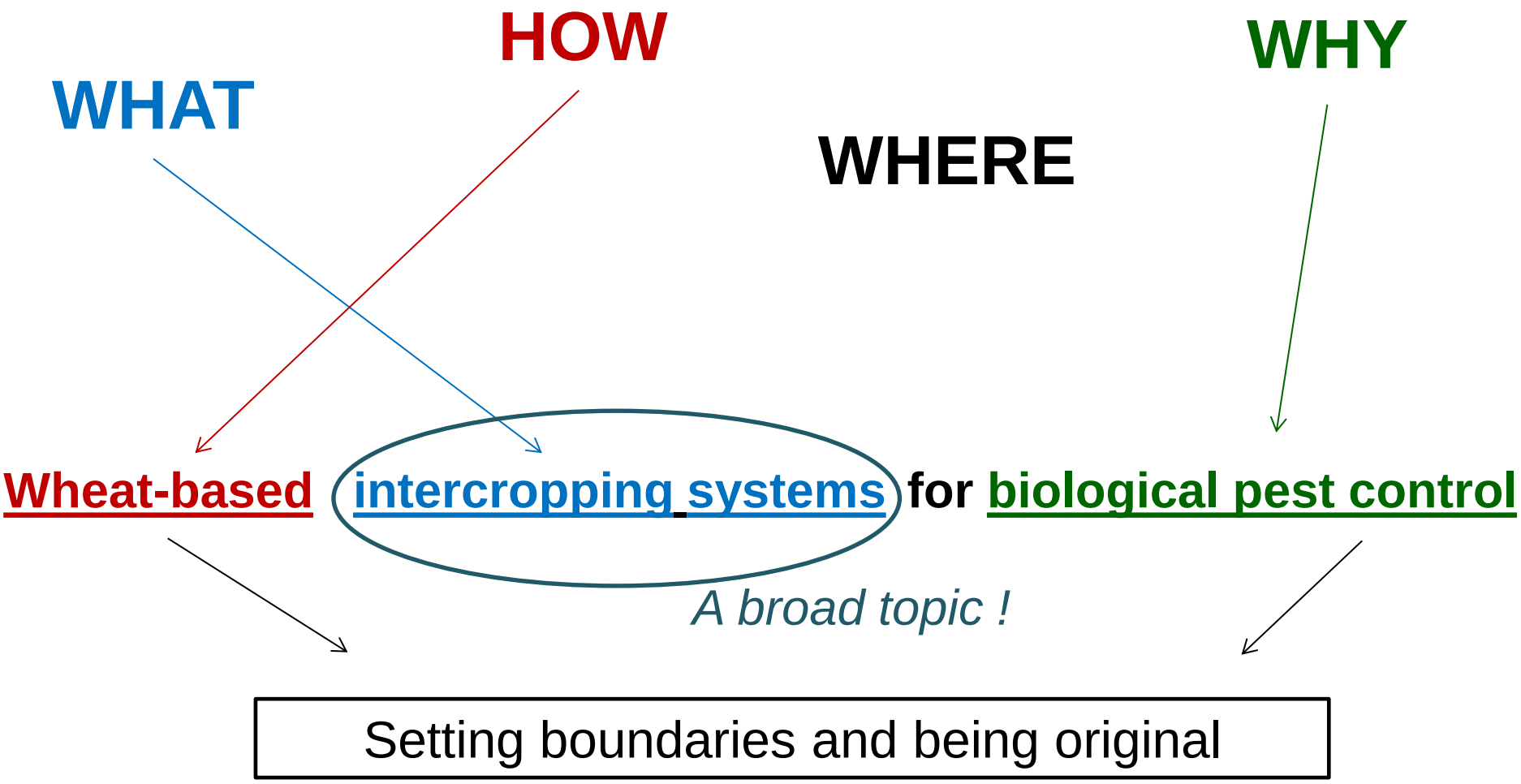
“A review of prior relevant literature is an essential feature of any academic project. An effective review creates a firm foundation for advancing knowledge. It facilitates theory development, closes areas where a plethora of research exists, and uncovers areas where research is needed.”

Webster J. & Watson R.T., 2002. Analyzing the past to prepare the future - Writing a literature review. MIS Quarterly (26)2, pp. xiii-xxiii

PART I

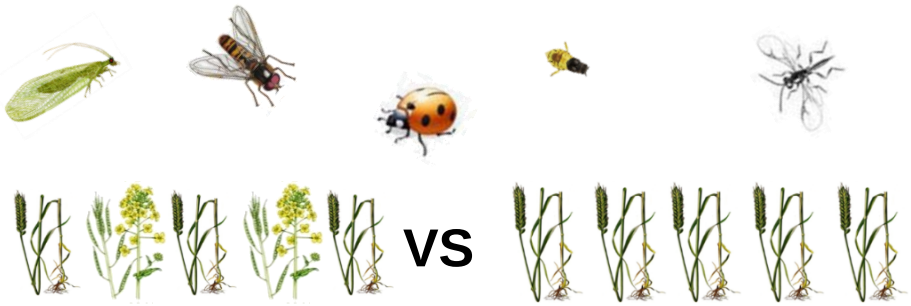
DEFINING AND DISSECTING YOUR TOPIC

Step 1: Define your topic and set the boundaries of your research



Step 2: Define your research questions

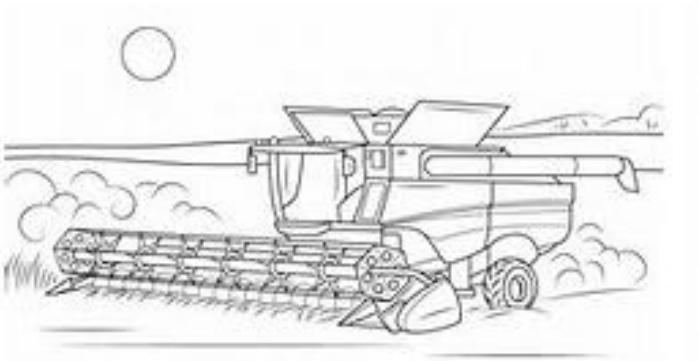
1. Effect of intercropping on pests and natural enemies?



