GLOBAL RESEARCH PATTERNS IN FERTILIZER MANAGEMENT IN PEAR PRODUCTION: A 25-YEAR BIBLIOMETRIC JOURNEY (2000-2024)

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Abstract. The Pear is one of the world's most important fruit crops. fertilizer management is crucial for regulating its growth, yield, quality, and ecological sustainability. Lacking systematic bibliometric analyses, this study used the Web of Science Core Collection to analyze relevant research from 2000–2024, aiming to reveal global trends and future directions. Results showed an overall upward trend in annual publications, with significant growth post-2015. China is the leading contributor, followed by Brazil and the US. Core journals include Acta Horticulturae and Scientia Horticulturae. Research focuses on optimizing growth-yield-quality, with two main directions: synergistic optimization under fertilization regimes, and genetic-environmental interaction mechanisms in nutrient uptake/utilization. This study summarizes theoretical and technical frameworks to provide scientific support for green, efficient cultivation and the sustainable development of the pear industry.
Keywords: *Pyrus, nutrient stewardship, scientometrics, yield optimization, soil health*

Introduction

Under the dual pressures of global population growth and climate change, agricultural production is facing serious challenges of water scarcity and ecological degradation. As a key industry for maintaining ecosystem stability and ensuring food security, agriculture is highly dependent on water resources and fertilizers. Data show that the total agricultural water consumption of 180 major countries or regions in the world accounted for 71.49% of the total global water consumption in 2019, while the total amount of agricultural nitrogen fertilizer used in 164 major countries or regions reached 1.13×10^8 t in 2020 (Lu et al., 2022). However, traditional irrigation and fertilizer practices not only cause significant resource waste but also induce environmental problems such as soil salinization, water eutrophication, and increased greenhouse gas emissions, which constrain sustainable agricultural development.

As one of the world's three major fruits, pear (*Pyrus* L.) plays an important role in global fruit supply and is highly favored by consumers (Bel, 1991). Its cultivation history has a long history, as early as thousands of years ago, Ancient Egypt, Ancient Greece and other civilizations have begun to plant the pear tree, after a long period of time of varieties selection and cultivation technology evolution, now the pear tree has been widely planted around the world, and has become an important fruit tree with strong adaptability and high economic value (Musacchi et al., 2021). According to the United Nations Food and Agriculture Organization (FAO) data in December 2024, the global pear planting area has stabilized at more than 5 million hectares, and pear production in 2024/25 is estimated to be 28 million tons, a slight increase over the previous year (Gannuscio, 2025). Pears not only provide human beings with rich vitamins, dietary fiber and other nutrients, but

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are also an important part of the local agricultural economy in the main producing regions of Asia, Europe and the Americas, which is related to the livelihoods of fruit growers and the development of the regional economy. China, for example, pear production in 2024 reached 18 million tons, a record high, accounting for more than 60% of global production, ranking first in the world (Kan et al., 2024); the United States Department of Agriculture (USDA) data show that the 2024/25 United States pear production is estimated to be 700, 000 tons, the European Union production is estimated to be 2.3 million tons (Deckers and Schoofs, 2007).

Given its global significance, the sustainable development of the pear industry is closely tied to food security and farmers' livelihoods. fertilizer management is a key factor influencing yield and fruit quality, as well as an entry point for alleviating conflicts between agricultural production and environmental protection (Fu et al., 2023). Reasonable application of fertilizer can improve soil structure, regulate soil water and fertilizer retention capacity, enhance the physiological functions of pear trees, and improve their ability to resist environmental stress (Zörb et al., 2014); on the contrary, irrational application of fertilizer may lead to imbalance in the growth of pear trees, reduce fruit quality, and even exacerbate soil degradation and environmental pollution (Carranca et al., 2018). Thus, exploring efficient fertilization strategies in pear production is of great practical significance.

However, pear production faces several limiting factors, including soil nutrient imbalance, physiological disorders (e.g., iron deficiency chlorosis), and environmental stresses. Proper fertilization management is therefore critical to mitigate these constraints, ensuring optimal fruit quality and yield stability.

Over the past 25 years (2000–2024), global research in the field of fertilizer management for pear production has continued to grow, with a large number and richness of research results. However, there is a lack of systematic compilation and summarization of research results in this area. Based on this, this study applies bibliometric methods to comprehensively analyze literature on pear fertilization management from 2000 to 2024. The aim is to identify research hotspots, development trends, and the global distribution of research capacity, thereby providing scientific evidence and references for promoting the green and sustainable development of the pear industry.

Materials and methods

Data sources and screening

The data for this study were based on the Web of Science (WOS) Core Collection database, citation indexed as SCI-EXPANDED, and fully searched using advanced search terms. The year of search was 2000-01-01 - 2024-12-31. specific search terms were TS = ("pear" OR "pyrus") AND TS = ("fertiliz*" OR "nutrient fertilization management" OR "fertilizer application" OR "nitrogen" OR "phosphorus" OR "potassium" OR "NPK" OR "manure" OR "compost" OR "organic fertilizer" OR "foliar fertiliz*" OR "fertigation"). A total of 1, 036 articles and reviews were retrieved. To ensure completeness, records were exported in batches of 500 entries, using the option Full record with cited references. Thus, all data were downloaded in three separate exports.

The raw text files were first processed with NoteExpress reference fertilization management software and subsequently converted into Excel format for statistical analysis. To improve the accuracy of the bibliometric assessment, irrelevant keywords

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were removed, and synonyms were standardized. The workflow of the data collection and screening process is illustrated in *Figure 1*.

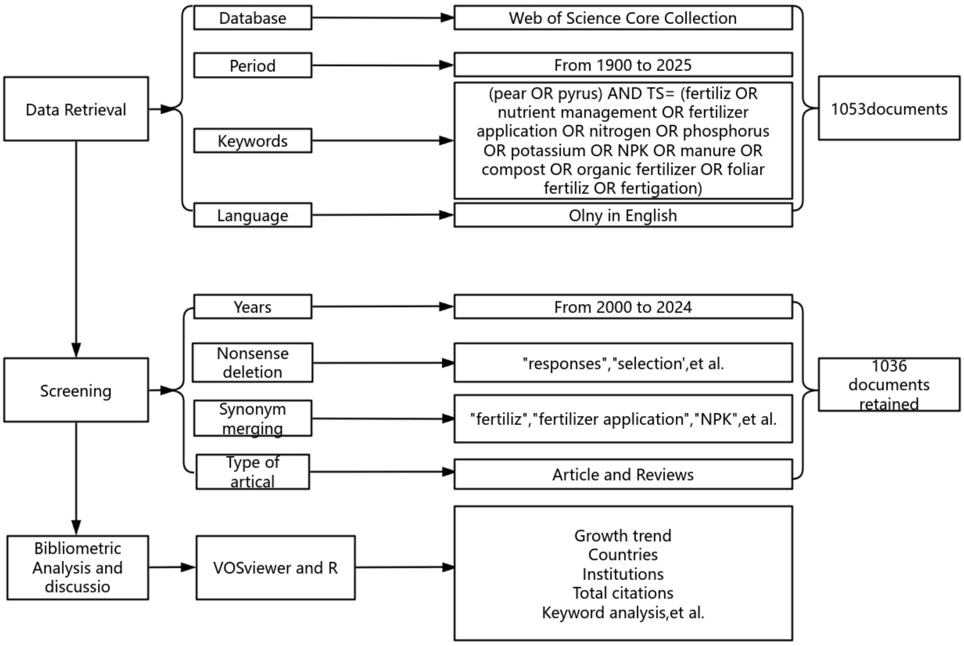

Figure 1. *The research flowchart of present study*

Data visualization and analysis

The data for this study were obtained from the Web of Science (WOS) core dataset, which covers the literature in the field of pear fertilizer management from 2000-2024, and contains multi-dimensional indicators such as the number of articles published in the country/region, the annual trend of publications, the contribution of journals to the publication, and the frequency of citations in the literature. In order to systematically analyze the research pattern and knowledge evolution in this field, the study integrates bibliometric methods and visualization techniques, and uses VOSviewer (version 1.6.18) and R software (version 4.3.0; R Core Team, 2023) with the 'bibliometrix' package (Aria and Cuccurullo, 2017) to construct the analysis framework. software to construct the analysis framework.

