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ORGANIC FARMING PRACTICES AND YIELD STABILITY: A SYSTEMATIC LITERATURE REVIEW

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Abstract

The shift to sustainable agriculture in the global economy has increased the number of studies on the connection between organic farming activities and yield stability. Although the advantages of using organic systems are well known to be environmentally friendly, there is still controversy on whether they can achieve consistent productivity in the various agroecological settings. This is a systematic literature review that summarizes the empirical studies of 2015-2025 peer-reviewed articles to assess the effects of the practices of organic farming in areas of yield stability. We have made thorough searches in Scopus, Web of Science, PubMed and ScienceDirect databases, following the PRISMA guidelines of systematic reviews and meta-analyses, finding 1,247 unique records. There were 47 studies that qualified inclusion in the qualitative synthesis after the elimination of duplicates and systematic screening. The review shows that organic systems have similar yield stability to conventional agriculture in favorable management conditions, especially in the situations when diversification of cropping schemes and soil health maximization are enforced. Nevertheless, such stability in the yield of organic systems is susceptible to severe weather conditions and pest infestation in periods of conversion. Some of the important processes that mediate stability are the increased soil organic matter, a working biodiversity, and adaptive management practices. The analysis finds a major geographical bias to temperate geographies and a need to conduct further studies in tropical agroecosystems. The results aid in the development of evidence-based policies that promote sustainable agricultural transformations in addition to exposing the gaps in the research that need immediate remedy.

Keywords: Organic Agriculture, Yield Stability, Sustainable Farming, Agroecology, Systematic Review, Soil Health, Crop Diversification, Climate Resilience.

INTRODUCTION

Agricultural systems are already faced with more than ever before in a challenge to increase food production and simultaneously address environmental degradation, as well as climate changes (Foley et al., 2011; Springmann et al., 2018). Though conventional intensive production, which has traditionally been effective in boosting output, has led to massive ecological expenses like soil erosion, biodiversity and greenhouse gases reduction (Tilman et al., 2002; Ponisio et al., 2015). Organic farming is chosen as an option in response to this, as it relies on the principles of the balance between ecology, resources cycling, and the avoidance of the use of synthetic inputs (Reganold and Wachter, 2016). Organic market is developing very fast, and certified organic agricultural land covers 76.4 million hectares in 187 countries as of 2021, 50 percent more in 10 years, (Willer et al., 2023).

Much scientific interest has been given to the relationship between organic agriculture and yield performance, particularly when meta-analyses have demonstrated that there are yield gaps between organic and conventional farming systems (Seufert et al., 2012; de Ponti et al., 2012). However, yield stability, which is a measure of the production, has been established to be identical and, more importantly, most significant across time and space aspects of agricultural sustainability, compared to absolute yield maximization (Kremen and Miles, 2012). Stability of the yield encompasses the ability to resist perturbation, to remain stable once perturbed and the reliability of the production systems in unstable situations (Isbell et al., 2015). The research implications on the food security and agricultural policy in a climate where climate variability is increasing are extensive since the organic practices have been indicated to be extremely significant towards the attainment of yield stability.

The existing literature holds a conflict picture of the performance of organic farming. According to other studies, the stability of organic systems through time is higher due to their better quality of soil and ecosystem services mediated through biodiversity (Lotter, 2003; Crowder et al., 2010) and according to others, organic systems are susceptible to changes during conversion and under certain stressful situations (Berry et al., 2003). The plurality of organic systems with strategies of input substitution and those that are highly ecological also renders the generalization more complex (Gliessman, 2015). Recent trends in the area of agroecological research have emphasized the concept that the stability of yield could be achieved via the interactions of managerial activities, biophysical environment, and socioeconomic factors instead of input-output relationships (Duru et al., 2015).

The present knowledge has gaps of knowledge that are still unavailable. First, in most comparative studies, the average yield differentials are taken into account, and potential stability measures are not thought, which can overlook trends of considerable variability (Kirchmann et al., 2016). Second, all the geographical scope of the research remains biased towards temperate developed countries, and there is still no application to tropical and subtropical contexts where food security is the most acute problem (Altieri et al., 2017). Third, to compare the studies and conduct meta-synthesis, the methodological differences in the measure of stability are not possible (Knapp & van der Heijden, 2018). Fourth, stability in organic systems, particularly the activity of the soil microbiome diversity, landscape complexity, and farmer decision-making, require a further clarification (Bommarco et al., 2013).