2. Correlation between pest control and yield?

3. Where such studies took place?

4. Technical characteristics of such studied systems?



Step 3: Defining the terms and finding synonyms

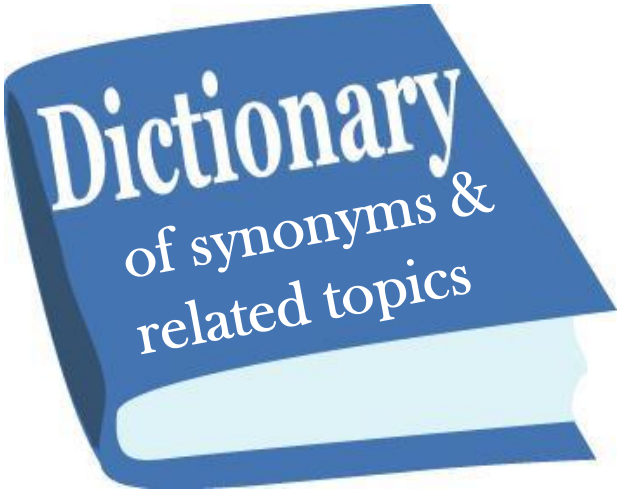
Wheat-based **intercropping systems** **for** **biological pest control**

Wheat
Triticum aestivum

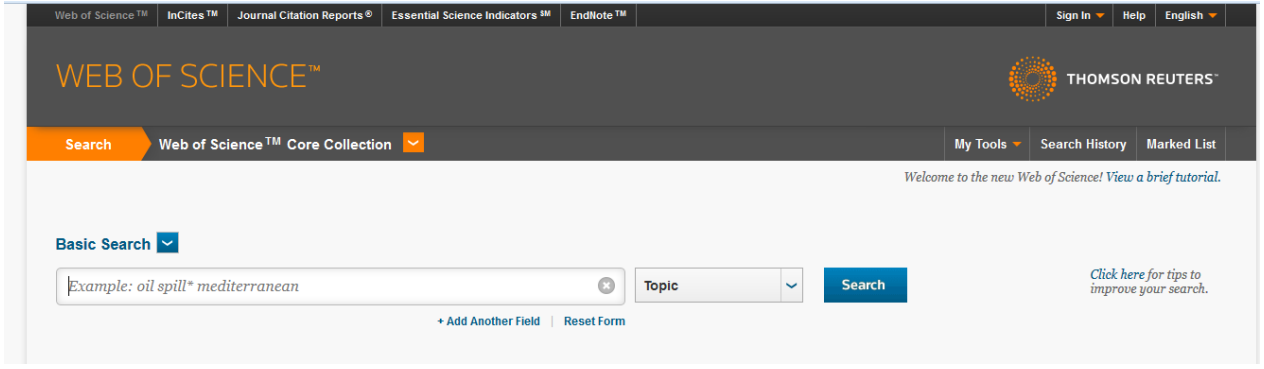
Intercrop*
Crop association
Crop combination
Combined crop
Associated crop
Crop mix
Mixed crop
Mixed cropping

Row cropping
Relay cropping
Strip cropping

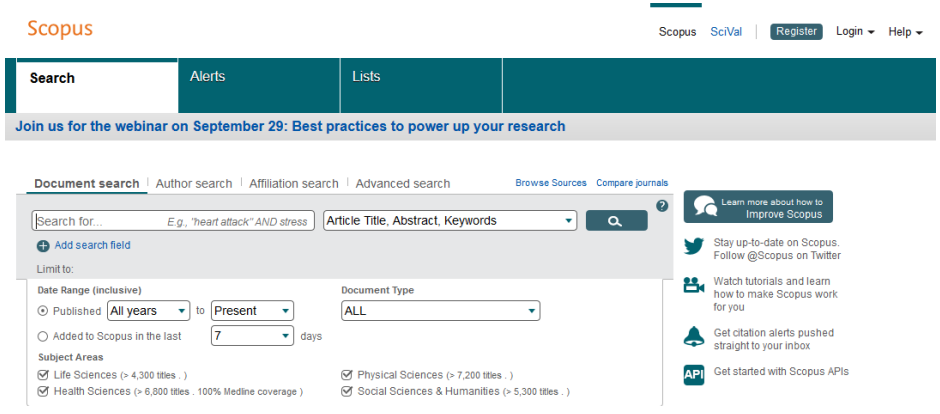
Pest*
Herbivor
Natural enemy
Predator*
Parasit*



