

How agricultural techniques mediating bottom-up and top-down regulation foster crop protection against pests

A review

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Ecological Management of Bioagressors in Agrecosystems

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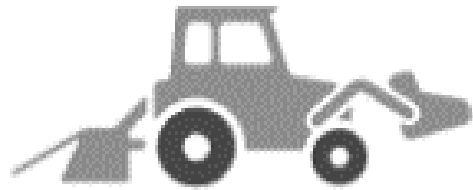
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Programme

- Background/Context
- Method
- Results
- Discussion/Conclusion

Context



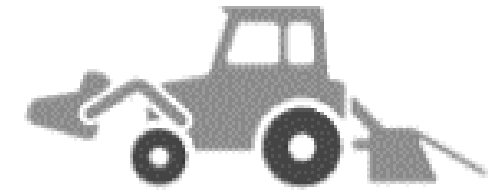
Agriculture

(Foley *et al.* 2005)



Synthetic pesticides

(Cooper & Dobson, 2007)



Biodiversity

(Geiger *et al.* 2010)



Pollution

(Arias-Estévez *et al.*, 2008;
Silva *et al.*, 2019)



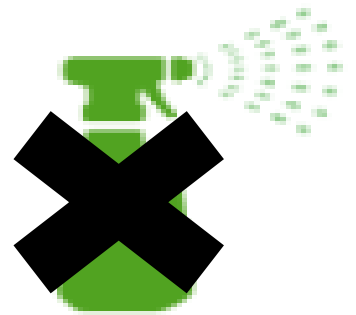
Health

(Budzinski & Couderchet, 2018)



Tolerance

(Hawkins *et al.*, 2019)

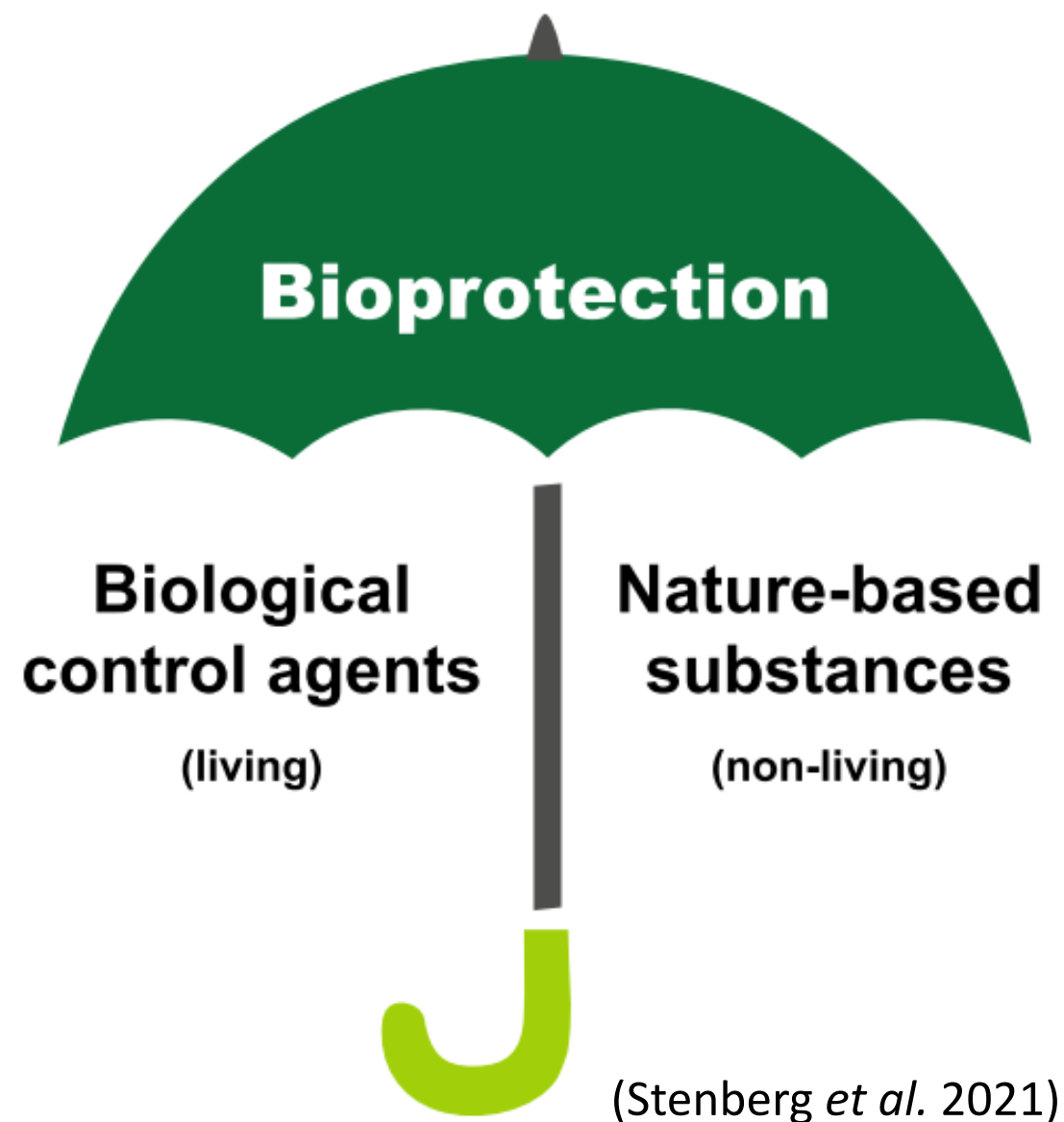


Call for a sustainable pest management strategy

Alternative Pest Management Strategies

Directive 2009/128/EC (European Parliament, 2009)

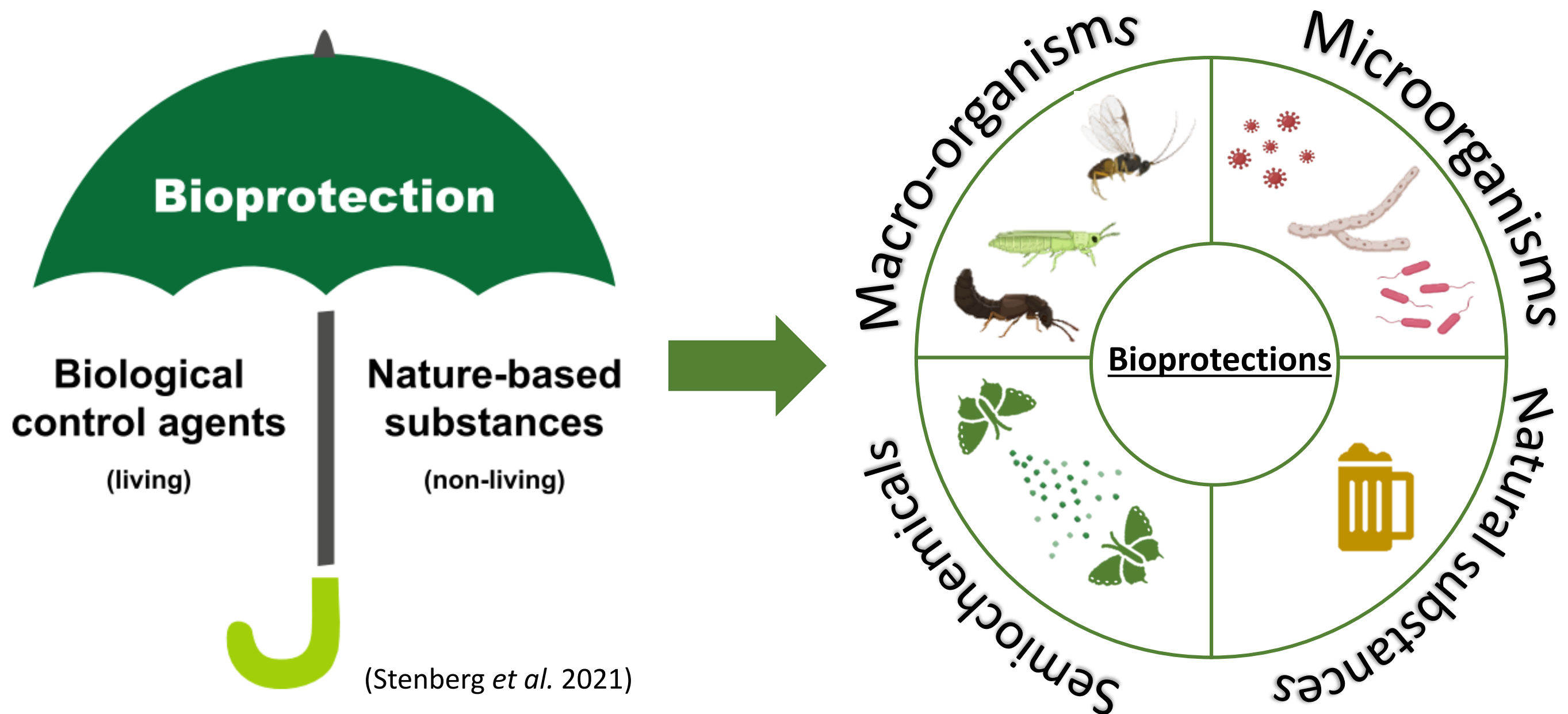
A framework for an integrated pest management (IPM)