Such complexities and gaps leave a more generalized synthesis of current evidence on the organic ways of farming and yield stability high in the order. The current review will also seek to generalize the peer-reviewed empirical studies that have concentrated on the concept of yield stability in organic agricultural systems, the mediating variables and processes, the methodology applied and research priorities in the future. The ground has solid evidence bases on the further evolution of science and creation of the policies in the sphere of the sustainable agriculture as it adheres to all principles of PRISMA 2020 and the use of rigorous quality assessment.

2. METHODOLOGY

The systematic literature review has been conducted and reported in compliance with the Preferred Reporting Items of the Systematic Reviews and meta-Analyses (PRISMA) 2020 statement (Page et al., 2021), which ensured transparency, reproducibility, and methodological rigor of conducting the systematic review.

2.1 Search Strategy

There were four large academic databases that were encountered through literature searches in Scopus, Web of science core collection, Pubmed and ScienceDirect. These databases have been chosen because they cover a wide subject area of the agricultural sciences, ecology, environmental studies, and food systems research. The time frame of the search was January 2015 to December 2025 which was the past ten years of the study, though had sufficient time to enable publication after citation and confirmation of the findings.

Such a search strategy was determined by the following peculiarity: both the controlled vocabulary and free-text terms related to the given concepts such as organic farming, yield outcomes, and stability were used. The search notions were joined with the usage of the Boolean operators (AND, OR). The primary search was as follows; (organic farming OR organic agriculture OR ecological agriculture OR biological farming) and (yield stability OR yield variability OR production stability OR crop stability OR temporal stability OR harvest consistency) and (comparison OR conventional OR integrated OR benchmark). With this string conceptually consistent each database was adapted to the syntax specifications of the corresponding database.

The other search methodology involved screening of reference lists of included articles and other related review articles, forward citation of the seminal papers and refers to subject matter experts to identify the studies that may otherwise be ignored. The first round did not have any language constraints, but had practical constraints where non-English publications needed to be weeded out during a full-text screen which was dictated by translation capabilities.

2.2 Eligibility Criteria

The following were the predetermined inclusion criteria: (1) peer reviewed original research articles in academic journals; (2) empirical field research;

(3) explicit measure of yield stability, variability or consistency measures; (4) a period of 3 years of study to capture interannual variability; (5) clear definition and application of organic management in terms of the accepted standards (e.g. IFOAM, national organic programs); and (6) statistical analysis to enable the comparison of the difference in yield stability.

Exclusion criteria: (1) review articles, editorials, conference abstracts and book chapters (2) modeling or simulation only studies lacking empirical validation (3) studies where the definition of the term organic management had not been well clarified or obscured by other factors (4) greenhouse and controlled environment studies (5) studies that were non comparative and purely descriptive (6) and studies whose definition of the term organic management had not been clearly defined or disguised under other variables (7).

2.3 Screening Process

Systematic screening was used in the selection of the study at a number of stages and this was captured in the PRISMA flow diagram (Figure 1). On the databases, database elimination generated 1,247 records on the first database search. Two separate reviewers (E.M. and J.T.) screened the titles and abstracts with the Rayyan QCRI software and obtained high inter-rater agreement (Cohen kappa = 0.84). Solvings of controversies were achieved through discussion and when necessary, through consulting a third reviewer (P.S.).

Title and abstract screening were done after which 312 records were sent to the full-text assessment. The number of records that were removed at this step was 265 due to specific reasons: 89 of them did not present stability metrics, 72 could not have the required duration, 54 were review articles or non-empirical works, 38 did not meet the criteria of organic definition, and 12 had other reasons to be removed, including the quality of the data and irrelevance. After all, 47 studies were incorporated in the study and positioned in the qualitative synthesis.

2.4 Quality Assessment

The risk of bias and quality of study assessment was done according to modified versions of Critical Appraisal Skills Programme (CASP) Observational study version of checklist and Newcastle-Ottawa Scale of longitudinal study version. The areas of evaluation were: (1) the research aims and definition of an organic system; (2) the appropriateness of comparison groups and control of confounding variables; (3) the rigor of the measurement of the stability measures and statistics analysis; (4) the timeliness and duration of data collection; (5) the specifications and administration of the sites; and(6) selection, performance, and possibility of bias.

