

# Research topics and trends on the potential of *Ricinus communis* as biopesticide

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## ABSTRACT

**Objective:** To analyze the scientific production published in journals included in the Science Citation Index Expanded (SCIE) and Social Sciences Citation Index (SSCI) databases of the Core Collection of the Web of Science (WoS), using bibliometric indicators, with the aim of determining the dynamics, quality, structure, and emergent topics on the subject of *Ricinus communis* L., during the 2001-2022 period.

**Design/Methodology/Approach:** The above-mentioned databases were subjected to an exploratory analysis to extract and evaluate bibliographical records, based on a search equation. The evolution of scientific production and the relationship between documents, authors, and key words were determined and characterized. In addition, relevant research topics and trends were identified. Finally, the VOSviewer software was used to develop one-dimensional (performance) and multidimensional (science mapping) indicators, based on records recovered from the databases.

**Results:** The results were used to determine the dynamics of scientific production regarding the topic in question. The topic had an oscillatory behavior as time went by, increasing from <5 documents in 2001 to 25 documents in 2022. This increase showed the interest of scientists on the subject. The highest number of publications was recorded in 2014.

**Findings/Conclusions:** The documents with the highest influence on the generation of new research addressed the use of *R. communis* as biocide, highlighting its harmlessness and environmental preservation. A similar behavior was reported with the use of *R. communis* extracts with larvicide, insecticide, acaricide, and antimicrobial activity. Regarding emerging research trends in *R. communis*, the most notable were *in vitro* studies, its association with nanotechnology; its antimicrobial, antioxidant, and acaricidal activity; and its use in combination with other plant species, as well as its use in metabolic or physiological studies.

**Keywords:** biopesticides, plant protection, bibliometric analysis, natural products.

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## INTRODUCTION

Castor oil plant (*Ricinus communis* L.) is a fast-growing annual or perennial bush, 3 to 5 m tall (Kaur and Bhaskar, 2020; Chouhan *et al.*, 2021). It is a monotypic species from

family Euphorbiaceae. Its oily seeds are not edible. *R. communis* has a polyphyletic origin (Ranjitha *et al.*, 2019): its point of origin has been shrouded by its wide distribution (Muraguri *et al.*, 2020). Four points of origin have been proposed: 1) Eastern Africa (specifically Ethiopia); 2) Northeast Asia, Southeast Asia, and the Arabian Peninsula; 3) the Indian subcontinent; and 4) China (Rukhsar *et al.*, 2018). *R. communis* can thrive under diverse environmental conditions; therefore, it has spread towards temperate, subtropical, and tropical regions of the world (Landoni *et al.*, 2023). It can be found both in the wild and as crop, because it adapts to arid conditions and it can withstand extended droughts (Abel *et al.*, 2022).

The seeds of *R. communis* have a high lipid content, which is extracted to be used by the pharmaceutical and industrial sectors. Despite some harmful effects to the organism, it is widely used in traditional and Western medicine, given the wide impact of its numerous phytochemicals: antifertility, contraception, antinociception, anticarcinogenic, antioxidation, immunomodulation, hepatoprotection, antidiabetic, anti-ulcer, antimicrobial, insecticides, molluscicides, larvicides, bone regeneration, central analgesics, antihistamines, antiasthmatic, cytotoxins, lypolitic, anti-inflammatory, and scar formation (Kumar, 2017; Ergu, 2022). *R. communis* can also be applied for phytoremediation purposes, given its potential to extract metals (*e.g.*, Cd, Pb, Ni, As, and Cu) and pesticide residues. Therefore, it can be a good alternative for the remediation of polluted soils, increasing soil fertility and reducing erosion. It can also be used to produce biofuels, contributing to social development, the generation of local employment, carbon sequestration, and the reduction of greenhouse gases (Baudhh *et al.*, 2015).

Given the numerous harmful effects of synthetic pesticides on the environment and health, the interest on biopesticides as a natural alternative has increased in the last two decades; India and China lead the race to substitute synthetic pesticides with biopesticides (Smith *et al.*, 2021). This segment currently accounts for 5 to 6% of the world pesticide market (Marčić, 2019). Against this background, the use of biopesticides could increase crop production without compromising human health (Sharma *et al.*, 2020). Plant- or microorganism-based pesticides are not toxic for mammals and are biodegradable (Sharma *et al.*, 2020).