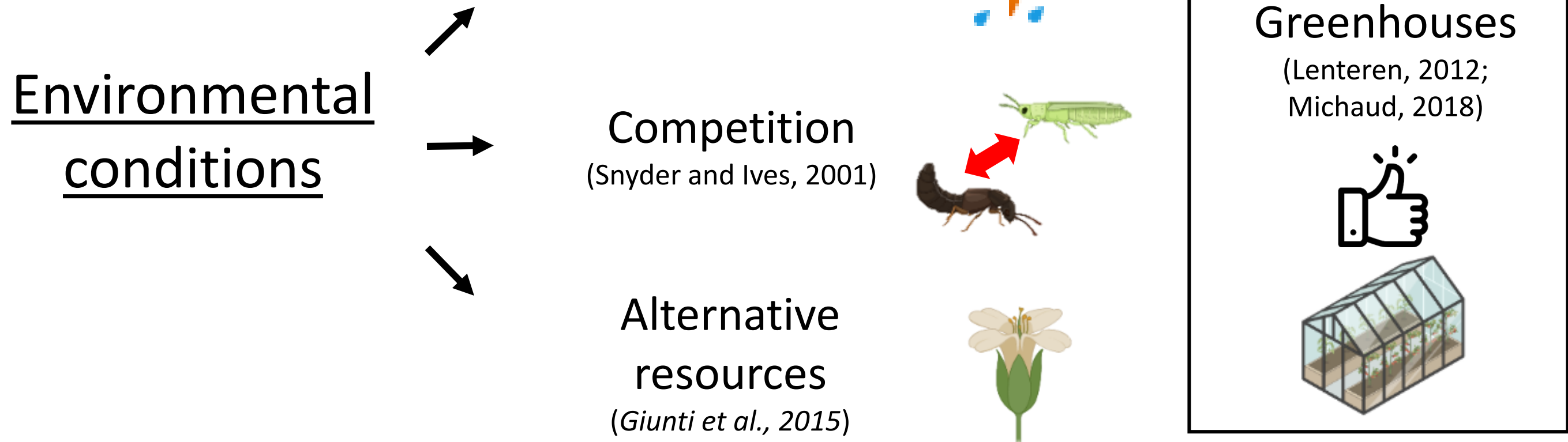
Alternative Pest Management Strategies

Directive 2009/128/EC (European Parliament, 2009)

A framework for an integrated pest management (IPM)

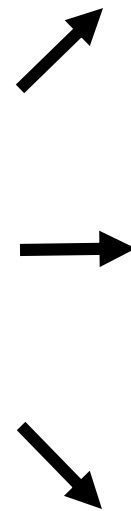


Limitations for the integration of bioprotections in the agroecosystem



Limitations for the integration of bioprotections in the agroecosystem

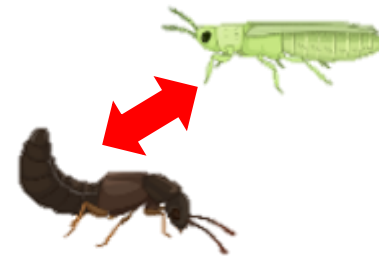
Environmental conditions



Weather
(Norris *et al.*, 2002)



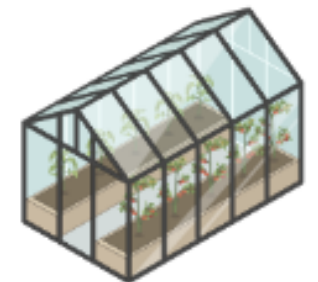
Competition
(Snyder and Ives, 2001)



Alternative resources
(Giunti *et al.*, 2015)



Greenhouses
(Lenteren, 2012;
Michaud, 2018)



“Silver bullet”
(Hokkanen, 2015)



Knowledge gap

Bottom-up
Agricultural techniques



Direct effect
on crop pest

Reducing crop accessibility

Interrupting pest life cycle

(Hokkanen, 1991)

Knowledge gap

Bottom-up
Agricultural techniques



Direct effect
on crop pest

Reducing crop accessibility
Interrupting pest life cycle
(Hokkanen, 1991)

Top-down
Bioprotections



Indirect effect
on crop pest

Food resources
Nests, refugees
(Médiène *et al.*, 2011;
Hatt *et al.*, 2018)

Knowledge gap

Bottom-up
Agricultural techniques



Direct effect
on crop pest

Reducing crop accessibility
Interrupting pest life cycle
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Top-down
Bioprotections



Indirect effect
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Nests, refugees
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Bioprotections and Agricultural techniques may benefit each other
but still remain analyzed independently

Aim

We reviewed the scientific literature of the last ten years focused on the integration of agricultural techniques and bioprotections for a holistic pest management strategy

Bottom-up effect on crop pests

Agricultural techniques

- Crop spatial diversification
- Crop temporal diversification
 - Soil management

Top-down effect of bioprotections

Bioprotections

- Macroorganisms
- Microorganisms
- Semiochemicals
- Natural substances

Aim

- We provide information for the design of future experimental trials in open field
- We test if agricultural techniques which support bioprotections represent an efficient pest management strategy in comparison with a single agricultural technique

Bottom-up effect on crop pests

Agricultural techniques

- Crop spatial diversification
- Crop temporal diversification
 - Soil management

Top-down effect of bioprotections

Bioprotections

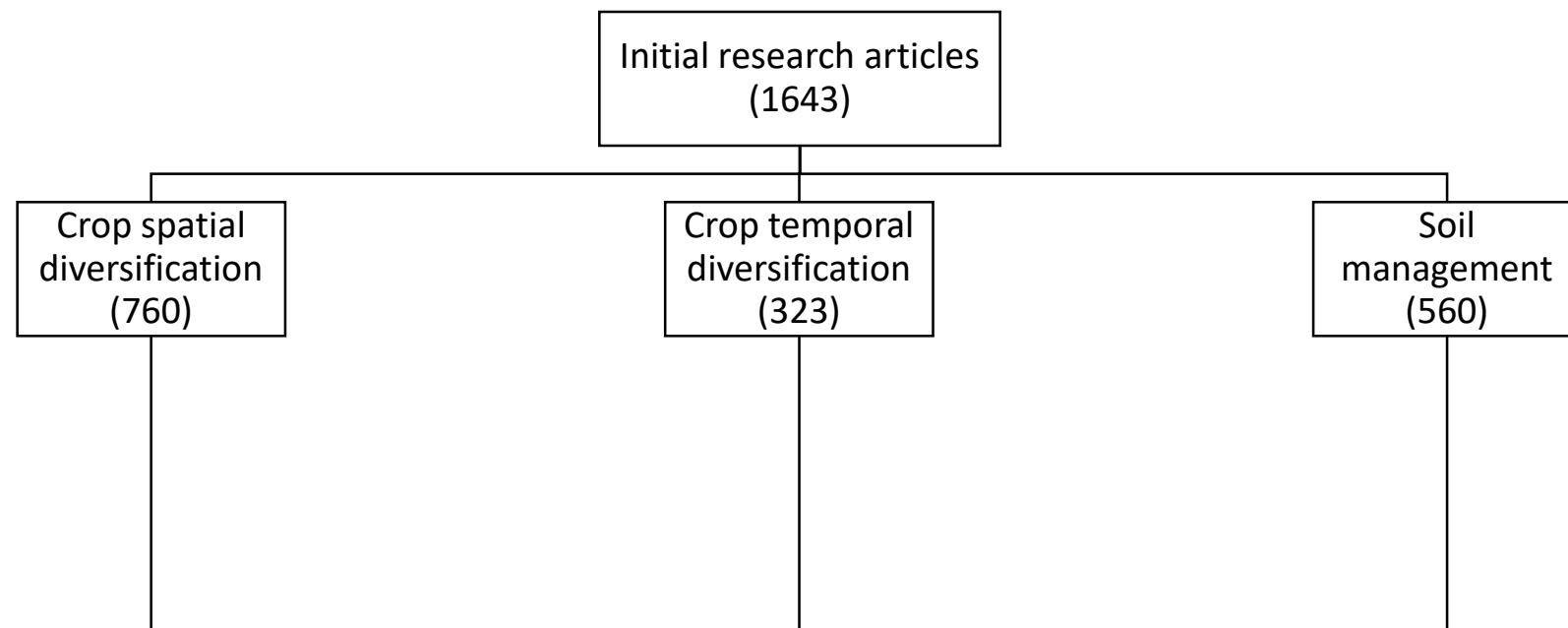
- Macroorganisms
- Microorganisms
- Semiochemicals
- Natural substances