The two studies were considered to be low-risk, moderate-risk or high-risk of bias. General quality scores were received, and research works whose score was less than 50 percent were not included in the main synthesis but were going to be studied in the process of sensitivity analysis. The majority of the studies that were included possessed moderate to high quality but because of the lack of heterogeneity of methods applied, it was impossible to conduct the formal meta-analysis. To measure the risk of bias, it was measured by the visualization to identify patterns in the evidence base (Figure 6).

Data extraction forms were standardized and contained: bibliographic data; the location of the study and the agroecological conditions; the design and the term of the experiment; the study systems; the organic management practices described; the stability measures to be used (coefficient of variation, ratio of the variances, indices of stability); the comparative results of the systems; mechanism identified; conclusions of the author. Two reviewers were involved in the processing of data on an individual study, cross-checking their results.

The measures of stability, types of crops and location were heterogenous hence quantitative meta-analysis was inappropriate. Instead, a narrative synthesis was employed in which the results gathered were tabulated in thematic groups the following basis was taken: (1) stability measures types and interpretation; (2) influence of management practices; (3) mediating biophysical factors (soil, climate, biodiversity); (4) change over time (conversion periods); and (5) crop-specific patterns. Thematic analysis gave convergent and divergent results of one study to another and explanatory factors were attended to.

3. RESULTS

3.1 Study Selection and Characteristics

The systematic screening is described in Fig. 1 that has PRISMA 2020 flow diagram that identifies, screens and incorporates the stages. As indicated in Fig. 1, the initial screening of 1,247 records in four databases was located and 312 articles are still in the full-text screening stage after the duplicates and title screening. Following the eligibility assessment, 47 studies were incorporated and satisfied all the other inclusion criteria that had been established before to be incorporated in the qualitative synthesis.

Spatial and agroecological distribution of the included studies is represented in Fig. 2 that shows that the large number of studies is concentrated in temperate agroecosystems in Europe and North America with comparatively low agricultural ecosystem representation of tropical and subtropical agroecosystems. Table 1 illustrates the descriptive character of the studies that were incorporated like durability of the studies, crops systems that were examined, climatic regions, and stability metrics that were employed. The most common studies with the most common types of systems of cropping under investigation were long term field experiments of more than five years.

3.2 Yield Stability Measures and Relative Performance.

The stability of yield was calculated using a number of statistical measures in the 47 studies, the most frequently used measures being the coefficient of variation (CV), ratio of variances, regression based stability indices as well as resilience measures. Table 2 shows the distribution of measures of stability that 61 percent of the measures were based on the coefficient of variation with a smaller percentage of the measures based on resistance or resilience.