Step 4: Search for literature…



Choose one

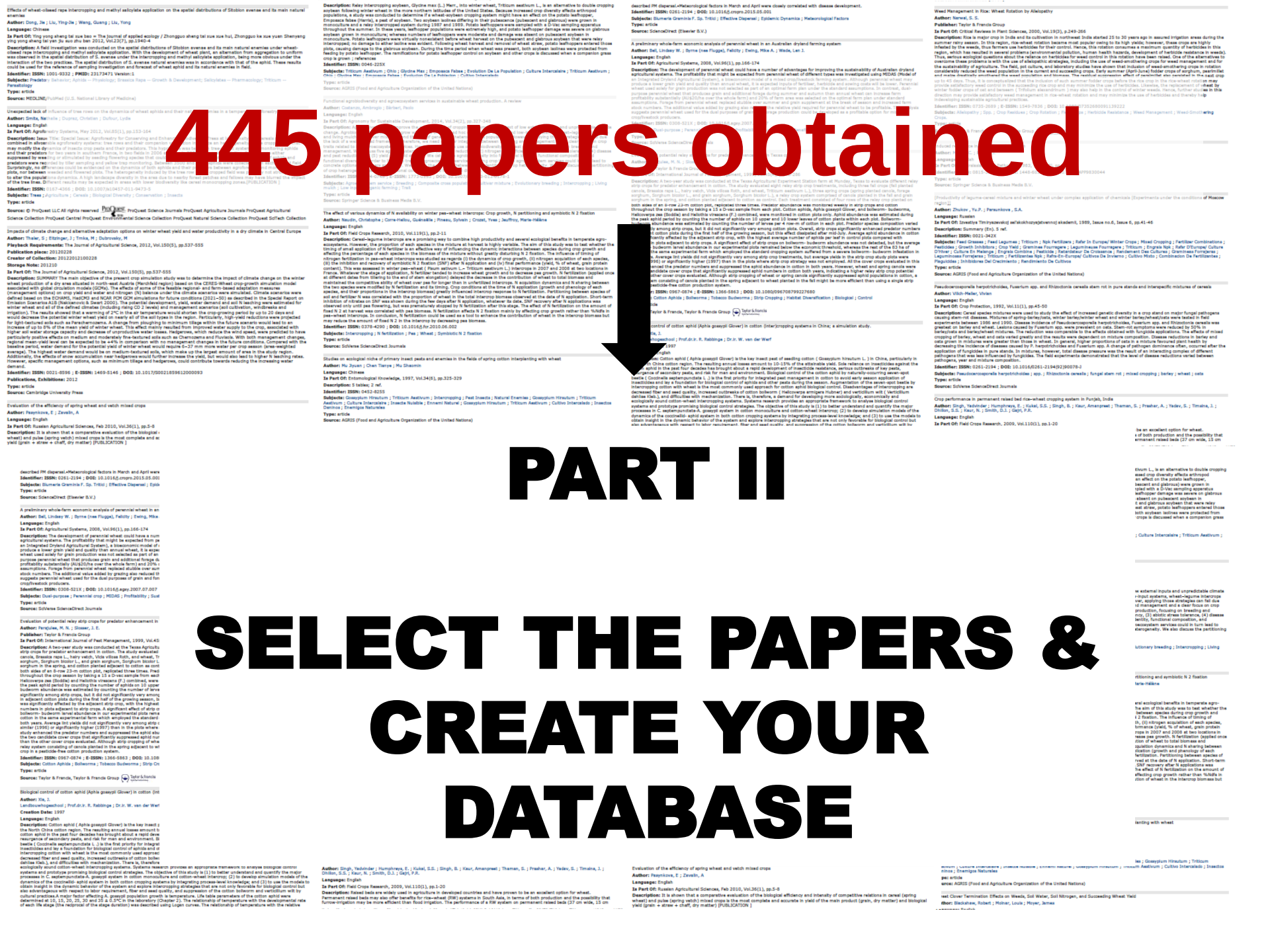


Step 4: …by setting a request

using the boolean operators

Wheat-based **intercropping systems** **for** **biological pest control**

(intercrop* *OR* ‘crop association’ *OR* ‘crop combination’ *OR* ‘combined crop’ *OR* ‘associated crop’ *OR* ‘crop mix’ *OR* ‘mixed crop’ *OR* ‘mixed cropping’ *OR* ‘row cropping’ *OR* ‘relay cropping’ *OR* ‘strip cropping’**)** **AND** **(**wheat *OR* ‘triticum aestivum’**)** **AND** **(**pest* *OR* herbivor* *OR* ‘natural enemy’ *OR* predator* *OR* parasit***)**


445 papers obtained
PART II
SELECT THE PAPERS &
CREATE YOUR
DATABASE

Step 5: Read abstracts and select the relevant papers according to criterias

1. Research papers from peer-reviewed journals

REVIEW

Do polycultures promote win-wins or trade-offs in agricultural ecosystem services? A meta-analysis

Rejected

2. Intercropping: wheat + harvestable and consumable other crop(s)

3. Studying insect pests and/or natural enemies + the effect of biological control

4. Comparison of intercropping with a pure stand control

VS

Step 5: Read abstracts and select the relevant papers according to criterias

	A	B	C	D	E	F	G	H
1	Title	Authors	Year	Abstract	Research paper?	Association?	Including wheat?	Analyzing pests and/or natural enemies?
2	Maize rev	Smale , Melin	2011	There have b	no	no	no	no
3	Should Af	Larson , Donal	2012	In Africa, mo	no	no	no	no
4	Editorial	Naylor, R. E. L.	2006	In our Editor	no	no	no	no
5	Annual M	NONE	2005	NONE	no	no	no	no
6	Breeding	Njoku, D. N. ;	2011	This review p	no	no	no	no
7	Agriculture	R. ; Sayre, Ker	2008		NO	NO	NO	NO
8	fer. A GIS	Aoogenboom,	2000	None	NO	NO	NO	NO
9	le,intensiv	Giliomee, J	2006		NO	NO	NO	NO
10	ere 2:: Stru	Leigh, Linda ;	1999		NO	NO	NO	NO
11	Cereal Pro	hu ; J. Krupnik,	2005		NO	NO	NO	NO
82	Faba bean	LopezBell	2003	The prese	yes	no	yes	no
83	Response	Hummel,	2010	Graphical	yes	yes	yes	yes
84	The ecolo	Wang Hou	1993	In 1988-19	yes	yes	yes	yes
85	How to re	Hansen, L	2008	There is a	yes	yes	yes	yes
86	IMPACT O	Singh, H.P	1999	To compar	yes	no	yes	no
87	Intercropp	Reynolds,	1994	Two cerea	yes	yes	yes	no
88	Reduced	Hobbs , P	1997	Changes i	yes	no	yes	no