Several reviews have determined the state, development, and research trends of biopesticides (Smith *et al.*, 2021; Hernández-Tenorio *et al.*, 2022). *Azadirachta indica* has been the subject of various research works (Vijayakumar and Naqvi, 2002; Singh, 2016). However, as far as this research team was able to determine, no information is available about the scientific production and research trends regarding the use of *R. communis* to control pests and diseases. Therefore, the aim of this research was to identify and characterize the scientific production on the use of *R. communis* as biocide, included in the Science Citation Index Expanded (SCIE) and Social Sciences Citation Index (SSCI) databases of the Core Collection of the Web of Science (WoS) from Clarivate Analytics. Research topics and their trends were emphasized through a bibliometric analysis.

## MATERIALS AND METHODS

### Information sources and databases

A bibliometric study was carried out to obtain an overview of the scientific production and the research topics and trends regarding the use of *R. communis* to control pests and diseases from 2001 to 2022. Bibliometric indicators (BI) were used to collect bibliographical records of the indexed documents published in mainstream journals (Salager-Zeyer 2015), which can be found in the SCIE and SSCI databases.

### Search protocols

The key terms or words were defined *a priori* by the research team and were brought together in the following search equation:

$$\left( TS = \left( \text{"ricinus communis*"} \text{ OR } \text{"castor plant"} \text{ OR } \text{"castor oil plant"} \right) \text{ AND } \right. \\ \left. TS = \left( \text{pest * OR insect * OR fung * OR acari * OR larv * OR bacter *} \right) \right)$$

These words and their search expression enabled the recovery of bibliographical records within the title, abstract, and keywords fields from the metadata of the bibliographical records. Additionally, the records were refined based on research articles and data articles. Finally, no language restrictions were considered appropriate for the search criteria. Consequently, 466 bibliographical records were recovered.

### Data homogenization and normalization

The extracted records were subsequently subjected to a cleansing, analysis, and selection process to guarantee that the documents did deal with the research subject. Therefore, the records were checked; those who discussed the topic were marked and sent to a marked list within WoS. The final database of this study contained the information of each record consisting of 241 full bibliographical records (including citations). The records were exported to a .txt file, using August 11, 2023, as the final date.

### Bibliometric indicators

The file with the extracted records was imported with VOSviewer (van Eck and Waltman, 2007). The said software was used to process the data and obtain the following bibliometric indicators: growth of scientific production, most cited articles, research topics, and research trends. The processing included the normalization of the key words allocated by the authors and the databases. The scientific production growth indicator was developed in Excel, importing the data from WoS, with the result analysis and years of publication options.

### Analysis tool

The VOSviewer software, developed by van Eck and Waltman (2010), was used to analyze the records imported from WoS. The research topics and research trends indicators

that make up these networks were developed using the “analysis of co-occurrence” option (van Raan, 1993). The software identified the authors with more citations (globally and during the last five years).

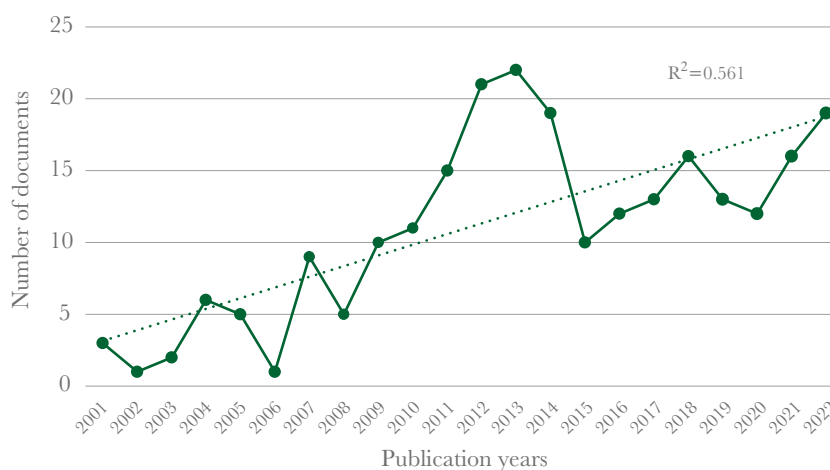
## RESULTS AND DISCUSSION

### Growth of Scientific Production

Based on the results, the scientific production on the topic did not show a clear linear trend towards a sustained growth throughout time. Instead, interannual oscillations were recorded, although scientific production had a moderate linear growth of  $R^2=0.561$  (Figure 1). The annual average of published documents during the study period was 10.95. Figure 1 also shows that the overall number of published documents increased from 5 (1991) to 25 (2021). Likewise, from 2001 to 2009, the average number of documents varied from 3 to 9 per year; however, from 2010 to 2014, the number of publications doubled from 11 to 22 documents, although it subsequently decreased. Finally, scientific production rebounded, reaching 16 and 19 documents in 2021 and 2022, respectively. The increasing trend from 2010 to 2014 was likely related to the worldwide boom of the species as a potential bioenergy source. Likewise, the behavior recorded during the past two years could be associated to the world trend towards green pesticides and the new agri-environmental milieu.