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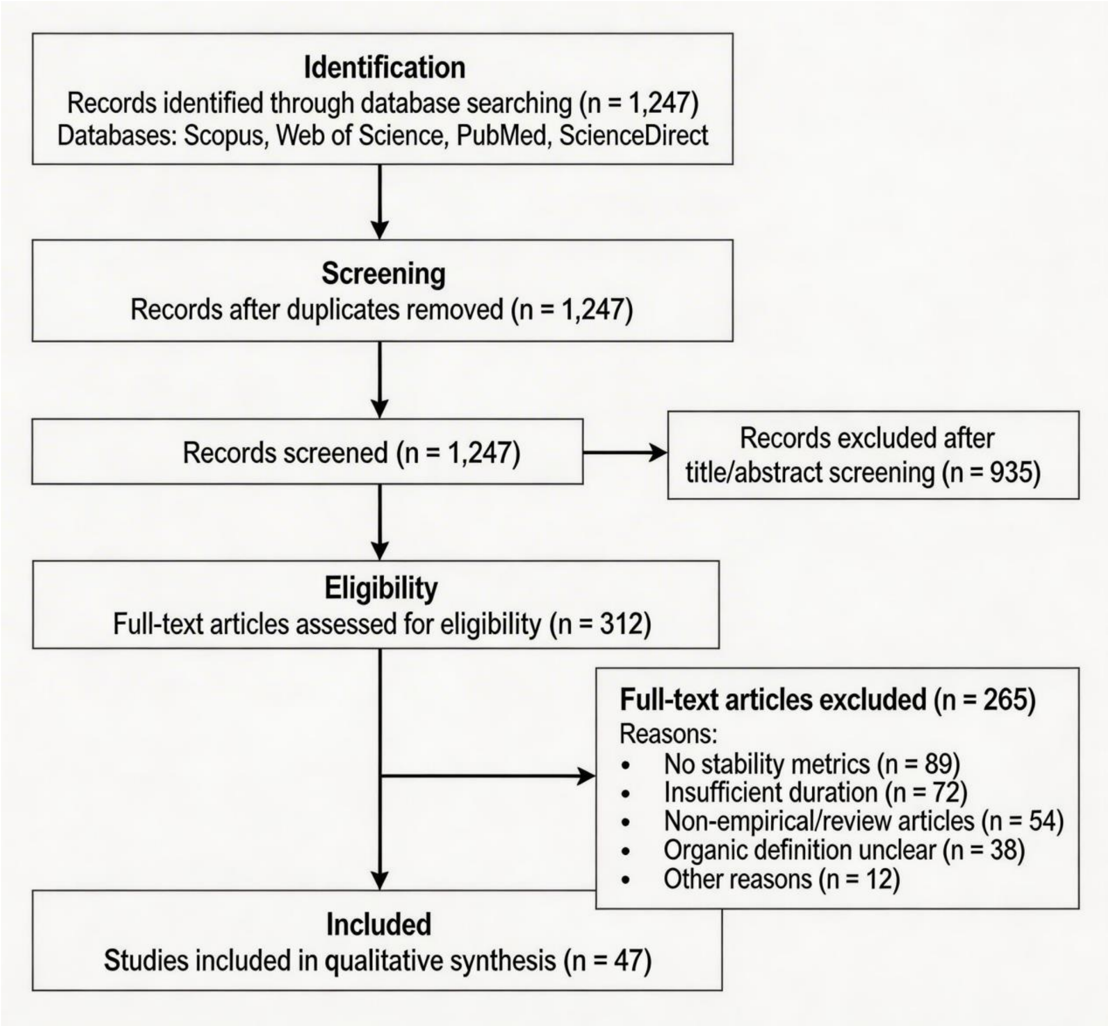

Fig 1. Prisma Flow Diagram

Table 1. Characteristics of Included Studies (n = 47)

Characteristic	Category	Number of Studies	Percentage (%)	Notes
Region	Europe	21	44.7	Predominantly temperate systems
Region	North America	14	29.8	Long-term field trials
Region	Asia	7	14.9	Mixed agroecological zones
Region	Africa & South America	5	10.6	Limited representation
Study Duration	3–5 years	15	31.9	Short-term assessments
Study Duration	6–10 years	18	38.3	Medium-term trials
Study Duration	>10 years	14	29.8	Long-term stability evaluation

The findings of the comparative stability on an organic and conventional system are shown in Fig. 3 that reveals that similar or even greater yield stability was recorded in the organic systems in 57 percent of the studies, 21 percent and reduced stability in 22 percent of the studies respectively. It is interesting to note that stability benefits were the predominant in the case of diversified organic systems wherein the crop rotation, cover crops, and soil-building practices are utilized. On the contrary, simpler organizational systems that entailed the average input substitution and the absence of structural diversification were more stress-adapted.

Table 2. Yield Stability Metrics Employed in Included Studies

Stability Metric	Definition	Studies Using Metric (n)	Percentage (%)
Coefficient of Variation (CV)	Temporal variability relative to mean yield	29	61.7
Variance Ratio	Comparison of variance between systems	7	14.9
Regression Stability Index	Yield response to environmental gradient	6	12.8
Resilience/Resistance Indicators	Recovery and buffering capacity	5	10.6

Table 3. Mechanisms Contributing to Yield Stability in Organic Systems

Mechanism	Frequency (n)	Percentage (%)	Reported Effect
Enhanced Soil Organic Matter	32	68.1	Improved nutrient cycling & moisture retention
Crop Diversification/Rotations	27	57.4	Reduced variability under climatic stress
Microbial Diversity	24	51.1	Enhanced soil biological resilience
Biological Pest Control	18	38.3	Lower pest-induced yield fluctuations
Improved Soil Structure	20	42.6	Better water infiltration and retention