50 papers answered our creterias and were selected for further analyses

Step 6: Fill your data table by reading the 50 abstracts (and the full papers if possible and needed)

Each paper is identified with a number

Other information potentially usefull

Research question 3

Location of the study

Research question 2

Indicator used

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	NumPap	Author_Date	Title	Year	Plants	Latin_name	Studied_for_insects	Type_association	Country	Insect_studied	Insect_class	Effect	biological_control
2	P_01	Skelton & Barrett, 2005	A comparison of conv	2005	Alfalfa	*Medicago_sativa*	*Wheat_Alfalfa*	Strip cropping	USA	Predators (spiders)	Predator	(-)	Abundance, Yield
3	P_01	Skelton & Barrett, 2005	A comparison of conv	2005	Alfalfa	*Medicago_sativa*	*Wheat_Alfalfa*	Strip cropping	USA	Pest	Pest	(-)	Abundance, Yield
4	P_02	Zhou et al., 2013a	Adaptation of WheatP	2013	Pea	*Pisum_sativum*	*Wheat*	Strip cropping	China	Sitobion avenae Fabricius	Pest	(-)	Abundance
5	P_02	Zhou et al., 2013a	Adaptation of WheatP	2013	Pea	*Pisum_sativum*	*Wheat*	Strip cropping	China	Ladybeetle	Predator	(+)	Abundance
6	P_02	Zhou et al., 2013a	Adaptation of WheatP	2013	Pea	*Pisum_sativum*	*Wheat*	Strip cropping	China	Parasitoid	Parasitoid	(+)	Abundance
7	P_03	Chen et al., 1994	Allothrombium pulvinu	1994	Cotton	*Gossypium_sp*	*Cotton*	Relay cropping	China	Aphis gossypii (Glover)	Pest	(-)	Abundance
8	P_03	Chen et al., 1994	Allothrombium pulvinu	1994	Cotton	*Gossypium_sp*	*Cotton*	Relay cropping	China	Aphidiids	Parasitoid	(0)	Abundance and predatory/prey ratio
9	P_03	Chen et al., 1994	Allothrombium pulvinu	1994	Cotton	*Gossypium_sp*	*Cotton*	Relay cropping	China	Coccinelids	Predator	(0)	Abundance
10	P_03	Chen et al., 1994	Allothrombium pulvinu	1994	Cotton	*Gossypium_sp*	*Cotton*	Relay cropping	China	syrphids	Predator	(0)	Abundance
11	P_03	Chen et al., 1994	Allothrombium pulvinu	1994	Cotton	*Gossypium_sp*	*Cotton*	Relay cropping	China	ectoparasite Allothrombium pulvi	Parasite	(-)	Abundance
12	P_03	Chen et al., 1994	Allothrombium pulvinu	1994	Cotton	*Gossypium_sp*	*Cotton*	Relay cropping	China	spiders	Predator	(0)	Abundance
13	P_04	Ma et al., 2006	Assessment of cotton	2006	Cotton	*Gossypium_* sp(Bt)	*Cotton*	Relay cropping	China	Aphis gossypii (Glover)	Pest	(-)	Abudance, nb mummies

One line per information = multiple « responses » for one paper

Crop associated with wheat

Type of intercropping

Research question 4

Research question 1

Insect group studied

Effect reported of intercropping on pests or natural enemies compared to pure stand

Step 6: Fill your data table by reading the abstracts (and the full paper if possible and needed)