Key-words

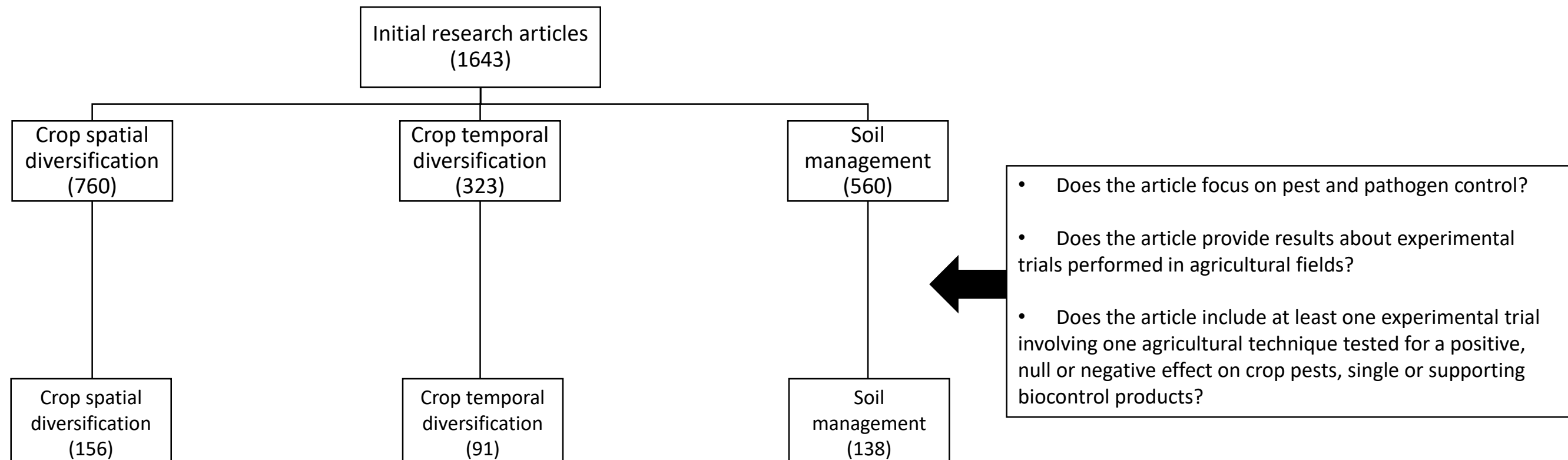
- Scopus database
- January-February 2021

<p><u>(i) Crop spatial diversification</u></p>	<p>(("biocontrol" OR "bio-control" OR "biological control" OR "control") AND ("pest*" OR "pathogen*" OR "herbivor*" OR "plant damage*") AND ("crop*" OR "agroecosystem*" OR "agroecosystem*") AND ("diversification*" OR "spatial crop diversit*" OR "intercrop*" OR "habitat manipulation" OR "push-pull" OR "hedgerow*" OR "service crop*" OR "living mulch*" OR "companion plant*" OR "trap crop*" OR "field margin*") AND NOT ("orchard*" OR "forest*" OR "weed*" OR "greenhouse*" OR "lab*"))</p>
<p><u>(ii) Crop temporal diversification</u></p>	<p>(("biocontrol" OR "bio-control" OR "biological control" OR "control") AND ("pest*" OR "pathogen*" OR "herbivor*" OR "plant damage*") AND ("crop*" OR "agroecosystem*" OR "agroecosystem*") AND ("diversification*" OR "temporal crop diversit*" OR "habitat manipulation*" OR "cover crop*" OR "rotation*" OR "crop rotation*" OR "crop cycle*") AND NOT ("orchard*" OR "forest*" OR "weed*" OR "greenhouse*" OR "lab*"))</p>
<p><u>(iii) Soil management</u></p>	<p>(("biocontrol" OR "bio-control" OR "biological control" OR "control") AND ("pest*" OR "pathogen*" OR "herbivor*" OR "plant damage*") AND ("crop*" OR "agroecosystem*" OR "agroecosystem*") AND ("soil management*" OR "habitat manipulation*" OR "tillage*" OR "no-tillage*" OR "manure*" OR "PGPR*" OR "amendment*" OR "mulch*") AND NOT ("orchard*" OR "forest*" OR "weed*" OR "greenhouse*" OR "lab*"))</p>