In the data pre-processing stage, VOS viewer is used to conduct basic index mining: screening the top 20 countries, institutions and journals in terms of the number of publications to identify the core research power; extracting the top 30 high-impact literature in terms of the frequency of citations to reveal the key theoretical contributions in the field; and counting the top 20 high-frequency keywords in terms of the frequency of Keywords Plus to locate the hotspots of research. Meanwhile, we construct inter-country co-authorship network, institutional coupling relationship, journal co-citation mapping and keyword co-occurrence network based on VOS viewer to visualize the knowledge structure in terms of dimensions such as cooperation network, academic influence and research themes. In R software, we mapped the knowledge maps of thematic keywords and trending topics. Given that author keywords are often highly subjective and lack statistical consistency, Keywords Plus was chosen for this study due to its higher accuracy, authority and statistical relevance in data analysis and visualization.

Results

Trends in communications

The annual number of publications provides an indirect measure of the development of a research field and the level of scholarly attention it attracts. By analyzing the yearly dynamics of both publication counts and citation frequencies, it is possible to identify research trends and assess the degree of academic activity in the field of pear fertilizer management. The trend of citation frequency and publication distribution by year in the field of global pear fertilizer management was plotted using the year as the horizontal coordinate and the vertical coordinate with publications measured on the left and cited literature on the right (*Fig. 2*).

In recent years, there has been a general upward trend in the number of publications in the field of pear fertilizer management by scholars around the world, but there have also been some fluctuations in individual years. In the WOS database, the number of publications is not less than 10 per year. *Figure 2* is a biaxial folded bar mixed plot for presenting the changes of “Publications” and “Frequency of citations” data from 2000–2024: purple bar (left axis): The purple bar (left axis) represents the number of publications, with an overall fluctuating increase from 2000–2024, and a significant increase in 2015, 2020–2023, and other phases. The dark blue line (right axis): represents the frequency of citations, which grew slowly in the early period and climbed rapidly after 2017, which is related to the change in the number of publications.

The overall trend of publications and citation frequency in the past twenty-five years can assist in analyzing the relationship between academic output and influence, combined with the trend in the number of articles published worldwide, it can be concluded that research related to pear fertilizer management is still a hot topic for research in the present and in the future.

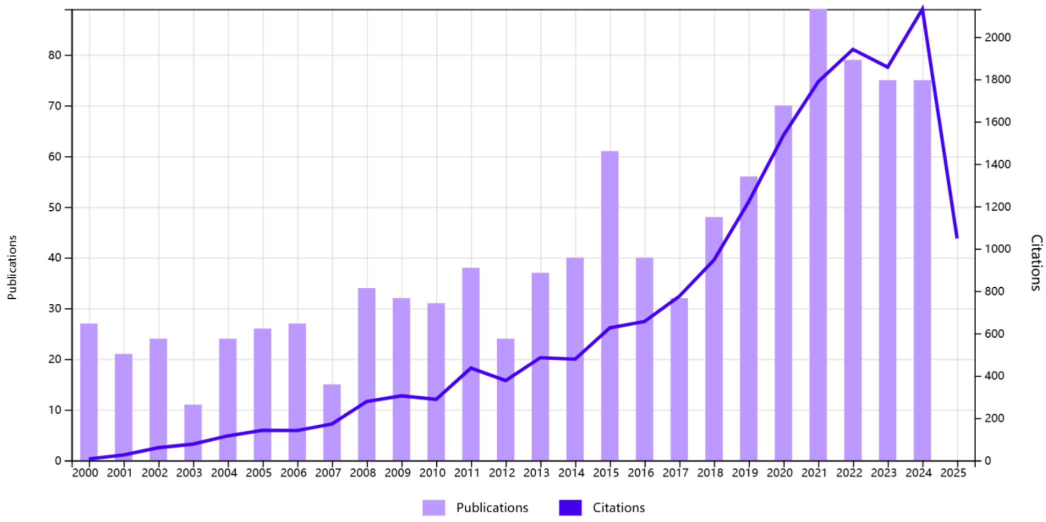

Figure 2. *Trends in global distribution of citations and publications in the field of pear fertilizer management by year*

National and institutional distribution of literature

The global distribution of countries and regions engaged in pear fertilizer management research, as well as their cooperative dynamics, is illustrated in *Figure 3*. China is the

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country with the highest number of publications, with the largest node representing 242 publications. In addition, China has established collaborations with 26 countries, with the strongest collaboration being with Brazil (with the highest total link strength TLS), followed by the United States. Brazil, the second largest node, published 130 articles and cooperated with 21 countries. Overall, China leads in terms of article contributions and has the most extensive international cooperation. This suggests that despite China's significant contribution, international collaboration could be further strengthened in this research area.

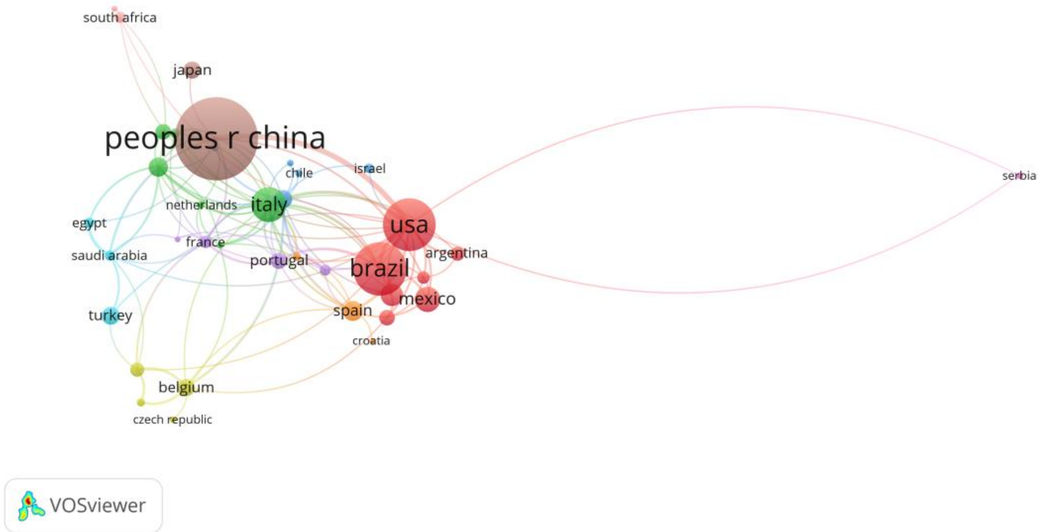

Figure 3. *Network map of countries and their partnerships in the field of pear fertilizer management*

The institutional collaboration analysis helps to understand the organizational contribution and inter-agency interactions in this research topic. *Figure 4* shows the results of the literature coupling analysis between institutions through the Scientific Knowledge Graph. Nanjing Agricultural University (NAU) is not only the institution with the highest number of publications, with 56 articles, but also the core node in the field with the most extensive field relationships (highest total link strength). They are closely followed by Univ Bologna (UB), with 27 articles, and China Agricultural University (CAU), located in China, with 16 articles, all of which play an important role in the academic network. The dominance of Chinese institutions in pear fertilizer management research in *Figure 4* is consistent with the trend of the country-based analysis in *Figure 3,* highlighting China's leading position in pear fertilizer management research.