A data table to be analysed…

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	NumPap	Author_Date	Title	Year	Plants	Latin_name	Studied_for_insects	Type_association	Country	Insect_studied	Insect_class	Effect	biological_control
2	P_01	Skelton & Barrett, 2005	A comparison of cor	2005	Alfalfa	*Medicago_sativa*	*Wheat_Alfalfa*	Strip cropping	USA	Predators (spiders)	Predator	(-)	Abundance, Yield
3	P_01	Skelton & Barrett, 2005	A comparison of cor	2005	Alfalfa	*Medicago_sativa*	*Wheat_Alfalfa*	Strip cropping	USA	Pest	Pest	(-)	Abundance, Yield
4	P_02	Zhou et al., 2013a	Adaptation of Wheat	2013	Pea	*Pisum_sativum*	*Wheat*	Strip cropping	China	Sitobion avenae Fabricius	Pest	(-)	Abundance
5	P_02	Zhou et al., 2013a	Adaptation of Wheat	2013	Pea	*Pisum_sativum*	*Wheat*	Strip cropping	China	Ladybeetle	Predator	(+)	Abundance
6	P_02	Zhou et al., 2013a	Adaptation of Wheat	2013	Pea	*Pisum_sativum*	*Wheat*	Strip cropping	China	Parasitoid	Parasitoid	(+)	Abundance
7	P_03	Chen et al., 1994	Allothrombium pulvir	1994	Cotton	*Gossypium_sp*	*Cotton*	Relay cropping	China	Aphis gossypii (Glover)	Pest	(-)	Abundance
8	P_03	Chen et al., 1994	Allothrombium pulvir	1994	Cotton	*Gossypium_sp*	*Cotton*	Relay cropping	China	Aphidiids	Parasitoid	(0)	Abundance and predatory/prey ratio
9	P_03	Chen et al., 1994	Allothrombium pulvir	1994	Cotton	*Gossypium_sp*	*Cotton*	Relay cropping	China	Coccinelids	Predator	(0)	Abundance
10	P_03	Chen et al., 1994	Allothrombium pulvir	1994	Cotton	*Gossypium_sp*	*Cotton*	Relay cropping	China	syrphids	Predator	(0)	Abundance
11	P_03	Chen et al., 1994	Allothrombium pulvir	1994	Cotton	*Gossypium_sp*	*Cotton*	Relay cropping	China	ectoparasite Allothrombium pu	Parasite	(-)	Abundance
12	P_03	Chen et al., 1994	Allothrombium pulvir	1994	Cotton	*Gossypium_sp*	*Cotton*	Relay cropping	China	spiders	Predator	(0)	Abundance
13	P_04	Ma et al., 2006	Assessment of cotto	2006	Cotton	*Gossypium_* sp(B	*Cotton*	Relay cropping	China	Aphis gossypii (Glover)	Pest	(-)	Abudance, nb mummies
14	P_04	Ma et al., 2006	Assessment of cotto	2006	Cotton	*Gossypium_* sp(B	*Cotton*	Relay cropping	China	A. gifuensis	Parasitoid	(+ ou 0)	Abundance and predatory/prey ratio
15	P_04	Ma et al., 2006	Assessment of cotto	2006	Cotton	*Gossypium_* sp(B	*Cotton*	Relay cropping	China	Lacewings	Predator	(0)	Abundance and predatory/prey ratio
16	P_04	Ma et al., 2006	Assessment of cotto	2006	Cotton	*Gossypium_* sp(B	*Cotton*	Relay cropping	China	Coccinelids	Predator	(+)	Abudance, nb mummies
17	P_04	Ma et al., 2006	Assessment of cotto	2006	Cotton	*Gossypium_* sp(B	*Cotton*	Relay cropping	China	Parasitoid	Parasitoid	(+)	Abudance, nb mummies
18	P_04	Ma et al., 2006	Assessment of cotto	2006	Cotton	*Gossypium_* sp(B	*Cotton*	Relay cropping	China	spiders	Predator	(0)	Abudance, nb mummies
19	P_05	Chevalier Mendes Lopes et a	Associations of Whe	2015	Pea	*Pisum_sativum*	*Wheat_Pea*	Strip cropping and Mixec	Belgium	Acyrthosiphon pisum	Pest	(-)	Populations density and dynamics
20	P_05	Chevalier Mendes Lopes et a	Associations of Whe	2015	Pea	*Pisum_sativum*	*Wheat_Pea*	Strip cropping and Mixec	Belgium	Metopolophium dirhodum	Pest	(-)	Populations density and dynamics
21	P_05	Chevalier Mendes Lopes et a	Associations of Whe	2015	Pea	*Pisum_sativum*	*Wheat_Pea*	Strip cropping and Mixec	Belgium	Adult lacewings	Predator	(NSA)	Abundance and predatory/prey ratio
22	P_05	Chevalier Mendes Lopes et a	Associations of Whe	2015	Pea	*Pisum_sativum*	*Wheat_Pea*	Strip cropping and Mixec	Belgium	Adult ladybirds	Predator	(-)	Populations density and dynamics
23	P_05	Chevalier Mendes Lopes et a	Associations of Whe	2015	Pea	*Pisum_sativum*	*Wheat_Pea*	Strip cropping and Mixec	Belgium	Adult hoverflies	Predator	(-)	Populations density and dynamics
24	P_05	Chevalier Mendes Lopes et a	Associations of Whe	2015	Pea	*Pisum_sativum*	*Wheat_Pea*	Strip cropping and Mixec	Belgium	Adult parasitoids	Parasitoid	(NSA)	Populations density and dynamics
25	**P_06**	Hummel et al., 2009a	CanolaWheatIntercrc	2009	Oilseed	*Brassica_napus*	*Canola*	Mixed cropping	Canada	Flea beetle (Phyllotreta spp.)	Pest	(0)	Abundance and predatory/prey ratio
26	**P_07**	Wang et al., 2011	Combining intercrop	2011	Oilseed	*Brassica_napus*	*Wheat*	Strip cropping	China	Sitobion avenae Fabricius	Pest	(-)	Populations density, Parasitism rates, Yield
27	P_07	Wang et al., 2011	Combining intercrop	2011	Oilseed	*Brassica_napus*	*Wheat*	Strip cropping	China	All stages of Lady beetles	Predator	(+)	Populations density, Parasitism rates, Yield
28	P_07	Wang et al., 2011	Combining intercrop	2011	Oilseed	*Brassica_napus*	*Wheat*	Strip cropping	China	aphid mummies	Parasitoid	(+)	Populations density, Parasitism rates, Yield
29	P_08	Miklasiewicz & Hammond, 20	Density of Potato Le	2001	Soybea	*Glycine_ma_L*	*Soybean*	Relay cropping	USA	potato leafhopper Empoasca f	Pest	(-)	Abundance
30	P_09	Dong et al., 2012a	Ecological effects of	2012	Oilseed	*Brassica_napus*	*Wheat*	Strip cropping	China	Sitobion avenae Fabricius	Pest	(-)	Populations density and biological control index (BCI) ?
31	P_09	Dong et al., 2012a	Ecological effects of	2012	Oilseed	*Brassica_napus*	*Wheat*	Strip cropping	China	All stages of ladybeetles	Predator	(+)	Populations density and biological control index (BCI) ?
32	P_09	Dong et al., 2012a	Ecological effects of	2012	Oilseed	*Brassica_napus*	*Wheat*	Strip cropping	China	Adult aphid parasitoids	Parasitoid	(0)	Populations density and biological control index (BCI) ?
33	**P_10**	Ma et al., 2007a	Economic profit of ir	2007	Cotton	*Gossypium_sp*	*Cotton*	Relay cropping	China	Aphis gossypii (Glover)	Pest	(-)	Abundance, damage, Yield
34	P_10	Ma et al., 2007a	Economic profit of ir	2007	Cotton	*Gossypium_sp*	*Cotton*	Relay cropping	China	ladybeetles	Predator	(+)	Abundance, damage, Yield
35	P_10	Ma et al., 2007a	Economic profit of ir	2007	Cotton	*Gossypium_sp*	*Cotton*	Relay cropping	China	mummified aphids	Parasitoid	(+)	Abundance, damage, Yield
36	P_10	Ma et al., 2007a	Economic profit of ir	2007	Cotton	*Gossypium_sp*	*Cotton*	Relay cropping	China	spiders	Predator	(+)	Abundance, damage, Yield
37	**P_11**	Sherawat et al., 2012	Effect of Brassica St	2012	Oilseed	*Brassica_napus*	*Wheat*	Strip cropping	Pakistan	Wheat aphids	Pest	(-)	Abundance, yield
38	P_11	Sherawat et al., 2012	Effect of Brassica St	2012	Oilseed	*Brassica_napus*	*Wheat*	Strip cropping	Pakistan	Chrysoperla carnea	Predator	(+)	Abundance and predatory/prey ratio
39	P_11	Sherawat et al., 2012	Effect of Brassica St	2012	Oilseed	*Brassica_napus*	*Wheat*	Strip cropping	Pakistan	Lady beetles	Predator	(+)	Abundance, yield
40	P_11	Sherawat et al., 2012	Effect of Brassica St	2012	Oilseed	*Brassica_napus*	*Wheat*	Strip cropping	Pakistan	Spiders	Predator	(0)	Abundance, yield
41	P_12	Masih et al., 1988	Effect of different int	1988	Sugarca	*Saccharum_sp*	*Sugarcane*	?	Pakistan	Whitefly	Pest	(0)	Insect incidence
42	P_12	Masih et al., 1988	Effect of different int	1988	Sugarca	*Saccharum_sp*	*Sugarcane*	?	Pakistan	Pyrilla	Pest	(-)	Insect incidence
43	P_12	Masih et al., 1988	Effect of different int	1988	Sugarca	*Saccharum_sp*	*Sugarcane*	?	Pakistan	Borer	Pest	(-)	Insect incidence