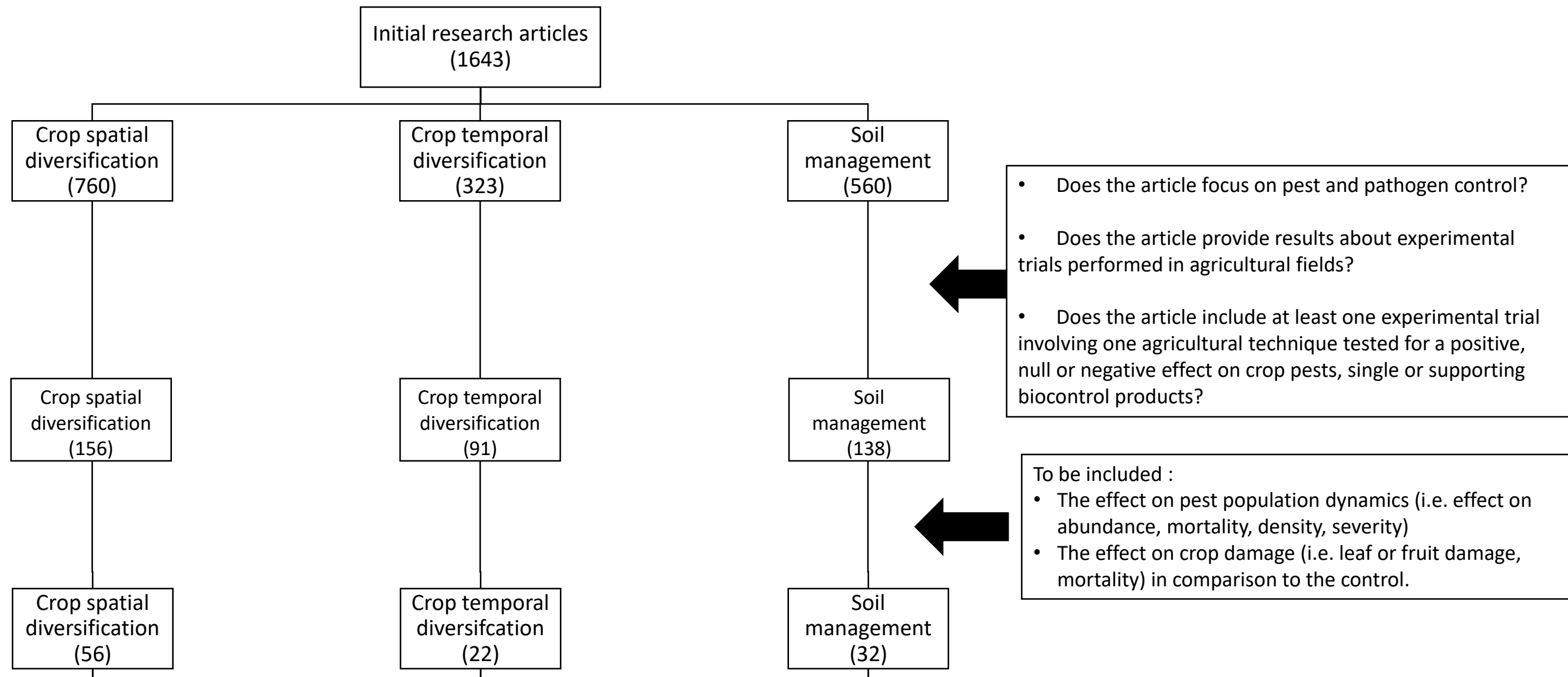
Review method



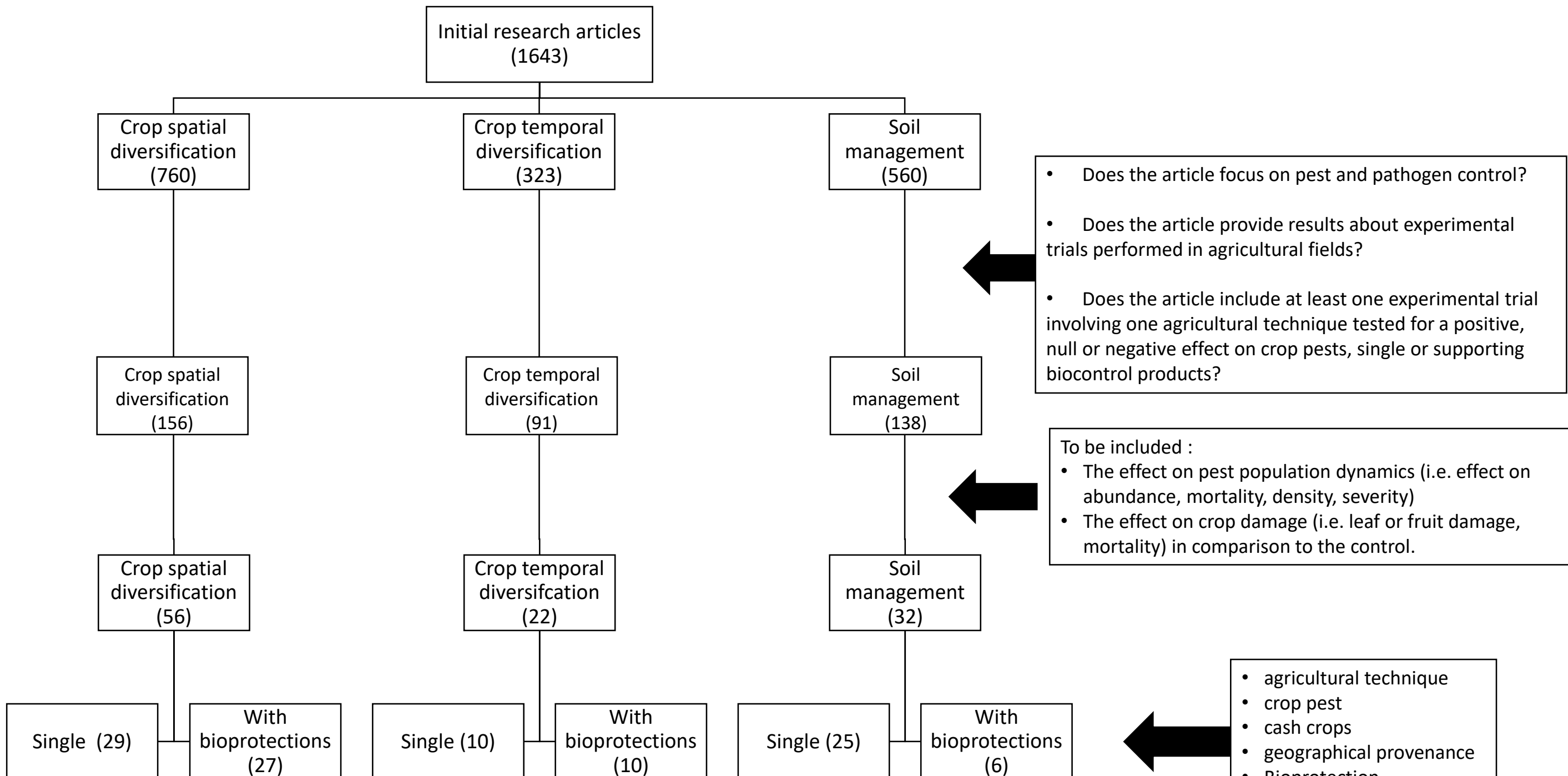
Review method



Review method

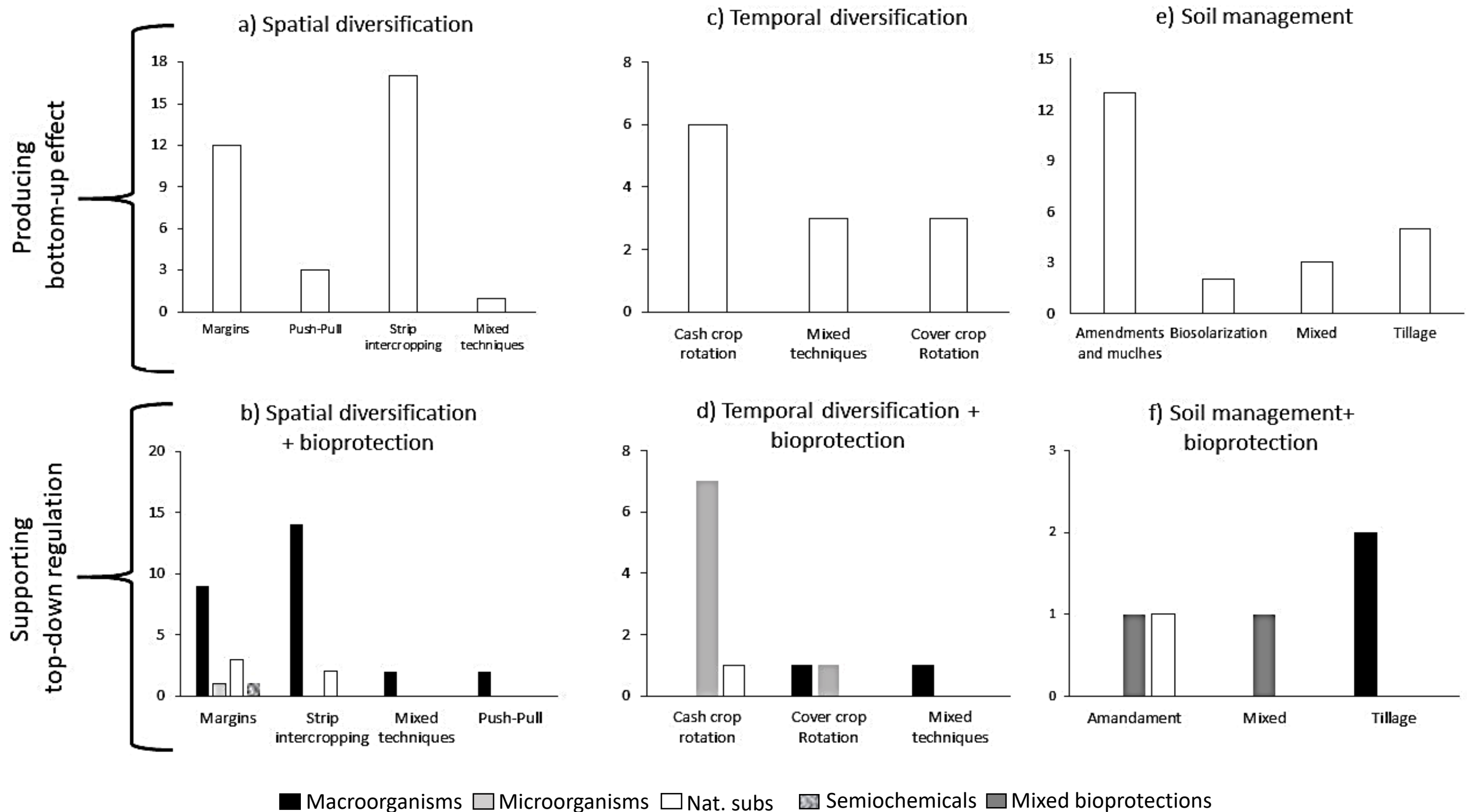


Review method



Results

The number of research articles with experimental trials for bottom-up effect and top-down regulation on crop pest