Major journals and most influential papers

To identify the core journals and foundational knowledge base in this field, a co-citation analysis of source journals was performed (*Fig. 5*; *Table A1* in the *Appendix*). The analysis revealed 261 journals with significant co-citation relationships. The largest node represents *Acta hortic*, with 860 citations, the most cited journal in this research area. This is closely followed by *SCI hortic-amsterdam*, with 753 citations, and *Plant physiol*, with 496 citations. The connecting line between *Acta hortic* and *SCI hortic-amsterdam* is the thickest, indicating that articles from both journals are often

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cited together. Similarly, there is a clear link between *Hortscience* and *Jagr food chem*. In these journals, especially *Acta hortic*, were significantly cited and are key publications in the field of pear fertilizer management research. They can be clearly divided into four different clusters: the green cluster, led by *Plant Physiol*, focuses on plant physiological aspects of pear fertilizer management, involving the study of fertilizer application on the material metabolism, growth and development of pear plants and their interaction with the environment, and analyzing how fertilizer application can regulate the growth of pears by affecting plant physiological processes; the red cluster, centered around *Plant and Soil*, focuses on the study of pear - soil system, and how fertilizer application affects plant physiological processes. The red cluster, with Plant and Soil as its core, explores the pear-soil system in depth, and studies the interactions between fertilizer application and soil science, such as how fertilizer application alters the physico-chemical properties of the soil, which in turn affects the uptake and utilization of nutrients by pears, as well as the association between soil health and the response of pears to fertilizer application; the blue cluster, with *J Exp Bot* as its core, focuses on experimental research on pears, and involves the direction of crop genetics and breeding in relation to fertilizer application, for example, by means of fertilizer application experiments. The purple cluster associated with *Hortscience* focuses on horticultural science, focusing on pear as a horticultural crop and studying the application of fertilization in horticultural cultivation and fertilization management, covering the optimization of pear orchard fertilization program and the effect of fertilization under different cultivation modes, so as to serve the pear industry in production practice. In conclusion, the research related to pear fertilizer management is mainly published in professional journals such as Plant Physiology, Plant and Soil Interaction, Crop Genetic Breeding, Horticultural Science, etc., which are used to disseminate the research results on the impact of fertilizer application on the growth of pear trees, the soil environment and industrial practice.

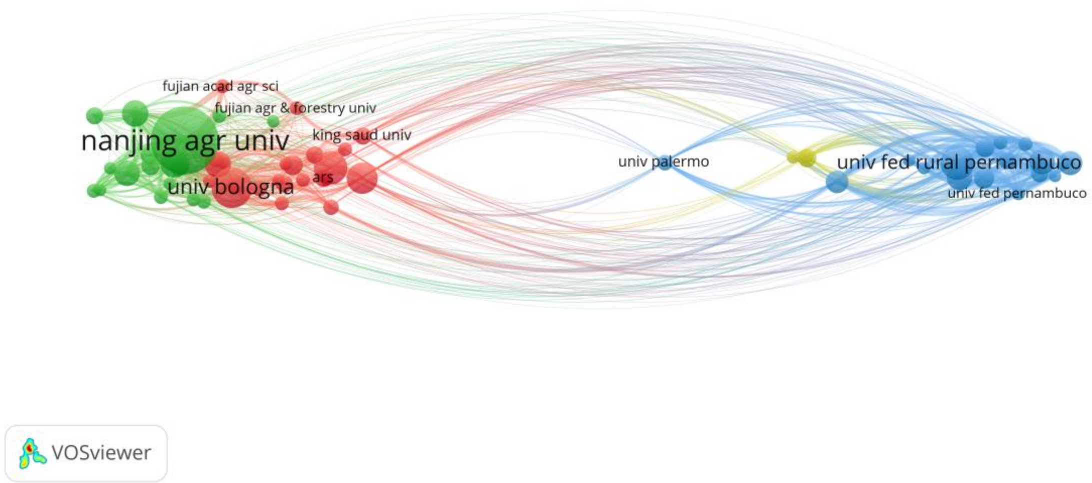

Figure 4. *Map of institutional co-operation in the field of pear fertilizer management research*

A total of 334 authors contributed to 1036 articles on pear fertilizer management in this dataset. The top 30 cited articles were selected for a focused bibliometric analysis to determine their impact on the development of pear fertilizer management research. The

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most cited article was published in *Agricultural Water Fertilization Management* in 2005 by Kang, SZ; Hao, XM et al. with 547 citations. The next most highly cited articles were published in *International Journal of Food Science and Technology* by Azeredo, HMC et al. in 2009 and in *Carbohydrate Polylists* by Kurosumi, A; Sasaki, C; et al. in 2009. *Carbohydrate Polymers* in 2009 by Kurosumi, A; Sasaki, C; et al. These articles are highly recognized in the field for their number of citations. The analysis showed that research on pear fertilizer management mainly involves collaboration between domestic institutions, which highlights the need for greater international collaboration.

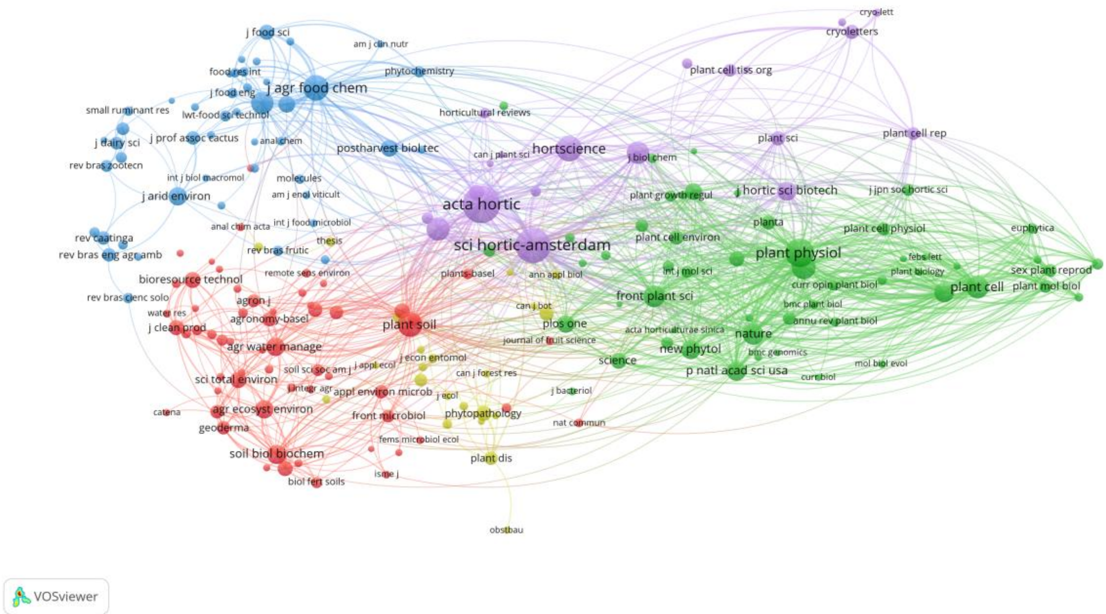

***Figure 5.** Co-citation knowledge domains of journals on pear fertilizer management (frequency ≥ 30) were mapped*

According to the content of these 30 papers (*Table A1*), the research in the field of pear fertilization management includes: (1) Morphological and quality response: Fertilizer application affects pear fruit morphology, chemical composition (e.g. sugars, organic acids, antioxidants, etc.), and alters the quality of the fruit.(2) Physiological and biochemical mechanisms: through the regulation of photosynthesis, nutrient metabolism, antioxidant defenses and hormonal signals, to adapt the fertilization conditions to maintain the physiological balance of the tree.(3) Molecular genetic linkage: involving the mining of genes responsive to fertilization, molecular marker-assisted breeding, and the cultivation of nutrient-efficient varieties with the help of gene regulation and genetic selection.(4) Cultivation practice: covering irrigation-fertilization synergy, prevention and control of nutrient disorders such as iron deficiency and yellowing, as well as sustainable fertilization management solutions such as organic fertilizer substitution and precision fertilizer application.(5) Multidisciplinary research: integrating plant physiology, soil science, horticulture, biotechnology and other disciplines to build a fertilizer management technology system and promote precision and sustainability.