### Most Cited Articles

The most cited articles in any area of science are a sign of the interest among academic peers, who believe that their content is important for their research and that the information included in them can back up their work. Table 1 shows the five most cited documents out of the 241 documents from the said period recovered for this study. “Effect of butanolic extracts from terrestrial herbs and seaweeds on the survival, growth and pathogen (*Vibrio parahaemolyticus*) load on shrimp *Penaeus indicus* juveniles” by Immanuel *et al.* (2004) was the most cited article (139 citations). In second place, “Suitability of different pollen



**Figure 1.** Increase in documents about the use of *R. communis* as a biocide, published in indexed journals included in the Science Citation Index Expanded and Social Sciences Citation Index (2001-2022).

**Table 1.** Five most cited articles about the use of *Ricinus communis* as biocide, published in indexed journals included in the Science Citation Index Expanded and Social Sciences Citation Index (2001-2022).

Position	Bibliographic reference	Received citations
1	Immanuel, G, Vincybai, VC, Sivaram, V, Palavesam, A, & Marian, MP (2004). "Effect of Butanolic Extracts from Terrestrial Herbs and Seaweeds on the Survival, Growth and Pathogen ( <i>Vibrio parahaemolyticus</i> ) Load on Shrimp <i>Penaeus indicus</i> Juveniles". <i>Aquaculture</i> , 236(1), 53-65, <a href="https://doi.org/10.1016/j.aquaculture.2003.11.033">https://doi.org/10.1016/j.aquaculture.2003.11.033</a>	139
2	Goleva, I, & Zebitz, CPW (2013). "Suitability of Different Pollen as Alternative Food for the Predatory Mite <i>Amblyseius swirskii</i> (Acari, Phytoseiidae)". <i>Experimental and Applied Acarology</i> , 61(3), 259-283 <a href="https://doi.org/10.1007/s10493-013-9700-z">https://doi.org/10.1007/s10493-013-9700-z</a>	99
3	Bigi, MFMA, Torkomian, VL, Groote, ST de, Hebling, MJA, Bueno, OC, Pagnocca, FC, Fernandes, JB, Vieira, PC, & Silva, MFGF da (2004). "Activity of <i>Ricinus communis</i> (Euphorbiaceae) and Ricinine Against the Leaf-cutting Ant <i>Atta sexdens rubropilosa</i> (Hymenoptera : Formicidae) and the Symbiotic Fungus <i>Leucoagaricus gongylophorus</i> ". <i>Pest Management Science</i> , 60(9), 933-938, <a href="https://doi.org/10.1002/ps.892">https://doi.org/10.1002/ps.892</a>	81
4	Luseba, D, Elgorashi, EE, Ntloedibe, DT, & Staden, J Van (2007). "Antibacterial, Anti-inflammatory and Mutagenic Effects of Some Medicinal Plants Used in South Africa for the Treatment of Wounds and Retained Placenta in Livestock". <i>South African Journal Of Botany</i> , 73(3), 378-383, <a href="https://doi.org/10.1016/j.sajb.2007.03.003">https://doi.org/10.1016/j.sajb.2007.03.003</a>	81
5	Upasani, SM, Kotkar, HM, Mendki, PS, & Maheshwari, VL (2003). "Partial Characterization and Insecticidal Properties of <i>Ricinus communis</i> L. Foliage Flavonoids". <i>Pest Management Science</i> , 59(12), 1349-1354, <a href="https://doi.org/10.1002/ps.767">https://doi.org/10.1002/ps.767</a>	74

as alternative food for the predatory mite *Amblyseius swirskii* (Acari, Phytoseiidae)" by Goleva and Zebitz (2013) recorded 99 citations. The five most cited articles discuss the use of *R. communis* for the management of several phytosanitary and water issues, given its harmlessness to health and the environment. Interestingly, two of the five most cited documents were published in the *Pest Management Science* journal, which likewise was one of the publications with the highest number of cited documents on the topic.