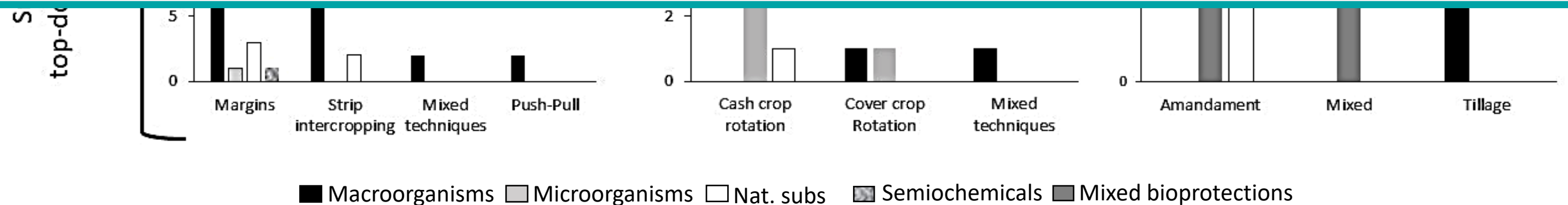


Results

The number of research articles with experimental trials for bottom-up effect and top-down regulation on crop pest

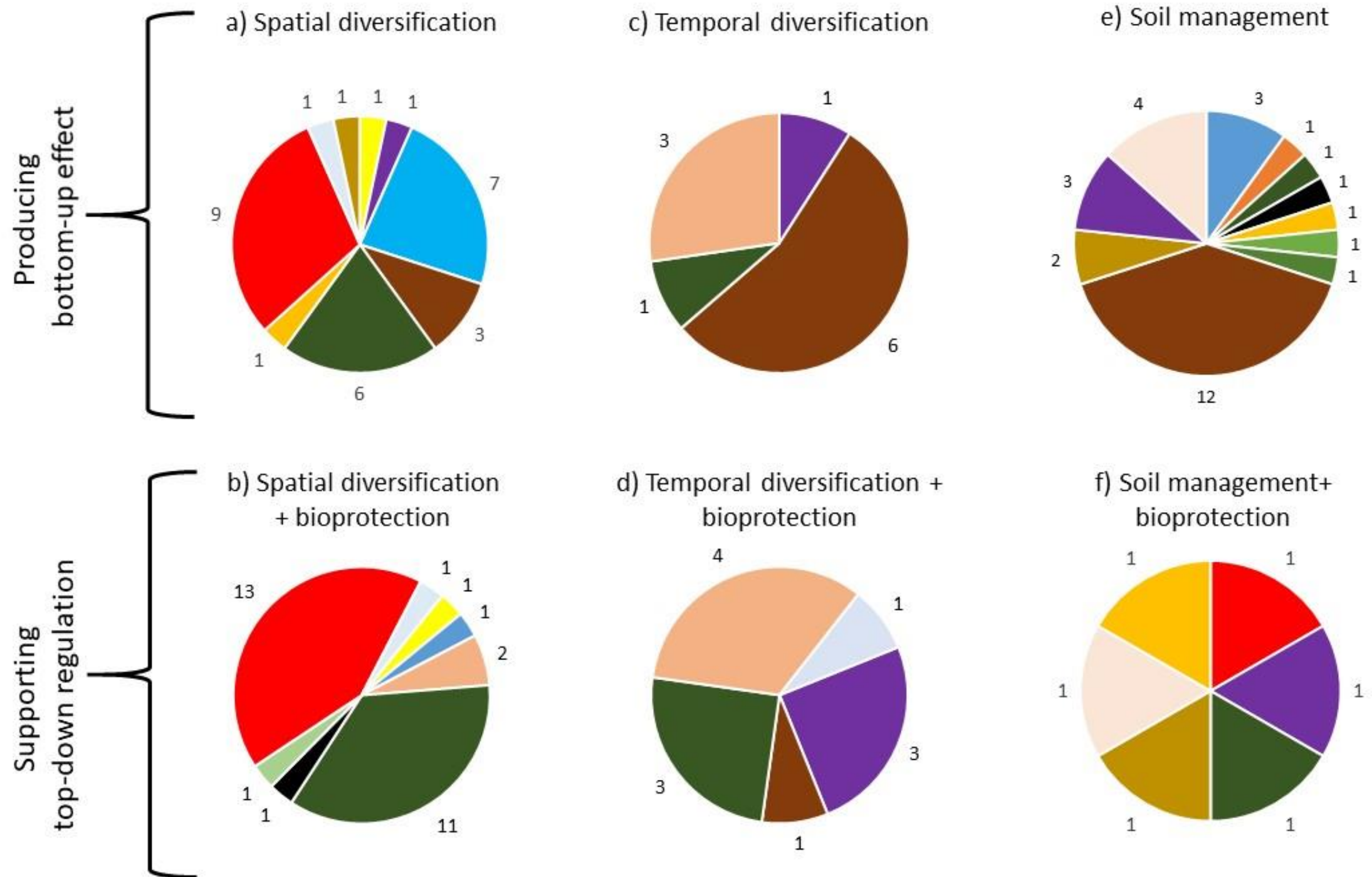
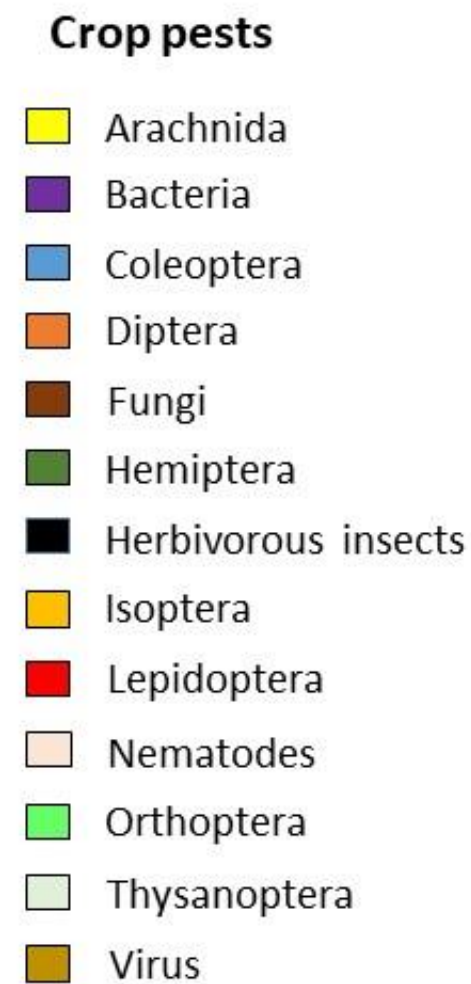
b) Spatial diversification c) Temporal diversification e) Soil management

- Research mainly interested in crop spatial diversification
- All agricultural techniques showed specificity for the bioprotection to which they support:
 - Spatial diversification → Macro-organism bioprotection
 - Temporal diversification → Microorganism bioprotection
 - Soil management → Few research
- Non-living substances and semiochemicals were under-studied bioprotections
- Few research articles involving augmented bioprotections