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Analysis of research hotspots and evolutionary trends

Thematic keyword mapping and hotspot evolution trends

Keyword co-occurrence analysis reveals the intrinsic linkages and evolving hotspots in pear fertilizer management research. *Table 2* shows the top 20 keywords in the field, with "pear" and "fertilization" dominating, followed by "growth", followed by "growth", "yield", "nitrogen" and "quality". This pattern suggests that fertilization management has a significant effect on pear growth, yield and fruit quality, highlighting the importance of understanding the 'fertilization - growth - yield - quality' relationship as a direction for basic research in this area. Based on these keywords, the current research on pear fertilization management mainly covers two aspects: (1) Research on the regulation of pear tree growth, yield and quality by fertilization. (2) Fertilization and soil environment, varietal characteristics of the interaction mechanism.

Table 2. *Top 20 high-frequency keywords*

Rank	Keyword plus	Cluster	Occurrences	Links	TLS[f]
1	Pear	6	149	251	708
2	Growth	3	122	226	630
3	Nitrogen	2	121	210	586
4	Yield	4	99	184	526
5	Fertilization	4	89	179	462
6	Quality	2	84	170	389
7	Apple	6	62	144	316
8	Soil	2	54	126	243
9	Pyrus communis	8	58	124	231
10	Opuntia-ficus-indica	1	44	94	218
11	Nutrition	4	38	117	216
12	Fruit	7	43	120	207
13	Phosphorus	2	35	106	201
14	Potassium	8	36	95	187
15	Plants	3	36	76	184
16	Productivity	2	35	96	177
17	Fruit quality	4	35	84	172
18	Trees	2	31	82	164
19	Calcium	8	30	82	162
20	Identification	5	33	87	161

Keyword clustering analysis reveals the relationship between keywords to identify research hotspots. The results visualized in the figure identified 8 core clusters in pear fertilization management research (combined with keyword relevance and thematic focus, integrated and summarized into 8 typical directions): (1) Red cluster (cactus pear specialty research): focusing on the nutrients (dietary fiber, minerals), physiological characteristics (mucilage, cladode) and planting under arid environments (semiarid) in cactus pears (opuntia ficus indica, cactus pear, etc.).(opuntia - ficus - indica, cactus pear, etc.): focusing on the nutritional composition (dietary fiber, minerals), physiological characteristics (mucilage, cladode) and planting applications in arid environments

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(semiarid), involving the development of specialty resources and research on adaptation to adversity. (2) Green Cluster (Fertilization - Growth - Quality Core): Focusing on the regulation of pear fertilization on growth, yield and quality, we will take nitrogen and phosphorus as the core to explore the link between precision fertilization and production efficiency. The association between precision fertilizer application and production efficiency will be explored. (3) Blue Cluster (Genetic Breeding and Germplasm Innovation): Focusing on the genetic breeding (cultivar, genes), germplasm resources and genomics (genome, expression) of pears (pyrus communis, apple), the cluster will analyze the genetic basis, explore the function of genes, and promote the improvement of varieties and germplasm innovation. (4) Purple Cluster (4) Purple cluster (physiological mechanism of fruit development): taking fruit development (pear-set, tomato) as the core, research on pollen - tube growth, hormone regulation (auxin) and reproductive physiology (self-incompatibility), to analyze the molecular and physiological path of pear fruit formation. (5) Yellow cluster (environmental response and growth control): focus on pear tree growth (growth) response to environmental factors (water, soil properties, semiarid stress), to explore the growth of environmental stress under the adaptive mechanisms and regulatory strategies, associated with water and fertilizer management and environmental interactions.(6) Orange cluster (post-harvest treatment and preservation technology): focus on fruit (grape, pear) post-harvest link, involving storage, disease prevention and control (biological control, blue mold) and processing (juice), research on post-harvest quality maintenance and value-added technologies, extending the whole industrial chain.(7) Green cluster (resistance and metabolism molecular mechanism): through gene (genes, expression) analysis, explore the molecular basis of pear tree resistance (resistance), metabolism regulation (metabolism), mining resistance and high quality traits of the genetic regulatory network.(8) Shallow Green Cluster (Multiple Cropping System Linkage): Involving the planting linkage between pears and maize, vegetables and other crops, researching the use of resources (irrigation, soil) and ecological effects under intercropping and crop rotation modes, and expanding the systemic perspectives of fruit tree research.

Each cluster covers the whole chain of pear research from genetic basis, cultivation physiology to industrial application (planting, post-harvest), with green (cultivation practice) and blue (genetic basis) as the core driving force, and the other clusters extending to the dimensions of specialty resources, environmental adaptation, and multi-crop synergism, which present the diversified connection and cross-fertilization of research in the field.

Comprehensive analysis of the results in *Table 2* and *Figure 6* highlights two main research directions: (1) growth - yield - quality synergistic optimization under fertilization regulation: high-frequency words such as “pear, growth, yield, quality, fertilization, nitrogen” and high correlation (e.g. growth and fertilization co-occur closely) (e.g. growth and fertilization co-occur closely), focusing on “how fertilization strategies drive pear growth and enhance fruit yield and quality”. (2) Analysis of the mechanism of genetic-environmental interactions between fertilization: keywords such as “pyrus communis, apple, soil, nutrition, identification” point to “genetic differences in the response to fertilization and the mechanism of environmental adaptation”.”. These findings are consistent with the conclusions of the analyses of the top 30 most influential papers, demonstrating the consistency of research focus in this area.

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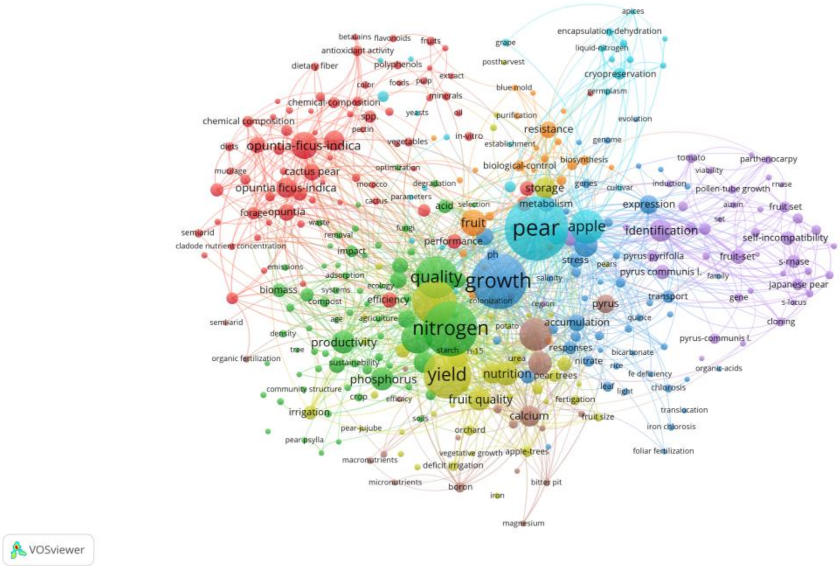

***Figure 6.** Knowledge domain map of the keywords co-occurrence network (frequency ≥ 3)*

Identification of research frontiers

Figure 7 illustrates the categorization of research themes for pear fertilizer management. The lower right quadrant of the "Foundation Themes" quadrant includes the keywords "pear, apple, pyrus communis", which are key to the field but still need to be researched further. In contrast, the "Driving Themes" quadrant in the upper right corner contains the established and important keywords "growth, nitrogen, yield", which corroborate the findings in the keyword data, highlighting their centrality in pear fertilizer management. "Niche topics" are located in the upper left quadrant and contain the keywords "cryopreservation, survival, encapsulation-dehydration", although their importance and slightly less developed than the "Driving Themes", they are still important and could expand the boundaries of pear fertilizer management research. The lower left quadrant represents the "Emerging or Declining Themes" and contains the keywords "identification, fruit-set, self-incompatibility". Analyzing this in conjunction with *Figure 8* will help to further clarify these research frontiers.