Feuil1 | Data

Prêt

PART III

ANALYSE YOUR DATA

Step 7: Perform data description…

Table 1. Plant species associated with wheat based on the type of intercropping

Type of intercropping	Crops associated with wheat	Number of papers	References
Strip cropping	Alfalfa (*Medicago sativa* L.)	4	70–73
	Garlic (*Allium sativum* L.)	2	74,75
	Mung bean [*Vigna radiata* (L.) Wilczek]	2	76,77
	Oilseed rape (*Brassica napus* L.)	7	42,66,74,78–81
	Pea (*Pisum sativum* L.)	4	82–85
	Chili pepper (*Capsicum frutescens* L.)	1	86
Relay cropping	Cotton (*Gossypium* sp.)	10	44,45,87–94
	Field bean (*Phaseolus vulgaris* L.)	1	95
	Sorghum (*Sorghum bicolor* L.)	1	96
	Soybean [*Glycine max* (L.) Merr.]	2	97,98
Mixed cropping	Oilseed rape (*Brassica napus* L.)	4	99–102
	Bean (*Vicia faba* L.)	1	103
Strip and mixed cropping	Pea (*Pisum sativum* L.)	2	43,104
Non-specified	Chickpea (*Cicer arietinum* L.)	3	105–107
	Cotton (*Gossypium* sp.)	2	108,109
	Bean (*Vicia faba* L.)	1	110
	Mustard (*Sinapis alba* L.)	3	111–113
	Sugarcane (*Saccharum officinarum* L.)	1	114

Step 7: Perform data description…

Table 3. Effect on pests, predators and parasitoids according to the plant species that was studied in the intercropping

Crop	Effect (–)	Effect (0)	Effect (+)	Number of papers	References
Pest abundance					
Bean	♦			1	103
	♦		♦	1	95
Chickpea	♦			3	105–107
Chili pepper	♦			1	86
Cotton	♦			10	44,45,87,88,90–94,108
	♦		♦	2	89,109
Mustard	♦			2	112,113
		♦		1	111
Oilseed rape		♦		3	99–101
	♦			2	79,102
Pea	♦			1	104
Sorghum	♦	♦		1	96
Soybean	♦			2	97,98
Sugarcane	♦	♦		1	114
Wheat	♦			15	66,71–78,80–85
Wheat and alfalfa	♦			1	70
Wheat and bean	♦			1	110
Wheat and pea	♦			1	43
Predator abundance and predation rate					
Cotton			♦	5	89,91,93,108,109
		♦		2	44,45
		♦	♦	2	92,94
Oilseed rape	♦		♦	1	42
Sorghum		♦		1	96
Wheat			♦	8	66,72,75,76,78,80,83,85
		♦	♦	2	74,81
		♦		1	73
Wheat and alfalfa	♦			1	70
Wheat and pea	♦			1	43
Parasitoid abundance and parasitism rate					
Cotton		♦		1	45
			♦	2	92,93
Oilseed rape	♦	♦		1	102
Wheat		♦		1	80
		♦	♦	1	74
			♦	8	66,71,75,76,78,82,83,85