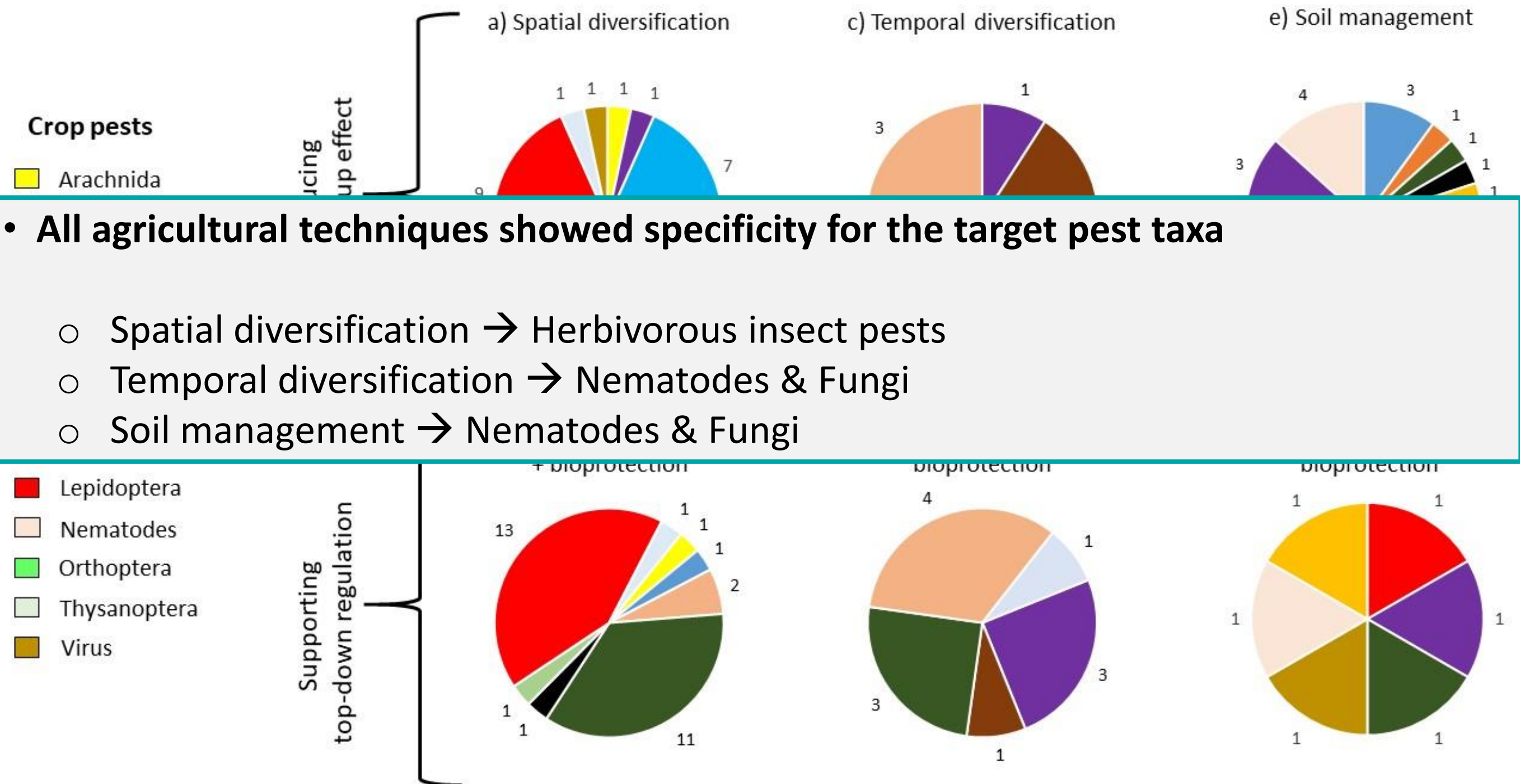
Results

The number of research articles focusing on different pest taxa for bottom-up effect and top-down regulation



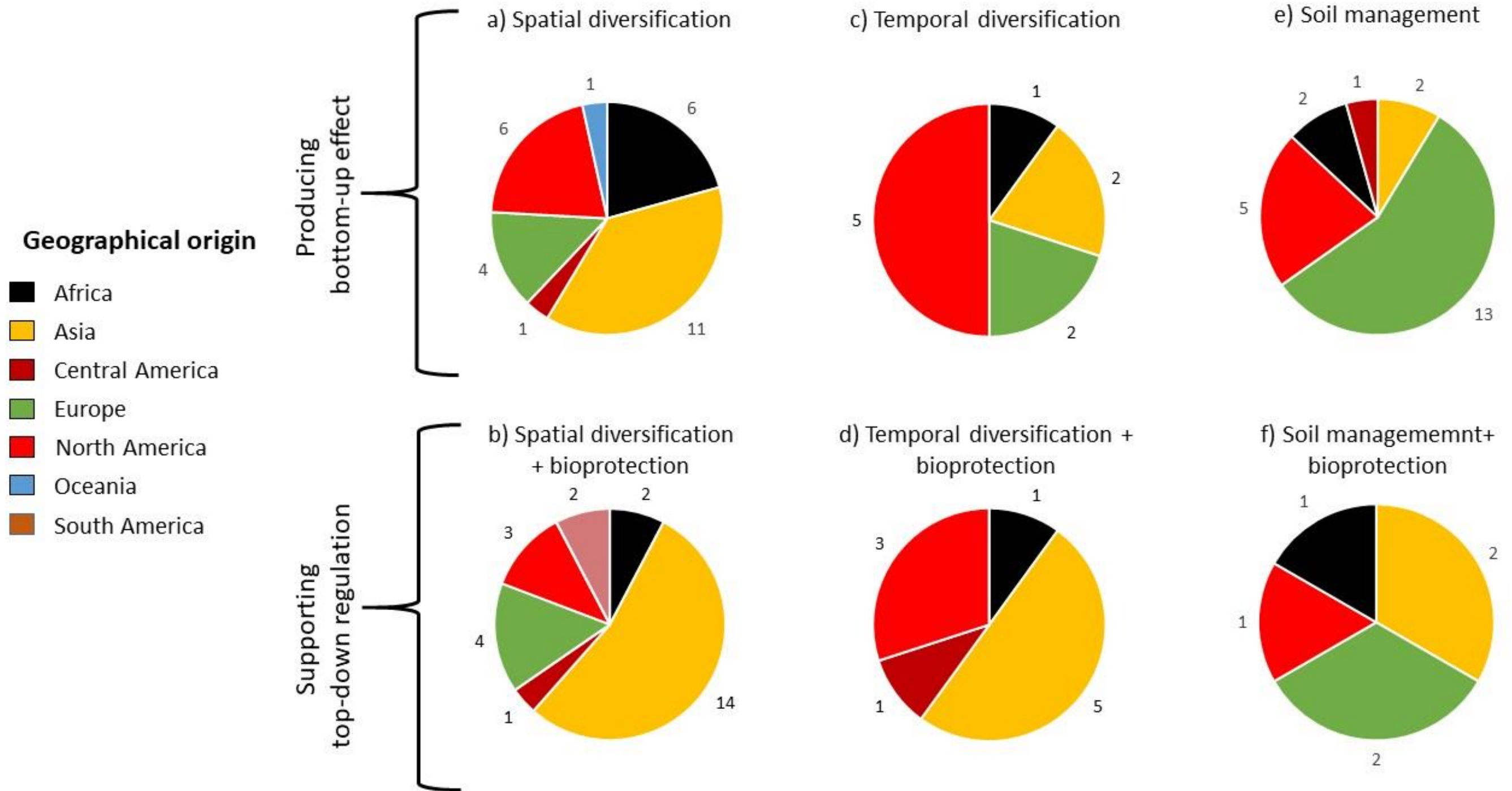
Results

The number of research articles focusing on different pest taxa for bottom-up effect and top-down regulation



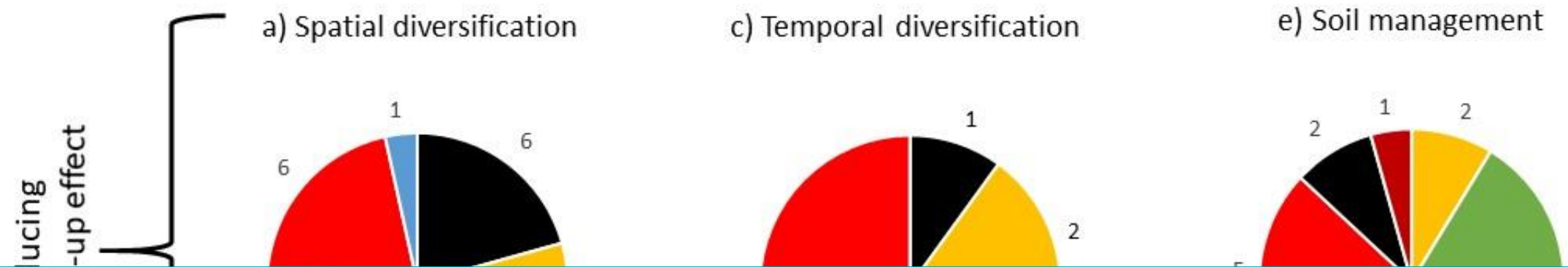
Results

The number of research articles originating in different continents for bottom-up effect and top-down regulation