The "Trending Themes" section helps to visualize, analyze and forecast the research focus on pear fertilizer management. The period 2017–2019 shows a significant concentration of research activity, with the largest nodes occurring in the "growth" "nitrogen" and "yield", highlighting the high level of interest in these themes. In addition, the appearance of keywords such as "fruit quality" "fertilization" and "nutrition" until 2022 suggest that they are likely to be continuing research hotspots. Similarly, terms such as "identification", "self - incompatibility", "encapsulation - dehydration", which appear until 2023, suggest that they may be a continuing research interest. dehydration" by 2023, suggesting that they may be a future research direction. A comparison of *Figures 7* and *8* shows that the topics in the lower left quadrant of *Figure 7* are emerging as emerging research areas. In conclusion, the current frontiers of pear fertilizer management research include studies on growth and yield regulation by nutrients such as nitrogen, fruit quality-related fertilizer studies and fertilizer management studies on specialty fruit trees (e.g. opuntia - ficus - indica, etc.).

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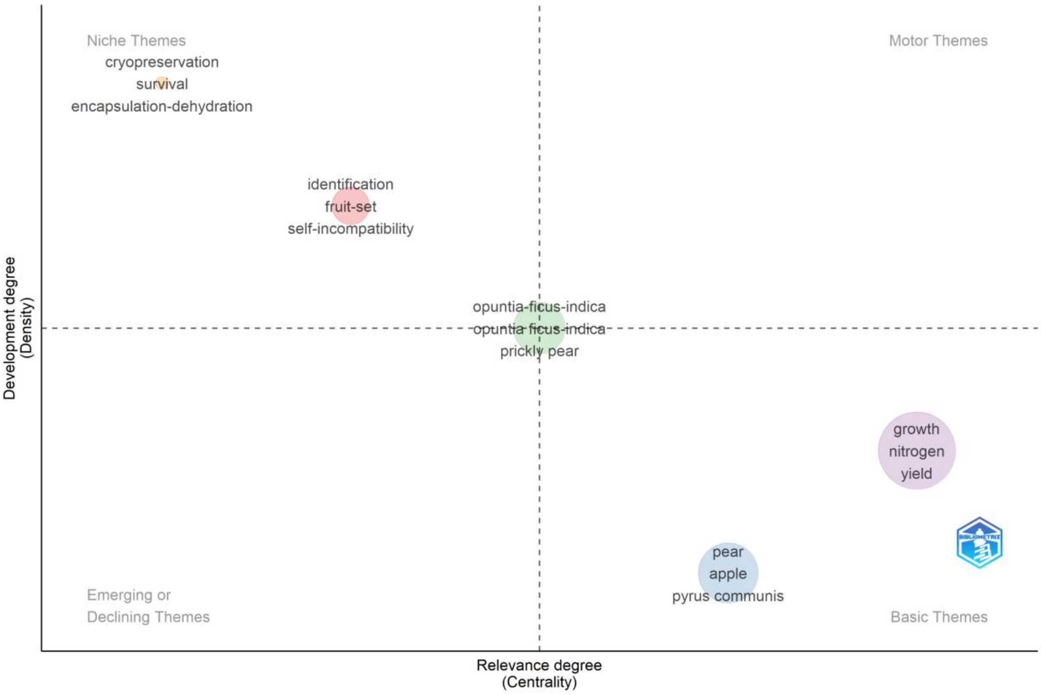

***Figure 7.** Keywords for the topic in the field of pear fertilizer management (frequency ≥ 8)*

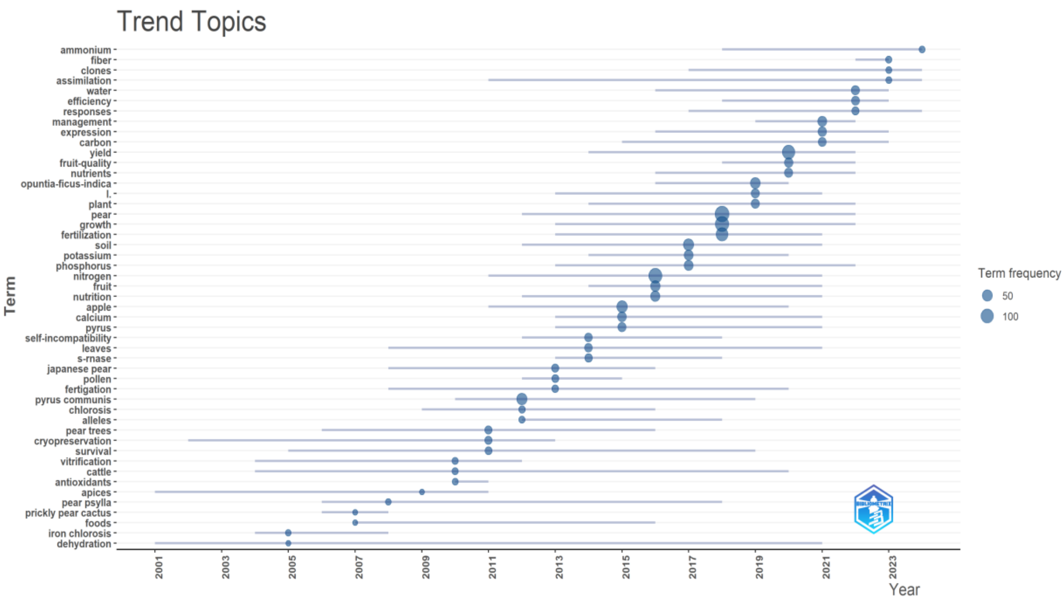

***Figure 8.** Keywords with the strongest occurrence bursts (frequency ≥ 5)*

Discussion

Climate change, food shortage, water scarcity, and population growth are major challenges facing the world today. As indicated by the exponential growth in publications after 2015 (*Fig. 2*), fertilizer management imbalance has become a key constraint to global pear yield improvement and quality optimization. With the intensification of global warming, the temporal and spatial matching of water and nutrients in pear orchards is

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becoming increasingly complex. Our keyword co-occurrence analysis (*Fig. 6*) identified distinct research clusters ranging from genetic breeding to cultivation practices. Therefore, it is of urgent practical significance to systematically analyze these trends. Based on the bibliometric clusters identified in this study, the current research focuses on two major directions: the biological response mechanisms (corresponding to the green and purple clusters) and the innovation of efficient cultivation technologies (corresponding to the yellow and blue clusters).

Mechanisms for pear fertilizer management revealed by keyword clusters

Morphological, physiological and biochemical response mechanisms (reflecting the "Green Cluster")

The "Green Cluster" in *Figure 6,* centered on "growth", "nitrogen", and "quality", highlights that nutrient supply is the primary driver of morphological and physiological plasticity in pears. Pear trees achieve efficient nutrient absorption and utilization through synergistic adjustments in root architecture, canopy structure, physiological function, and biochemical metabolism.

(1) Morphological response mechanisms Consistent with the high centrality of the keyword "root" in our network analysis, pear trees achieve efficient nutrient absorption through root architecture adjustments. Under sufficient nitrogen, phosphorus, and potassium supply, the number of fibrous roots increases by 30–40%, and root hair density by 25%, forming a dense shallow absorption network. Conversely, when a single nutrient (e.g., nitrogen) is in excess, the growth of the main root is inhibited, and the lateral roots expand deeper, forming a "horizontal-vertical" layered absorption structure (Auteri, 2023). For example, the biomass of fine roots (diameter < 0.5 mm) of pear trees increased from 28% to 42% under drip irrigation compared to conventional fertilizer application, and this structural optimization resulted in an increase in nutrient uptake efficiency of about 20% (Wang et al., 2021). Above-ground morphological regulation is also evident. With sufficient nitrogen fertilizer, the leaf area index (LAI) increased from 3.5 to 4.8, the specific leaf area (SLA) increased by 12-15%, and the number of leaf fenestrae layers increased from 2 to 3 to enhance photosynthesis (Verma et al., 2022). In the case of phosphorus and potassium deficiencies, the internodes of the new shoots were shortened by 18-25%, and the cuticle of the leaves was thickened by 15-20% to reduce the loss of transpired matter and prioritize the protection of fruit development (Ismayil et al., 2023).

