| **Section and Topic** | **Item No** | **Checklist item** | **Reported on Page Number/Line Number** | **Reported on Section/Paragraph** |
| --- | --- | --- | --- | --- |
| **TITLE** | | |  |  |
| Title | 1 | Impacts of fertilization and soil amendments on rhizosphere microbiota and growth of *panax*: A meta-analysis |  |  |
| **ABSTRACT** | | |  |  |
| Abstract | 2 | See the PRISMA 2020 for Abstracts checklist. |  |  |
| **INTRODUCTION** | | |  |  |
| Rationale | 3 | Continuous cropping of *Panax* species leads to soil acidification, reduced microbial diversity, and severe soil-borne diseases. Although various fertilizers and soil amendments have been tested, results are inconsistent and based on single-site studies. No systematic and quantitative synthesis comparing amendment types exists. This review addresses that gap. |  |  |
| Objectives | 4 | To quantitatively evaluate the comparative effects of four amendment types—conventional fertilizers, microbial fertilizers, organic amendments, and inorganic amendments—on soil physicochemical properties, rhizosphere microbial diversity and composition, disease incidence, and plant growth in *Panax* cultivation. |  |  |
| **METHODS** | | |  |  |
| Eligibility criteria | 5 | (1) Studies must include untreated controls and treatments with external inputs.  (2) Only studies focused on plants of the Panax genus will be included.  (3) Data were limited to high-throughput sequencing methods, excluding studies using alternative techniques (e.g., Phospholipid fatty acid, Denaturing gradient gel electrophoresis).  (4) Studies requiring a minimum of three replicates per treatment were selected.  (5) The additives belong to fertilizers or soil amendments.  Studies were grouped by amendment type: conventional fertilizers, microbial fertilizers, organic amendments, and inorganic amendments. |  |  |
| Information sources | 6 | Studies were identified from Web of Science and China National Knowledge Infrastructure (CNKI). Searches covered publications from January 2014 to December 2024.. |  |  |
| Search strategy | 7 | (bacterium OR bacteria OR microbial community OR microbial communities) AND (soil) AND (“*Panax ginseng*” OR “*Panax notoginseng*” OR “*Panax quinquefolius*”). No filters were applied except time window (2014–2024). |  |  |
| Selection process | 8 | All titles and abstracts were screened by two independent reviewers.  Full texts were assessed independently using the eligibility criteria.  Disagreements were resolved through discussion.  No automation tools were used. |  |  |
| Data collection process | 9 | Two reviewers independently extracted data from text, tables, and figures.  Data in figures were digitized using GetData 2.22.  When SD/SE/CI were missing, SD was imputed as 10% of the mean.  No automation tools were used. |  |  |
| Data items | 10a | Outcomes extracted:  Soil properties: pH, SOC, AN, AP, AK.  Microbial α-diversity: Chao1, ACE.  Microbial composition: phylum-level abundances.  Plant performance: disease incidence, plant height, root length, root fresh weight, root dry weight.  All available measurements from all time points were collected. |  |  |
| 10b | Additional variables extracted:  Location, amendment types, *Panax* species, sequencing method, sample sizes.  Assumptions for missing data:  SD imputed as 0.1 × mean when not reported.  SE converted to SD when needed. |  |  |
| Study risk of bias assessment | 11 | Publication bias in the meta-analysis was assessed using Rosenthal's fail-safe N method implemented in MetaWin(v2.1) software. Two reviewers independently conducted the publication bias assessment for each included study. |  |  |
| Effect measures | 12 | Effect size was calculated as log response ratio (lnRR) and converted to percent change for interpretation. |  |  |
| Synthesis methods | 13a | Studies were grouped by amendment category, ensuring comparability among synthesized studies. |  |  |
| 13b | In studies where no standard errors (SE), standard deviations (SD), or confidence intervals (CI) are reported, we assigned standard deviations that are 1/10 of the means.  In studies where only SE were reported, SD were calculated using the formula: SD = SE × √n. |  |  |