Step 7: Perform data description…

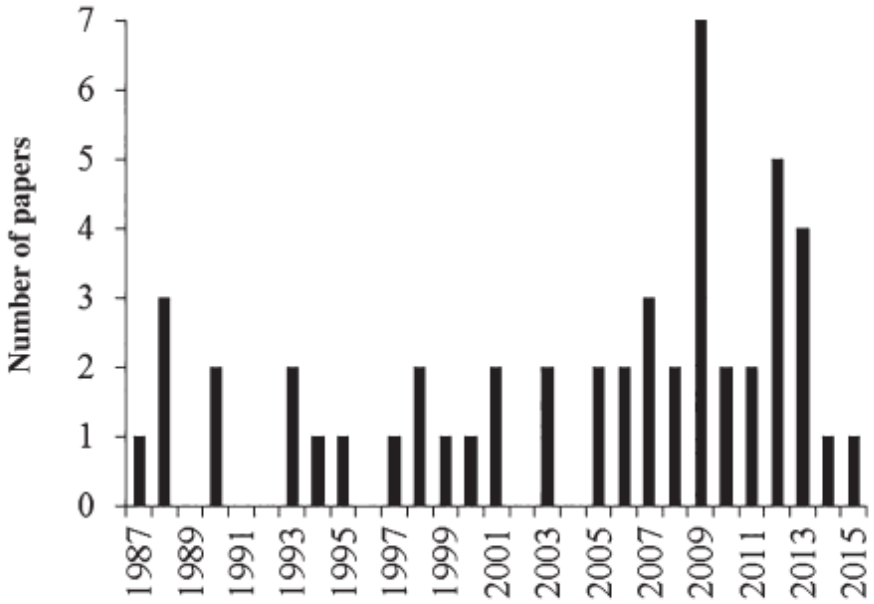


Figure 2. Evolution through time of the number of papers published on the effect of wheat-based intercropping on pests and their natural enemies.

Step 7: …and statistical analyses

1. Effect of intercropping on pests and natural enemies?

Positive (1) or negative/neutral (0) ?

→ Bernouilli test

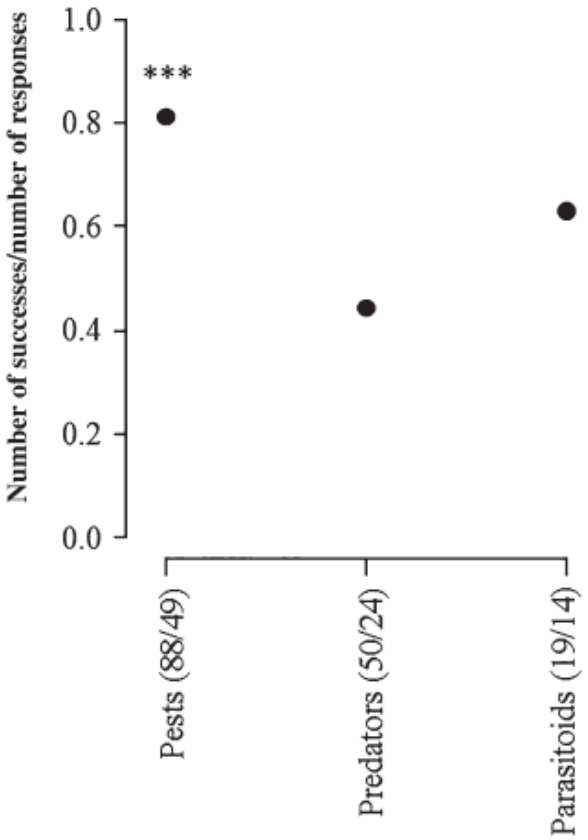


Figure 3. Ratio of the number of responses reporting a positive effect of wheat-based intercropping on biological control (i.e. decrease in pest and increase in natural enemy populations) on the total number of responses. The ratio given in brackets corresponds to the number of responses/number of papers. Exact Bernouilli test. *** $P < 0.001$.

Step 7: …and statistical analyses

2. Correlation between pest control and yield?

Positive (1) or negative/neutral (0) ?

Increased/neutral (1) or decreased (0)

Pearson correlation

Pest reduction and yield increase: φ=0.45, P =0.145

Increase of predator populations/predator rate and yield increase: φ=0.77, **P =0.024 ***

Increase of natural enemies/rate and yield increase: φ=0.81, **P =0.002 ****

Step 7: Perform statistical analyses

3. Where such studies took place?

4. Technical characteristics of such studied systems?

How these factors affect pest control?

Effects: Positive (1) or negative/neutral (0)

⇩

GLM – Binomial error distribution

&

Likelihood ratio-test (χ^2)

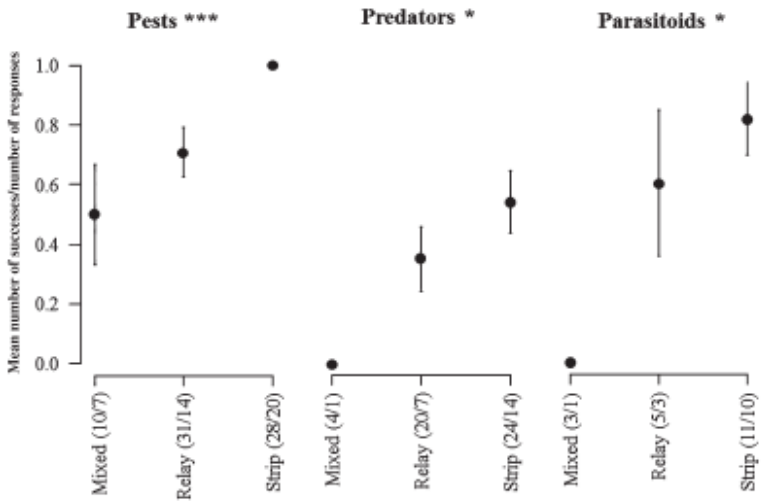
Table 2. Effect of wheat-based intercropping on pests and natural enemies according to the countries where the studies took place, the type of intercropping and the crop of primary interest. Likelihood ratio tests on GLMs. * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$. A dash indicates that it was not possible to perform the analysis