(2) Physiological and biochemical response mechanisms The co-occurrence of terms like "metabolism" and "photosynthesis" suggests that nutrient uptake drives complex physiological shifts. Nutrient uptake and metabolic regulation: Root ion channel activity was significantly affected by fertilizer application. For instance, high nitrogen supply activated the expression of ammonium transport protein (AMT) genes on the root plasma membrane, which increased NH_4 uptake by 40% (Muratore et al., 2021). Under phosphorus-deficient conditions, the inter-root acid phosphatase activity of pear trees was enhanced by two to three times to promote mineralization and uptake of organic phosphorus (Li et al., 2024). Furthermore, when soil effective potassium content was ≥ 150 mg/kg, leaf relative water content (RWC) was maintained above 85%, stomatal conductance increased by 30%, and water-use efficiency (WUE) increased to 2.8 g/kg (Yang et al., 2023).

Photosynthesis and material synthesis: Nitrogen fertilizer increases the photosynthetic rate from 18 μmol/m²/s to 24 μmol/m²/s by regulating chlorophyll synthesis and Rubisco enzyme activity (Ukozehasi, 2015). Phosphorus is involved in ATP synthesis and

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photosynthate transport; in the absence of phosphorus, the transfer efficiency of sucrose from leaves to fruits decreased by 40%, resulting in a 15%-20% decrease in the soluble sugar content of fruits (Malhotra et al., 2018).

Osmoregulation and hormonal signaling: The "Purple Cluster" (fruit development) links nutrient status to hormonal regulation. Pear trees accumulate osmoregulatory substances such as proline and soluble sugars under nutrient stress (Abd El-wahab and Shakweer, 2024). For example, leaf proline content increased significantly during nitrogen deficiency to maintain cell expansion pressure (Singh et al., 2016). Simultaneously, the antioxidant enzyme system scavenges reactive oxygen species and mitigates membrane lipid peroxidation (Ali et al., 2024). Regarding hormonal signaling, nitrogen fertilizer promotes the synthesis of growth hormone (IAA), which increases the growth of new shoots (Zaman et al., 2015), whereas abscisic acid (ABA) content rises during potassium deficiency to induce stomatal closure and inhibit cytokinin (CTK) activity, slowing down leaf senescence (Cakmak, 2005).

Molecular response mechanisms (linking to the "Blue Cluster")

The "Blue Cluster" in our bibliometric map, featuring keywords like "genes", "expression", and "genome", points to the increasing depth of molecular research. Recent studies highlight the molecular basis of fertilization responses: Nutrient transporter gene expression: The NRT1.1 gene (nitrate transporter protein) was up-regulated 4-fold in pear roots shortly after N fertilizer application, and PHT1 family genes were up-regulated under phosphorus-deficient conditions, driving nutrient transport across membranes (Bovill et al., 2013). Transcription factor regulatory network: The bZIP-like transcription factor PbABF2 is activated during phosphorus deficiency to promote efficient phosphorus utilization. Similarly, PbMYB44 regulates nitrogen metabolism, and its overexpression has been shown to increase nitrogen use efficiency significantly (Cao et al., 2016). Non-coding RNA regulation: Studies on non-coding RNAs align with the "Identification" hotspot in our Trend Topics (*Fig. 8*). miR399 is involved in the maintenance of phosphorus homeostasis by targeting the ubiquitin ligase gene PHO2 (Nilsson et al., 2010). Additionally, lncRNA PbLNC1 acts as a molecular sponge to adsorb miR169, deregulate the inhibition of the NF-YA transcription factor, and promote the expression of nitrogen-responsive genes (Ijaz et al., 2024).

Synergistic mechanisms of fertilization and environment (the "Yellow Cluster")

The "Yellow Cluster", focusing on environmental response, underscores that fertilizer effectiveness is constrained by external factors like climate and soil texture. Climate modulation: In temperate regions such as North China, autumn basal fertilization promotes carbohydrate storage in roots prior to overwintering, with soluble sugar concentrations increasing by approximately 18% (Wei et al., 2014). By contrast, in subtropical areas such as Brazil, fertilizer application during the rainy season must be combined with mulching to reduce nutrient loss; this practice has been shown to lower nitrogen leaching significantly (Erenstein, 2002). Influence of soil texture: Nitrogen fertilizer strategies must adapt to soil type. For instance, in sandy loam soils, small quantities should be applied to avoid leakage, whereas in clay loam soils, phosphorus fertilizer can be applied intensively to increase the utilization rate, often combined with deep ploughing to improve root penetration (Powlson et al., 2013).

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Optimizing breeding and cultivation techniques based on research trends

Optimizing breeding techniques (the "Genetic Breeding" trend)

As shown in the Trend Topics analysis (*Fig. 8*), keywords related to genetics have shifted from basic "selection" to precise "molecular breeding". (1) Conventional breeding technology innovation Crossbreeding directed screening remains fundamental. Selection of varieties tolerant to barrenness through crosses between resistant parents (e.g., sand pear × autumn pear) is a key strategy (Guzman and Dhingra, 2019). For example, the variety 'in pear 4' bred by the Chinese Academy of Agricultural Sciences showed a 15% yield increase over control varieties under reduced nitrogen application (Zhang et al., 2025). Additionally, sprouting selection has produced mutants like 'Ji Honey' with 30% higher phosphorus uptake efficiency (Li et al., 2024).

(2) Breakthroughs in molecular breeding technology Molecular marker-assisted selection (MAS) allows for the rapid screening of single plants with high nitrogen use efficiency (NUE) using SSR markers, shortening the breeding cycle from 8-10 years to 4-5 years (Gao et al., 2024). Furthermore, gene editing offers precise improvement. CRISPR/Cas9-mediated knockout of the PpNRT2.1 gene in roots has been shown to increase nitrogen-use efficiency from 35% to 50% (Malabarba et al., 2020)

(3) Genetically modified technology applications Transgenic technology offers new possibilities for abiotic stress tolerance. Introduction of exogenous salt tolerance genes (e.g., AtNHX1) into the pear genome enhances nutrient uptake in salinized soils (Serra, 2009). Field experiments showed that the potassium uptake of transgenic pear varieties increased by 25% compared with that of the wild type in saline soil, while fruit yield remained stable (Lebedev, 2023).

Optimized cultivation techniques (the "Cultivation Practice" trend)

Aligning with the "Orange Cluster" (post-harvest and management), modern cultivation requires a system of "precise control - ecological synergy". Precision Fertilizer Application: The integration of UAVs and multi-spectral sensors to obtain the pear orchard vegetation index (NDVI) allows for the dynamic adjustment of nitrogen, phosphorus, and potassium application (Guo et al., 2021). Precise control of water and fertilizer integration: The use of drip irrigation belts linked with fertilizer applicators ensures the precise supply of nutrients according to the pear tree climatic period (budding, fruiting, harvesting) (Verma, 2014).

Conclusion and outlook

This study conducted a bibliometric analysis of 1, 036 articles on pear fertilizer management retrieved from the Web of Science database. The results show that global research output in this field has been steadily increasing, despite fluctuations in some years. China leads with 242 publications, followed by Brazil (130) and the United States (89), reflecting both the dominance of major pear-producing countries and the growing internationalization of this research domain. The high citation frequency of *Acta Horticulturae* (860 citations) underscores its role as a core journal in advancing knowledge in this area. By analyzing the top 30 cited papers and high-frequency keywords, it can be seen that the current research hotspots are focused on the growth, physiology, biochemistry and molecular response mechanism of pear under fertilization conditions, while the research on fertilization breeding and optimization of cultivation

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technology has also attracted much attention. In the future, research on pear physiology, biochemistry and molecular response mechanisms will remain the core, and the importance of innovative research on nutrient fertilization management, such as transgenic technology and intelligent fertilization, will be further enhanced. This study aims to provide theoretical support for pear fertilization management research, help grasp the research dynamics and trends, and contribute to the improvement of pear yield and quality, and promote the sustainable development of pear industry.

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REFERENCES

[1] Abd El-wahab, M. A., Shakweer, N. H. (2024): Potential impacts of amino acids, putrescine and glycine betaine on productivity and fruit attributes of “Le-Conte” pear trees grown under water scarcity stress. – Fayoum Journal of Agricultural Research and Development 38(1): 15-35. https://doi.org/10.21608/fjard.2024.342079.