Table 1 also highlights that most of the articles are over 10 years old and that there is a lack of recent articles with high impact or visibility. Therefore, the articles with most citations from 2018 to 2022 were analyzed to identify current research trends on the topic (Table 2). In conclusion, research trends were focused on the combination of *R. communis* with silver, zinc, and magnesium nanoparticles to improve its antimicrobial potential and cytotoxicity. This trend matches the current demand for the reduction of synthesized insecticides and the search for new pesticides with high selectivity and low impact on the environment and agriculture. In this sense, nano-based pesticide formulations have several advantages over conventional pesticide formulations, including a greater environmental stability, controlled release of active ingredients, higher permeability, focused administration, etc. (Manna *et al.*, 2023). Nanotechnology is a new approach that improves the characteristics of insecticides, through the nanomanufacturing of particles. There are several ways in which these

**Table 2.** Most cited documents about the use of *Ricinus communis* as biocide published from 2018 to 2022 in indexed journals included in Science Citation Index Expanded and Social Sciences Citation Index (2001-2022).

Year	Bibliographic references	Received citations
2022	Ghaffar, N, Javad, S, Farrukh, MA, Shah, AA, Gatashah, MK, Al-Munqedhi, BMA, & Chaudhry, O (2022). "Metal Nanoparticles Assisted Revival of Streptomycin against MDRS <i>Staphylococcus aureus</i> ". <i>Plos One</i> , 17(3), <a href="https://doi.org/10.1371/journal.pone.0264588">https://doi.org/10.1371/journal.pone.0264588</a>	10
2021	Gul, A, Fozia, Shaheen, A, Ahmad, I, Khattak, B, Ahmad, M, Ullah, R, Bari, A, Ali, SS, Alobaid, A, Asmari, MM, & Mahmood, HM (2021). "Green Synthesis, Characterization, Enzyme Inhibition, Antimicrobial Potential, and Cytotoxic Activity of Plant Mediated Silver Nanoparticle Using <i>Ricinus communis</i> Leaf and Root Extracts". <i>Biomolecules</i> , 11(2), <a href="https://doi.org/10.3390/biom11020206">https://doi.org/10.3390/biom11020206</a>	34
2020	Dias, LP, Souza, PFN, Oliveir, JTA, Vasconcelos, IM, Araujo, NMS, Tilburg, MFV, Guedes, MIF, Carneiro, RF, Lopes, JLS, & Sousa, DOB (2020). "RcAlb-PepII, a Synthetic Small Peptide -bioinspired in the 2S Albumin from the Seed Cake of <i>Ricinus communis</i> , is a Potent Antimicrobial Agent against <i>Klebsiella pneumoniae</i> and <i>Candida parapsilosis</i> ". <i>Biochimica et Biophysica Acta-Biomembranes</i> , 1862(2), <a href="https://doi.org/10.1016/j.bbamem.2019.183092">https://doi.org/10.1016/j.bbamem.2019.183092</a>	31
2019	Panchal, P, Paul, DR, Sharma, A, Hooda, D, Yadav, R, Meena, P, & Nehra, SP (2019). "Phytoextract Mediated ZnO/MgO Nanocomposites for Photocatalytic and Antibacterial Activities". <i>Journal of Photochemistry and Photobiology A-Chemistry</i> , 385, <a href="https://doi.org/10.1016/j.jphotochem.2019.112049">https://doi.org/10.1016/j.jphotochem.2019.112049</a>	78
	Shobha, N, Nanda, N, Giresha, AS, Manjappa, P, Sophiya, P, Dharmappa, KK, & Nagabhushana, BM (2019). "Synthesis and Characterization of Zinc Oxide Nanoparticles Utilizing Seed Source of <i>Ricinus communis</i> and Study of its Antioxidant, Antifungal and Anticancer Activity". <i>Materials Science And Engineering C-Materials for Biological Applications</i> , 97, 842-850, <a href="https://doi.org/10.1016/j.msec.2018.12.023">https://doi.org/10.1016/j.msec.2018.12.023</a>	52
2018	Salem, N, Bachrouch, O, Sriti, J, Msaada, K, Khammassi, S, Hammami, M, Selmi, S, Boushah, E, Koorani, S, Abderraba, M, Marzouk, B, Limam, F, & Jemaa, JM Ben (2018). "Fumigant and Repellent Potentials of <i>Ricinus communis</i> and <i>Mentha pulegium</i> Essential Oils against <i>Tribolium castaneum</i> and <i>Lasioderma serricorne</i> ". <i>International Journal of Food Properties</i> , 20:sup3, S2899-S2913, <a href="https://doi.org/10.1080/10942912.2017.1382508">https://doi.org/10.1080/10942912.2017.1382508</a>	26
	Jiang, XY, Xie, Y, Ren, ZF, Ganeteg, U, Lin, F, Zhao, C, & Xu, HH (2018). "Design of a New Glutamine-Fipronil Conjugate with Alpha-Amino Acid Function and Its Uptake by <i>A-thaliana</i> Lysine Histidine Transporter 1 (AtLHT1)". <i>Journal of Agricultural and Food Chemistry</i> , 66(29), 7597-7605, <a href="https://doi.org/10.1021/acs.jafc.8b02287">https://doi.org/10.1021/acs.jafc.8b02287</a>	24