	Pests			Predators			Parasitoids		
Predictor variables	df	χ^2	Pr (> chi)	df	χ^2	Pr (> chi)	df	χ^2	Pr (> chi)
Country	10	19.47	0.035*	5	21.47	<0.001***	2	7.61	0.0223*
Type of intercropping[a]	2	18.39	<0.001***	2	6.20	0.045*	2	7.85	0.020*
Crop	11	27.63	0.004**	5	8.46	0.133	2	7.85	0.020*
Crop*type of intercropping[a]	–	–	–	–	–	–	–	–	–
Crop*country	–	–	–	1	1.29	0.255	–	–	–
Country*type of intercropping[a]	–	–	–	1	2.15	0.142	–	–	–

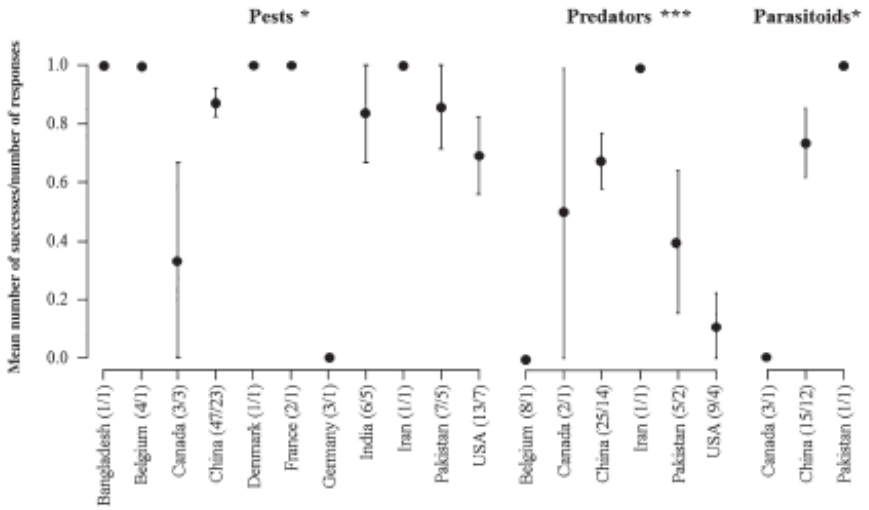
[a] Papers where the intercropping design was not defined were not considered in the analysis.

Step 7: …and statistical analyses

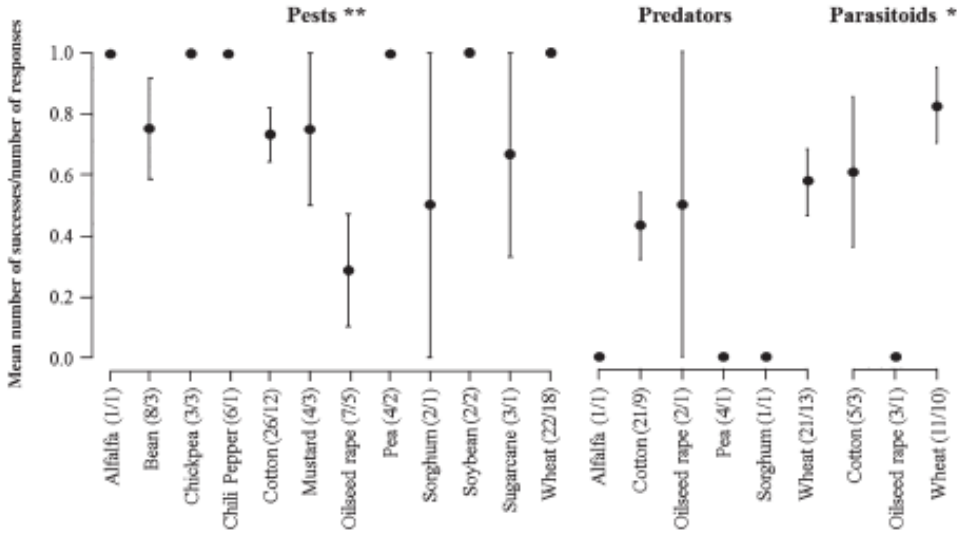
Type of intercropping



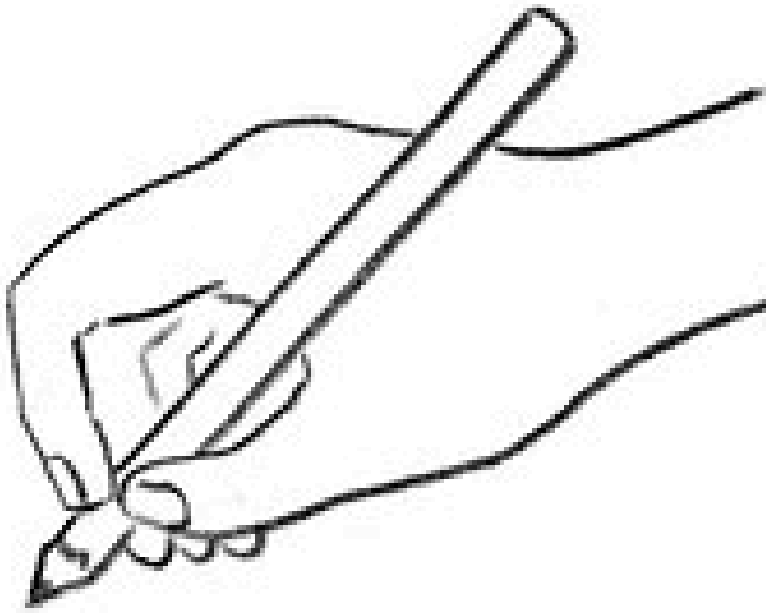
Country



Crop associated with wheat



Step 8: Lastly, write your review like a research paper



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