| 13c | Forest-plot-style figures created in R 4.4.1 using ggplot2. |  |  |
| 13d | Random-effects model using MetaWin 2.1 with 9,999 iterations.  Heterogeneity assessed using Q, Qw, Qb statistics.  Bias-corrected 95% CIs used. |  |  |
| 13e | Regression analyses conducted to examine relationships between pH and microbial metrics. |  |  |
| 13f | Rosenthal’s fail-safe N used to assess publication bias. |  |  |
| Reporting bias assessment | 14 | Publication bias assessed using fail-safe N. No significant bias detected. |  |  |
| Certainty assessment | 15 | Certainty evaluated narratively considering:  Consistency, magnitude, and direction of responses  Heterogeneity levels  Completeness of reporting across studies |  |  |
| **RESULTS** | | |  |  |
| Study selection | 16a | Flow diagram provided in Figure 1 |  |  |
| 16b | Flow diagram provided in Figure 1 |  |  |
| Study characteristics | 17 | Detailed in Supplementary Table 1:  Title  DOI  Type of additive  NCBI\_Accession  Pub Date  Sample size  Latitude  Longitude |  |  |
| Risk of bias in studies | 18 | Rosenthal's fail-safe N method was used to assess publication bias in the meta-analysis, and the results indicated no statistically significant evidence of publication bias for all parameters. |  |  |
| Results of individual studies | 19 | The results of the meta-analysis for all outcomes are presented as forest plots, which include the effect estimates and their corresponding confidence intervals to reflect the precision of each effect size. |  |  |
| Results of syntheses | 20a | Studies varied in amendment types, experimental designs, and soil conditions but generally moderate quality with consistent reporting of primary outcomes. |  |  |
| 20b | pH increased: microbial (+4%), organic (+7%), inorganic (+17%)  SOC, AN, AP strongly increased under organic amendments  Microbial diversity increased: Chao1 (+9%), ACE (+17%)  Disease incidence reduced under microbial (–36%), organic (–44%), inorganic (–23%)  Plant height increased under all amendments  Root traits improved most under organic and microbial amendments |  |  |
| 20c | Nutrient-related heterogeneity traced to soil type differences. |  |  |
| 20d | Fail-safe N confirmed robustness; exclusion of extreme values did not change conclusions. |  |  |
| Reporting biases | 21 | Fail-safe N inspection suggested no major reporting bias. |  |  |
| Certainty of evidence | 22 | Evidence moderately certain for pH and nutrient outcomes. |  |  |
| **DISCUSSION** | | |  |  |
| Discussion | 23a | Compared with conventional fertilizer, environment-friendly amendments (organic, microbial, inorganic) markedly improve soil conditions and *Panax* growth. |  |  |
| 23b | Heterogeneous soil conditions, incomplete variance reporting, and short experiment durations limit precision. |  |  |
| 23c | Potential unmeasured confounders cannot be fully excluded. |  |  |
| 23d | Overall, the research results of this work show that replacing conventional fertilizers with environmentally friendly and sustainable organic amendments can support healthier soils and higher-quality *Panax* production. |  |  |
| **OTHER INFORMATION** | | |  |  |
| Registration and protocol | 24a | The review was not registered. |  |  |
| 24b | No protocol was prepared. |  |  |
| 24c | Not applicable. |  |  |
| Support | 25 | This research was supported by the National Natural Science Foundation of China (No. 42388101, 82403271); Natural Science Foundation of Ningbo Municipality (No. 2024J420); Ningbo Top Talent Project (No. 215-432094250). We thank all of the data providers for the meta-analysis. |  |  |
| Competing interests | 26 | The authors declare no conflicts of interest to report regarding the present study. |  |  |
| Availability of data, code and other materials | 27 | The authors confirm that the data supporting the findings of this study are available within the article or its Supplementary Materials. |  |  |

\*As the checklist was provided upon initial submission, the page number/line number reported may be changed due to copyediting and may not be referable in the published version. In this case, the section/paragraph may be used as an alternative reference.