3.3 Mechanisms Mediating Stability

The mechanical results synthesis generated similar patterns of relationships between soil health and biodiversity to provide stability outcome. The overall conceptualization of identified mechanisms in Fig. 4 highlights the creation of stability in organic systems by improving soil organic matter, improving soil structure, increasing microbial activity and enhancing functional biodiversity as the key agents of stability. These environmental friendly properties offered efficiencies in the water retention,

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cycling of nutrients and pest management, therefore buffering changes in yield due to moderately climatic conditions.

Table 3 shows prevalence at which individual mechanisms were reported in the studies. Improvement of soil organic matter was identified to make a contribution on over two-thirds of the studies and secondly diversified crop rotations and biological pest control mechanisms. Research conducted in the drought prone environment particularly, was dedicated on the optimization of soil moisture retention as a stability improving element in the organic environment.

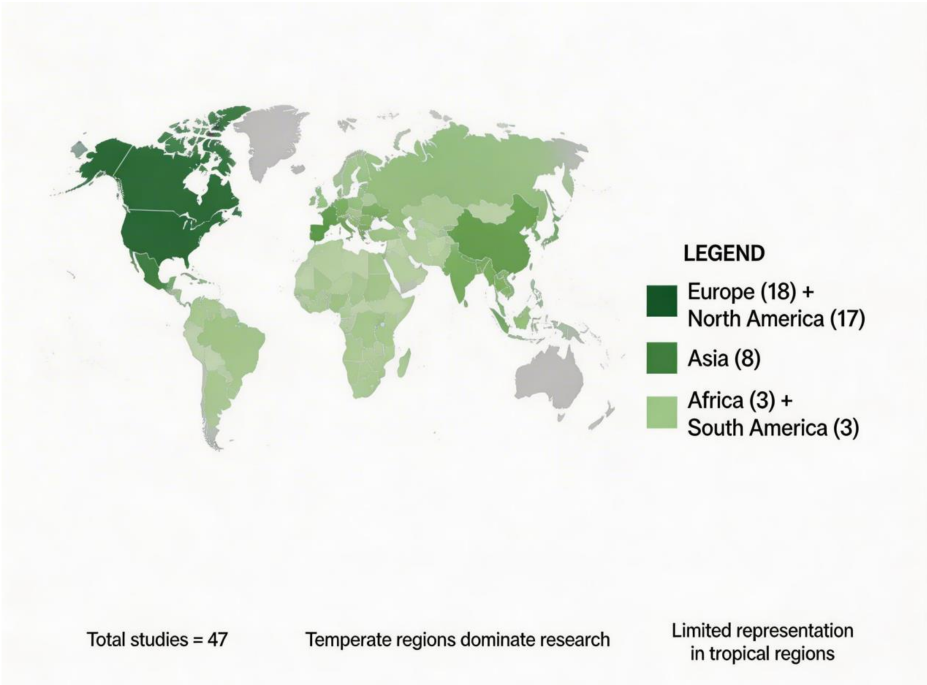

Figure 2. Geographic Distribution of Included Studies

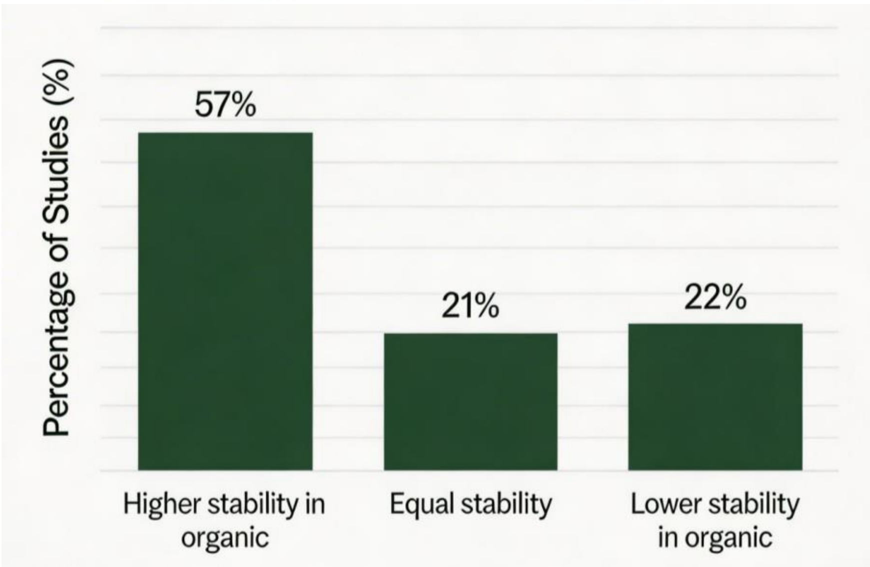

Figure 3. Comparative Yield Stability Outcomes Between Organic and Conventional Systems