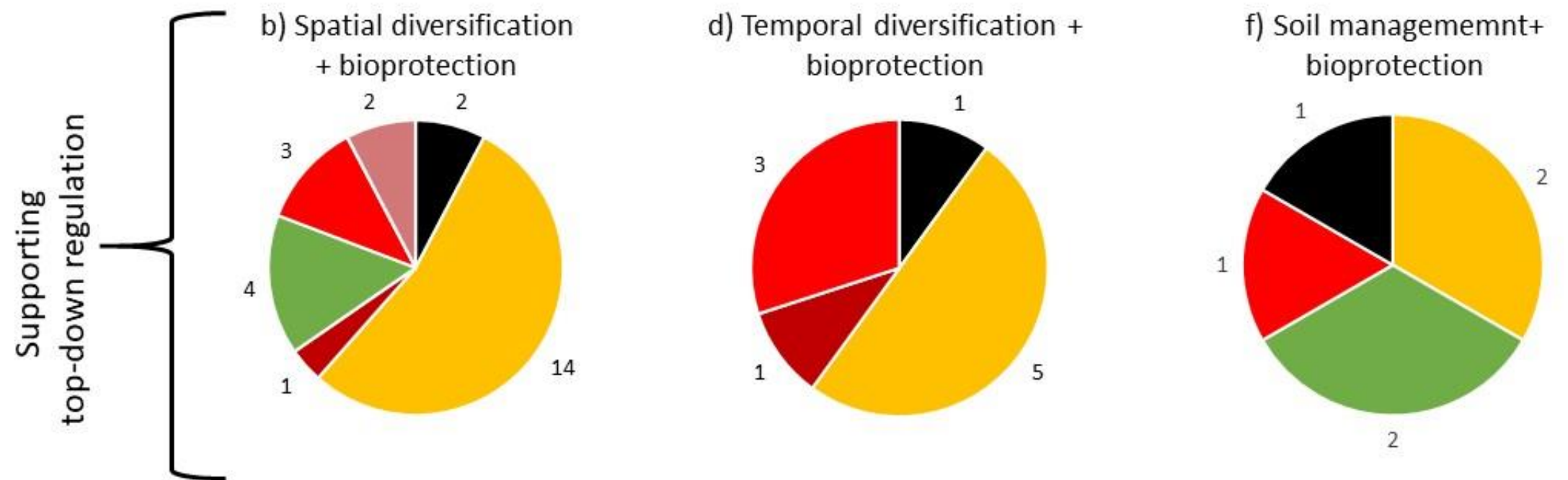
Results

The number of research articles originating in different continents for bottom-up effect and top-down regulation



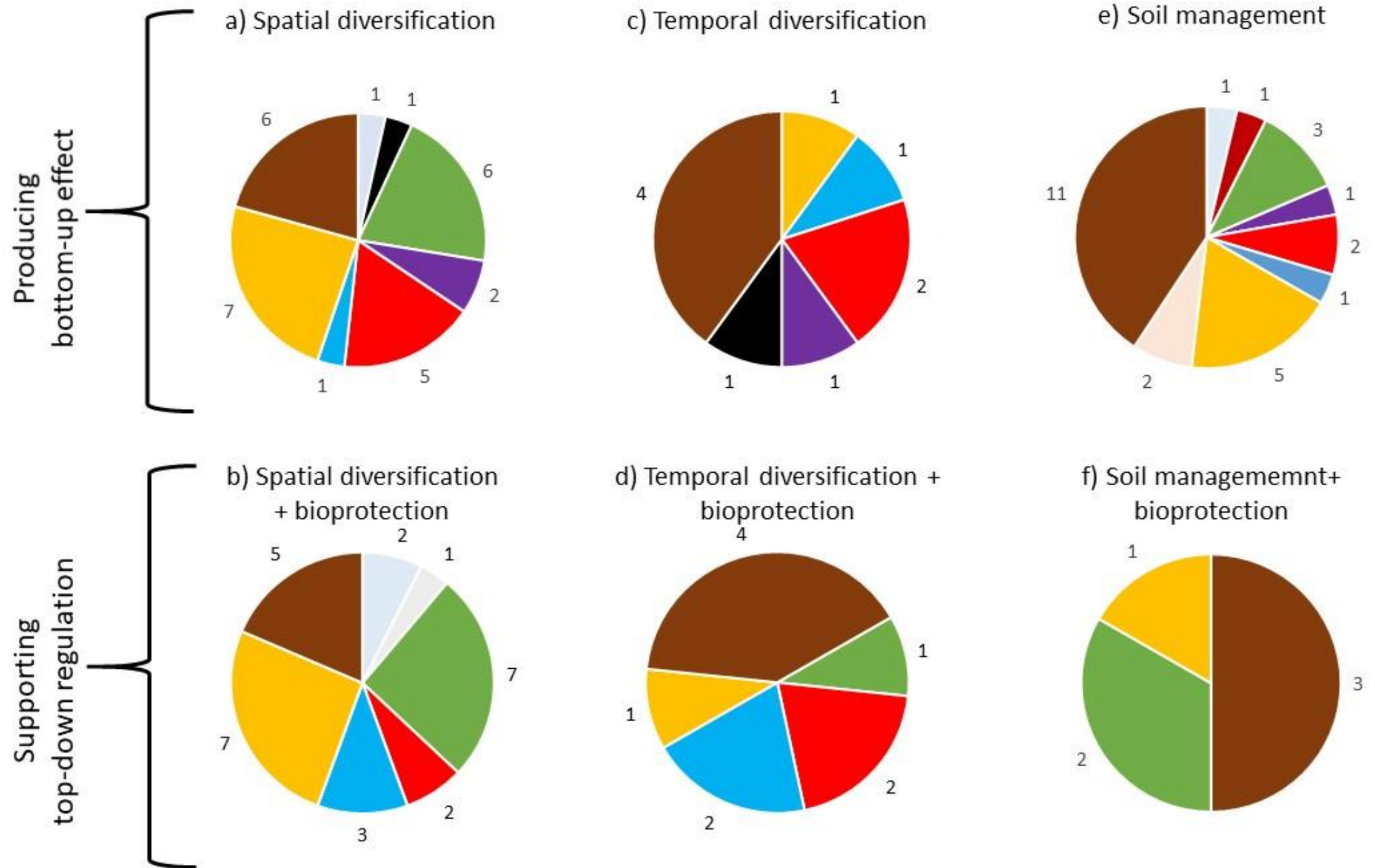
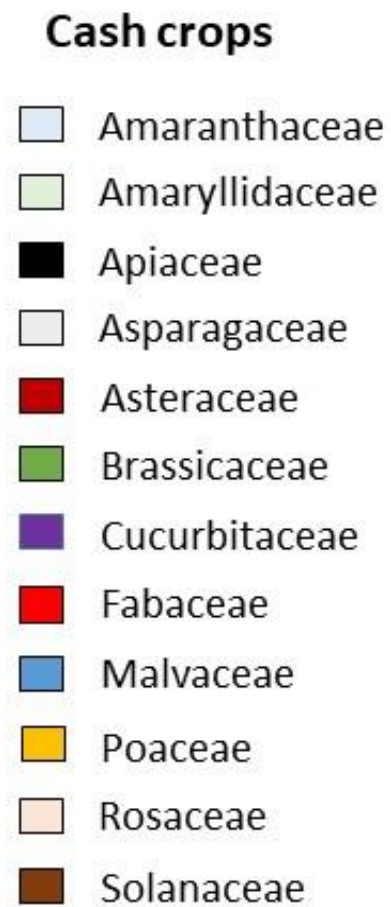
- **Some continents have more studies than others**