[2] Ali, A. E. E., Basson, G., Akanbi, M. O., et al. (2024): Comparison of antioxidant enzyme activities between Tylosema esculentum and Tylosema fassoglense in response to water deficit. – Preprint. https://doi.org/10.20944/preprints202412.1661.v1.

[3] Aria, M., Cuccurullo, C. (2017): Bibliometrix: An R-tool for comprehensive science map ping analysis. – Journal of Informetrics 11(4): 959-975. https://doi.org/10.1016/j.joi.2017.08.007.

[4] Auteri, N. (2023): Characterization of modified cactus pear (Opuntia ficus indica (L.) Mill) pruning waste as a sustainable and innovative solution to recycle phosphorus from agricultural streams. – Tesi di dottorato, Università degli Studi di Palermo.

[5] Bell, R. L. (1991): Pears (Pyrus). – Acta Hortic. 290: 657-700. https://doi.org/10.17660/actahortic.1991.290.15.

[6] Bovill, W. D., Huang, C. Y., McDonald, G. K. (2013): Genetic approaches to enhancing phosphorus-use efficiency (PUE) in crops: challenges and directions. – Crop and Pasture Science 64(3): 179-198. https://doi.org/10.1071/cp13135.

[7] Cakmak, I. (2005): The role of potassium in alleviating detrimental effects of abiotic stresses in plants. – Journal of Plant Nutrition and Soil Science 168(4): 521-530. https://doi.org/10.1002/jpln.200420485.

[8] Cao, Y., Han, Y., Li, D., et al. (2016): MYB transcription factors in Chinese pear (Pyrus bretschneider i Rehd.): genome-wide identification, classification, and expression profiling during fruit development. – Frontiers in Plant Science 7: 577. https://doi.org/10.3389/fpls.2016.00577.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_34193438

[9] Carranca, C., Brunetto, G., Tagliavini, M. (2018): Nitrogen nutrition of fruit trees to reconcile productivity and environmental concerns. – Plants 7(1): 4. https://doi.org/10.3390/plants7010004.

[10] Deckers, T., Schoofs, H. (2007): Status of the pear production in Europe. – International Pear Symposium 800: 95-106. https://doi.org/10.17660/actahortic.2008.800.8.

[11] Erenstein, O. (2002): Crop residue mulching in tropical and semi-tropical countries: an evaluation of residue availability and other technological implications. – Soil and Tillage Research 67(2): 115-133. https://doi.org/10.1016/s0167-1987(02)00062-4.

[12] Fu, H., Ma, Z., Wang, X., et al. (2023): Sustainable strategies related to soil fertility, economic benefit, and environmental impact on pear orchards at the farmer scale in the Yangtze River Basin, China. – Environmental Science and Pollution Research 30(7): 17316-17326. https://doi.org/10.1007/s11356-022-23319-8.

[13] Gannuscio, R. (2025): Study of New Agro-Industrial By-Products from Prickly Pear to Increase the Sustainability of Livestock Farming. – In: Cucina, M., Regni, L. (eds.) New Advances on Nutrients Recovery from Agro-Industrial and Livestock Wastes for Sustainable Farming. MDPI, Basel. https://doi.org/10.3390/books978-3-0365-2564-8.

[14] Gao, C., Chen, C., Liu, N., et al. (2024): Genetic diversity and association analysis of traits related to water-use efficiency and nitrogen-use efficiency of Populus deltoides based on SSR markers. – International Journal of Molecular Sciences 25(21): 11515. https://doi.org/10.3390/ijms252111515.

[15] Guo, Y., Chen, S., Wu, Z., et al. (2021): Integrating spectral and textural information for monitoring the growth of pear trees using optical images from the UAV platform. – Remote Sensing 13(9): 1795. https://doi.org/10.3390/rs13091795.

[16] Guzman, D., Dhingra, A. (2019): Challenges and opportunities in pear breeding. – In: Lang, G. A. (ed.) Achieving Sustainable Cultivation of Temperate Zone Tree Fruits and Berries. Vol. 2. Case Studies. Burleigh Dodds Science Publishing, Cambridge, pp. 129-156. https://doi.org/10.19103/as.2018.0040.19.

[17] Ijaz, S., Iqbal, J., Abbasi, B., A., et al. (2024): nc-RNA: A Key Player in Stress Response Pathways, a Molecular Perspective. – In: Prakash, C. S., Waseem, M., Fiaz, S. (eds.) ncRNAs: Mediated Regulation: The Unarguable Biological Function to Environmental Constrains. Springer Nature, Cham, pp. 139-163. https://doi.org/10.1007/978-3-031-69354-0_5.

[18] Ismayil, M. M. S., Kumar, N., Bankar, D. R., et al. (2023): Novel Approaches in Plant Protection. – Integrated Publications, Delhi. https://doi.org/10.22271/int.book.330.

[19] Kan, J., Yu, M., Li, X., et al. (2024): Current status and recommendations for the fruit tree industry in east China’s Jiangsu Province. – Technology in Horticulture 4(1). https://doi.org/10.48130/tihort-0024-0014.

[20] Lebedev, V. (2023): Fruit characteristics of transgenic pear (Pyrus communis L.) trees during long-term field trials. – Plant Foods for Human Nutrition 78(2): 445-451. https://doi.org/10.1007/s11130-023-01076-4.

[21] Li, T., Gao, Z., Bai, X., et al. (2024): Exploring the coupling mode of water and fertilizer for improving growth, fruit quality, and yield of the pear in the arid region. – Open Life Sciences 19(1): 20220911. https://doi.org/10.1515/biol-2022-0911.

[22] Li, Y., Li, Z., Gong, P., et al. (2024): Enhanced irrigation volume reduces salinity and improves deep root zone soil nutrients, phosphatase activity and changes root traits of fruit trees. – Agricultural Water Management 302: 109001. https://doi.org/10.1016/j.agwat.2024.109001.

[23] Lu, S., Bai, X., Zhang, J., et al. (2022): Impact of virtual water export on water resource security associated with the energy and food bases in Northeast China. – Technological Forecasting and Social Change 180: 121635. https://doi.org/10.1016/j.techfore.2022.121635.