particles can be encapsulated, including nanocapsules, nanospheres, nanogels, micelles, liposomes, etc. Overall, nanoinsecticides were more lethal and their residual activity lasted longer than commercial formulations. They can also alter the levels of several enzymes and hormones and delay the development of insects (Graily-Moradi and Asgari-Lajayer, 2021). Despite their advantages, recent research show that several nanoparticles included in the formulation of conventional nanopesticides can be toxic for crops and beneficial organisms, as a consequence of bioaccumulation and trophic transfer. Therefore, Manna *et al.* (2023) do not believe that traditional nanopesticides are advantageous for "green agriculture" (Manna *et al.*, 2023). Consequently, environmentally-friendly green nanotechnology (*e.g.*,



Gul *et al.*, 2021). Meanwhile, Cluster 3 (blue) covered physiological aspects such as: phloem mobility (Yang *et al.*, 2011; Yao *et al.*, 2017), biosynthesis, translocation, and insecticide (Baldin *et al.*, 2007), fungicide (Chollet *et al.*, 2005), and acaricide (Ghosh *et al.*, 2013) activity. Cluster 4 (yellow) accounted for the use of *R. communis* as a biological control agent (*i.e.*, a trap crop that captures phytophagous insects) (Galvao *et al.*, 2008); likewise, it can be used as an outstanding host of predators of pests that attack other crops (Miranda *et al.*, 2021). Finally, Cluster 5 (purple) includes the alternative use of *R. communis* to break the resistance to conventional insecticides, mainly among the greenhouse whitefly (*Trialeurodes vaporariorum*) (Ladys García *et al.*, 2014) and the silverleaf white fly (*Bemisia tabaco*) (Kurra and Pathipati, 2015), and to control fungi (Dikhoba *et al.*, 2019), bacteria (Londoño-Orozco *et al.*, 2010), and nematodes (Tiyagi *et al.*, 2012). According to the in-depth analysis of the scientific production, there is scarce information about the residuality, phytotoxicity, effect on non-target organisms and beneficial fauna of the various presentations (*e.g.*, extracts, essential oils). Such information would be essential to consider its massive use.

### Research trends

The trends in the scientific production from 2012 to 2022 about the use of *R. communis* as biocide were addressed from various analytical perspectives. Figure 3 shows the dynamics of the major topic patterns developed by the world research nuclei. The main applications identified were classified, according to their temporality, in three main research areas and are synthesized below:

1. **Purple-blue nodes:** they include studies about its use against insects that are a public health concern—such as *Anopheles stephensi*, *Aedes aegypti*, and *Culex quinquefasciatus*—, as well as its use against mites (*Tetranychus urticae*) and nematodes. Emergent studies evaluate their components, toxicity, translocation, and degradation.
2. **Blue-green nodes:** they discuss the combination of *R. communis* with other plant species, such as *Jatropha curcas* and *Azadiracta indica*, to increase its efficiency. Plants and leaves are studied to determine their insecticide and antimicrobial (fungi and bacteria) activity, as well as its use as biocontrol agent.
3. **Green-yellow nodes:** these nodes show the current research trends or the emergent areas of research. Outstanding research work has been made on nanoparticles (Ghaffar *et al.*, 2022) and green synthesis (Gul *et al.*, 2022); *in vitro* studies (Singh *et al.*, 2022); and its antimicrobial (mainly against bacteria) (Gul *et al.*, 2021; Matysiak *et al.*, 2018), antioxidant (El-Sayed *et al.*, 2022), and acaricide (Singh *et al.*, 2022) activity. Other remarkable studies have analyzed its combination with entomopathogenic fungi (Barbosa *et al.*, 2021) and widen their application on the spectrum of insects with economic importance, such as the tobacco cutworm (*Spodoptera litura*) (Vengates *et al.*, 2022). Finally, there has been a permanent and renewed interest in metabolic or physiological studies, mainly aimed at their mobility within the plant and amino acid transport (Li *et al.*, 2021).



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