- Asia, Europe and North America continents of origin of most of the articles



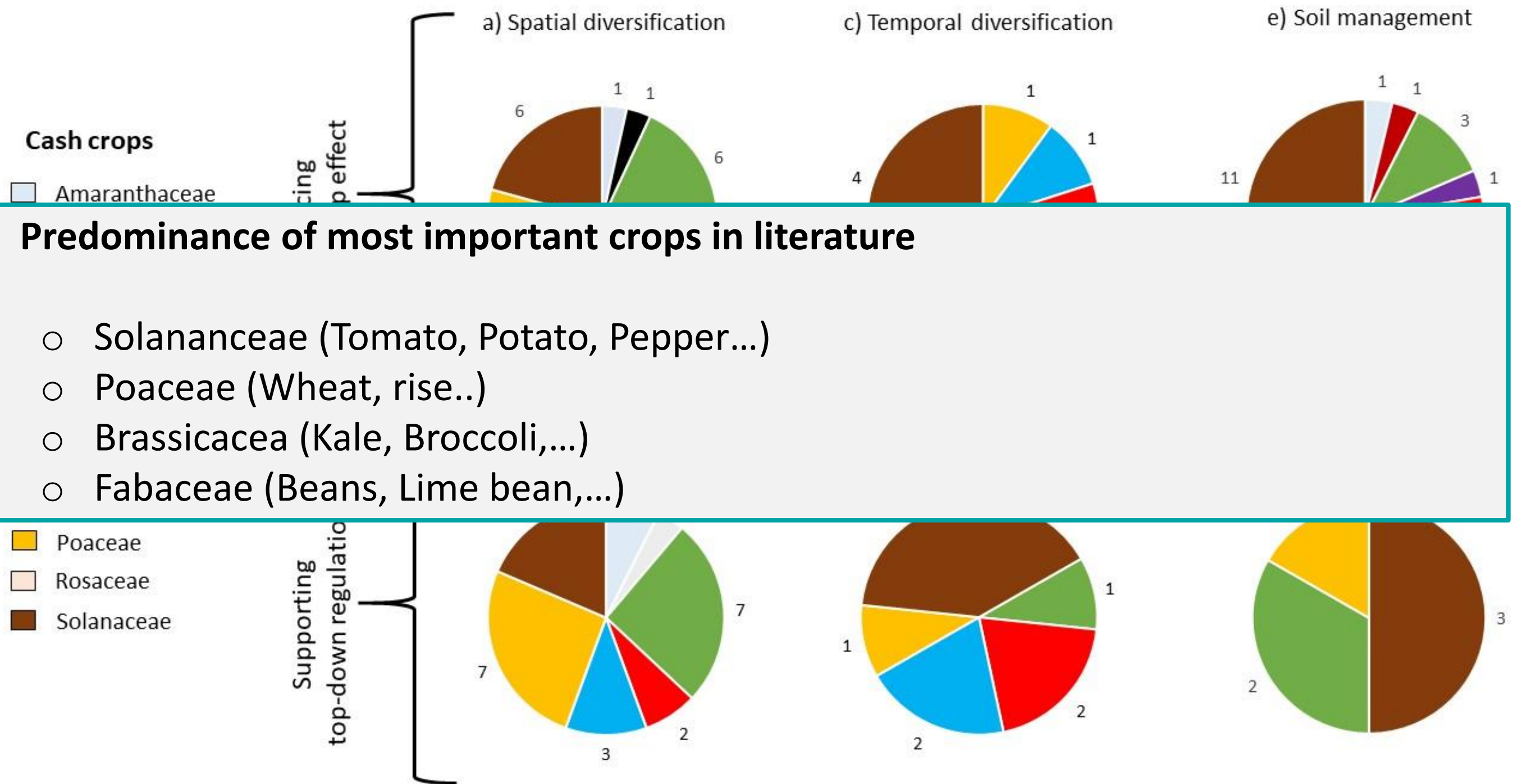
Results

The number of research articles focusing on different cash crop for bottom-up effect and top-down regulation



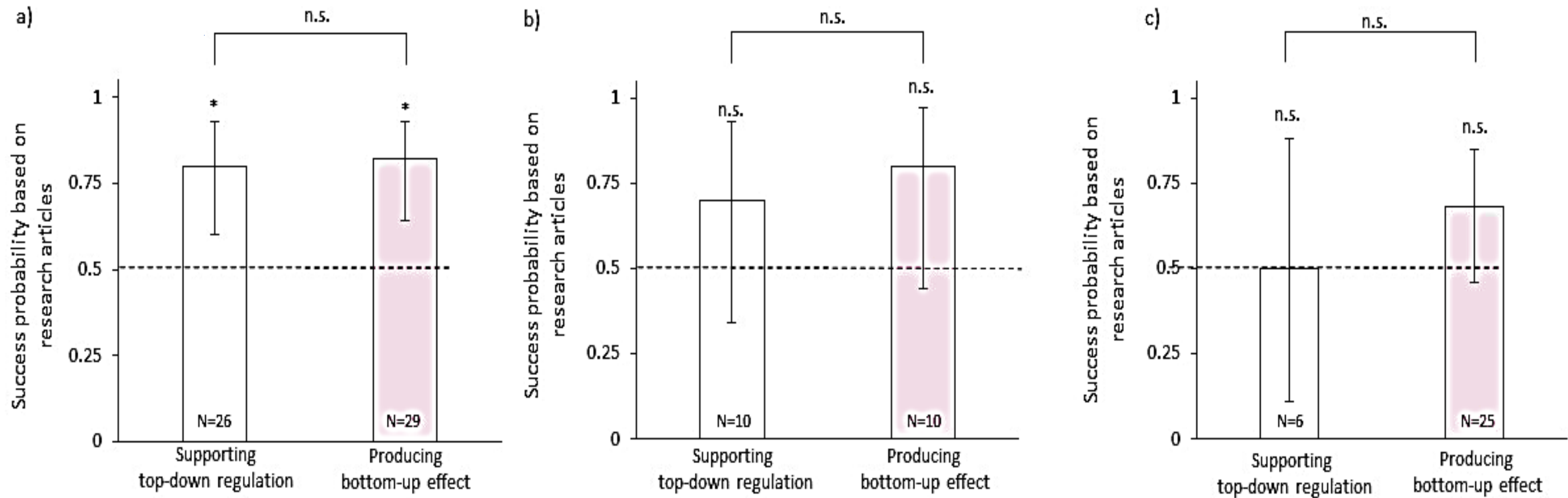
Results

The number of research articles focusing on different cash crop for bottom-up effect and top-down regulation



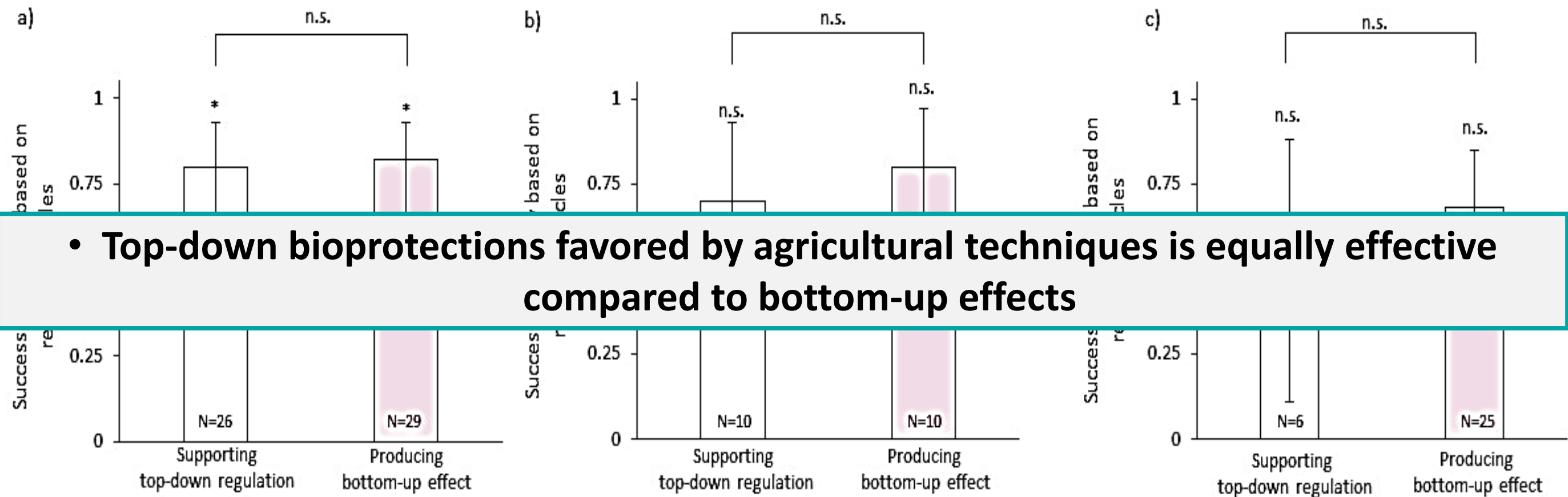
Results

Probability of success (\pm CI) of pest control
for bottom-up effect and top-down regulation



Results

Probability of success (\pm CI) of pest control
for bottom-up effect and top-down regulation



Discussion - Research agenda

- **All agricultural techniques showed specificity for the target pest taxa and for the Bioprotection to which they support**
Increase the investigation on those Bioprotections and combinations between agricultural techniques and Bioprotections that have not been tested yet
- **Few research articles that involving augmented Bioprotections**
Increasing experimental trial involving agricultural techniques and augmented Bioprotections.
- **Top-down Bioprotections is equally effective compared to bottom-up Agricultural technique effects**
Consider research articles showing negative or null effects on pest control
Perform experimental trials in multiple geographical location
Account for the heterogeneity (complexity and diversity) of the agroecosystem landscape
- **Limited participation by final users, i.e. farmers**
Increase participatory research, in particular, promoting a direct involvement of farmers

Discussion-Conclusion

- The adoption of agricultural techniques to obtain pest regulation through bioprotection have the potential to counteract pest damage.
- Multiple changes in the process of innovation and integration, i.e. changes in the experimental design, involving farmers and economists to test real on-field feasibility
- Cropping systems based on agroecological strategies will provide benefits beyond a pest control services and will support other ecosystem services leading to a multiple win solution toward a modern sustainable agriculture

Does the integration of different agricultural techniques and bottom-up or top-down regulations, foster crop protection?

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Thank you! Questions?

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