[24] Malabarba, J., Chevreau, E., Dousset, N., et al. (2020): New strategies to overcome present CRISPR/Cas9 limitations in apple and pear: efficient dechimerization and base editing. – International journal of molecular sciences 22(1): 319. https://doi.org/10.3390/ijms22010319.
[25] Malhotra, H., Vandana, Sharma, S., et al. (2018): Phosphorus Nutrition: Plant Growth in Response to Deficiency and Excess. – In: Hasanuzzaman, M. et al. (eds.) Plant Nutrients and Abiotic Stress Tolerance. Springer, Singapore, pp. 171-190. https://doi.org/10.1007/978-981-10-9044-8_7.
[26] Muratore, C., Espen, L., Prinsi, B. (2021): Nitrogen uptake in plants: the plasma membrane root transport systems from a physiological and proteomic perspective. – Plants 10(4): 681. https://doi.org/10.3390/plants10040681.
[27] Musacchi, S., Iglesias, I., Neri, D. (2021): Training systems and sustainable orchard fertilisation management for European pear (Pyrus communis L.) in the Mediterranean area: a review. – Agronomy 11(9): 1765. https://doi.org/10.3390/agronomy11091765.
[28] Nilsson, L., Müller, R., Nielsen, T., H. (2010): Dissecting the plant transcriptome and the regulatory responses to phosphate deprivation. – Physiologia Plantarum 139(2): 129-143. https://doi.org/10.1111/j.1399-3054.2010.01356.x.
[29] Powlson, D. S., MacDonald, A. J., Poulton, P. R. (2013): The Continuing Value of Long-Term Field Experiments: Insights for Achieving Food Security and Environmental Integrity. – In: Dent, D. (ed.) Soil as World Heritage. Springer, Dordrecht, pp. 131-157. https://doi.org/10.1007/978-94-007-6187-2_16.
[30] Serra, S. (2009): Salt stress responses in pear and quince: physiological and molecular aspects. – Dissertation thesis, Alma Mater Studiorum Università di Bologna. Dottorato di ricerca in Colture arboree ed agrosistemi forestali ornamentali e paesaggistici, 21 Ciclo. DOI 10.6092/unibo/amsdottorato/1620.
[31] Singh, M., Singh, V. P., Prasad, S. M. (2016): Responses of photosynthesis, nitrogen and proline metabolism to salinity stress in Solanum lycopersicum under different levels of nitrogen supplementation. – Plant Physiology and Biochemistry 109: 72-83. https://doi.org/10.1016/j.plaphy.2016.08.021.
[32] Ukozehasi, C. (2015): A physiological basis to crop improvement and agronomic develop ment. – Dissertation thesis, University of Cambridge. https://doi.org/10.17863/CAM.164 54
[33] Verma, B., Prasad, R., Srivastava, P. K., et al. (2022): Investigation of optimal vegetation indices for retrieval of leaf chlorophyll and leaf area index using enhanced learning algorithms. – Computers and Electronics in Agriculture 192: 106581. https://doi.org/10.1016/j.compag.2021.106581.
[34] Verma, M. K. (2014): Pear Production Technology. Training Manual on Teaching of Post-Graduate Courses in Horticulture (Fruit Science). 1st Ed. – Post Graduate School, Indian Agricultural Research Institute, New Delhi. https://doi.org/10.52768/2766-7820/1571.
[35] Wang, L., Wu, W., Xiao, J., et al. (2021): Effects of different drip irrigation modes on water use efficiency of pear trees in northern China. – Agricultural Water Management 245: 106660. https://doi.org/10.1016/j.agwat.2020.106660.
[36] Wei, H., Xu, C., Ma, L., et al. (2014): Effect of late-season fertilization on nutrient reserves and carbohydrate accumulation in bareroot Larix olgensis seedlings. – Journal of Plant Nutrition 37(2): 279-293. https://doi.org/10.1080/01904167.2013.859697.
[37] Yang, C., Zhang, W., Gu, H., et al. (2023): Field, plant, to leaf: a meta-analysis on crop water use efficiency response to potassium fertilization. – Journal of Hydrology 621: 129578. https://doi.org/10.1016/j.jhydrol.2023.129578.
[38] Zaman, M., Kurepin, L. V., Catto, W., et al. (2015): Enhancing crop yield with the use of N-based fertilizers co-applied with plant hormones or growth regulators. – Journal of the Science of Food and Agriculture 95(9): 1777-1785. https://doi.org/10.1002/jsfa.6938.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_34193438

[39] Zhang, Y., Cheng, Y., Ma, Y., et al. (2024): Regulation of pear fruit quality: a review based on Chinese pear varieties. – Agronomy 15(1): 58. https://doi.org/10.3390/agronomy15010058.
[40] Zörb, C., Senbayram, M., Peiter, E. (2014): Potassium in agriculture–status and perspectives. – Journal of Plant Physiology 171(9): 656-669. https://doi.org/10.1016/j.jplph.2013.08.008.

APPENDIX

Table A1. *The 30 most cited papers in the field of pear fertilizer management*

Rank	Title	Journal	Year	JC	JIF	JCI
(1)	Improving agricultural water productivity to ensure food security in China under changing environment: From research to practice	Agricultural Water Fertilization Management	2017	547	6.5	1.85
(2)	Betalains: properties, sources, applications, and stability - a review	International Journal of Food Science and Technology	2009	465	3.1	0.58
(3)	Utilization of various fruit juices as carbon source for production of bacterial cellulose by Acetobacter xylinum NBRC 13693	Carbohydrate Polymers	2009	253	12.5	2.41
(4)	Ammonia emission factors for UK agriculture	Water Resources Research	2000	248	3.7	0.88
(5)	Extraction and characterization of mucilage in Opuntia spp.	Journal of Arid Environments	2007	214	2.5	0.63
(6)	Minimal nitrogen and water use in horticulture: Effects on quality and content of selected nutrients	Food Research International	2010	188	8	1.53
(7)	Modulation of antioxidant compounds in organic vs conventional fruit (peach, Prunus persica L., and pear, Pyrus communis L.)	Journal of Agricultural and Food Chemistry	2002	188	6.2	1.29
(8)	Metals and micronutrients - food safety issues	Field Crops Research	2019	155	8.8	0.96
(9)	Genome sequence of Valsa canker pathogens uncovers a potential adaptation of colonization of woody bark	New Phytologist	2015	151	8.1	2.06
(10)	Chemical compositional characterization of eight pear cultivars grown in China	Food Chemistry	2007	146	9.8	1.85
(11)	Total antioxidant capacity, total phenolic content, mineral elements, and histamine concentrations in wines of different fruit sources	Journal of Food Composition and Analysis	2007	136	4.6	0.83
(12)	Response of organic and inorganic carbon and nitrogen to long-term grazing of the shortgrass steppe	Environmental Fertilization Management	2004	135	3	0.57

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Rank	Title	Journal	Year	JC	JIF	JCI
(13)	The partial compositional characteristics of apple juice from 175 apple varieties	Journal of Food Composition and Analysis	2011	130	4.6	0.83
(14)	Internal leaf anatomy and photosynthetic resource-use efficiency: interspecific and intraspecific comparisons	Tree Physiology	2007	130	3.7	1.38
(15)	Health of eastern North American sugar maple forests and factors affecting decline	Journal of Experimental Botany	2002	128	0.64	0
(16)	Modified version of ADM1 model for agro-waste application	Bioresource Technology	2009	123	9	1.67
(17)	Nature of Cu Species in Cu-SAPO-18 Catalyst for NH3-SCR: Combination of Experiments and DFT Calculations	Journal of Physical Chemistry C	2016	120	2.9	0.88
(18)	ROS-Activated Ion Channels in Plants: Biophysical Characteristics, Physiological Functions and Molecular Nature	International Journal of Molecular Sciences	2018	116	4.9	0.71
(19)	Ca2 + -Dependent Protein Kinase11 and 24 Modulate the Activity of the Inward Rectifying K + Channels in Arabidopsis Pollen Tubes	Plant Cell	2013	114	11.6	2.32
(20)	The use of sap flow measurements for scheduling irrigation in olive, apple and Asian pear trees and in grapevines	Plant and Soil	2008	111	4	1.07
(21)	A study on psychological strain in IVF patients	Journal of Assisted Reproduction and Genetics	2000	111	2.7	0.89
(22)	The role of mineral nutrition on yields and fruit quality in grapevine, pear and apple	Revista Brasileira de Fruticultura	2015	110	0.9	0.22
(23)	Agronomic means for the control of iron deficiency chlorosis in deciduous fruit trees	Journal of Plant Nutrition	2000	109	1.7	0.43
(24)	Life cycle assessment of fossil energy use and greenhouse gas emissions in Chinese pear production	Journal of Cleaner Production	2010	107	10	1.54
(25)	The association between tooth loss and the self-reported intake of selected CVD-related nutrients and foods among US women	Community Dentistry and Oral Epidemiology	2005	107	2.1	0.65
(26)	Electrocoagulation flocculation as a low-cost process for pollutants removal from urban wastewater	Chemical Engineering Research & Design	2017	104	3.9	0.59
(27)	Phytochemicals, nutritionals and antioxidant properties of two prickly pear cactus cultivars (Opuntia ficus indica Mill.) growing in Taif, KSA	Food Chemistry	2014	103	9.8	1.85
(28)	Elimination of textile dyes using activated carbons prepared from vegetable residues and their characterization	Journal of Environmental Fertilization Management	2016	101	8.4	1.56

Rank	Title	Journal	Year	JC	JIF	JCI
(29)	Recent advances in the cryopreservation of shoot-derived germplasm of economically important fruit trees of Actinidia, Diospyros, Malus, Olea, Prunus, Pyrus and Vitis	Biotechnology Advances	2013	96	12.5	1.51
(30)	Occurrence and assessment of veterinary antibiotics in swine manures: a case study in East China	Chinese Science Bulletin	2012	94	1.649	0

JC, journal citations; JIF, journal impact factor; JCI, journal citation indicators. Ranked by total citations (TC)

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