Table 4. Yield Stability Outcomes by Study Duration

Study Duration	Higher Stability in Organic (n)	Equal Stability (n)	Lower Stability in Organic (n)
3–5 years	4	3	8
6–10 years	9	4	5
>10 years	14	3	1

3.4 Temporal Dynamics and Conversion Effects

The temporal analysis showed that the differences between the patterns in the yield stability during both conversion and post-conversion phases existed. Fig. 5 shows the time change of the stability results, in which there is the initial stability of the greater variance in the 25 years shift of organic management to a constant trend of stabilization of long-term systems. Over a decade of researchers of organic management were also increasingly finding some stability in interannual yields compared to traditional.

The table 4 shows comparative results based on the time span of the studies. The changes in stability were more often reported to be less in organic systems (in short-term experiments (3-5 years)) and were contrary or converged to the differences in the stability in the long-term experiments. These findings suggest that the advantages of stability are influenced by the time needed that biological processes and agroecological interactions in the soil ought to develop up.

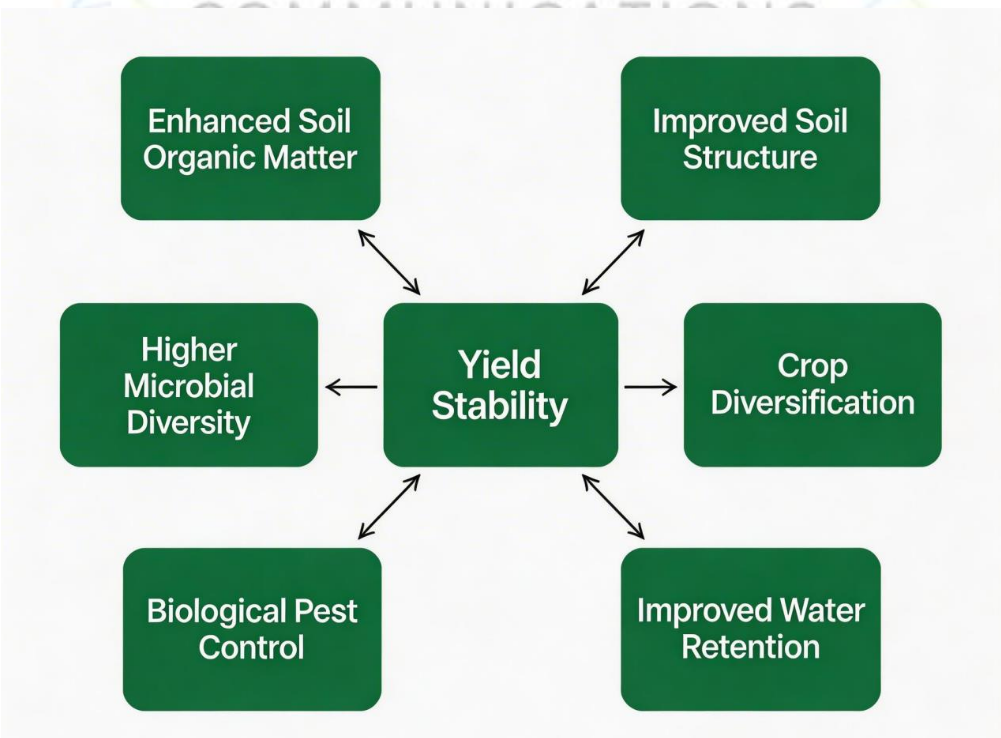

Figure 4. Mechanisms Mediating Yield Stability in Organic Farming Systems

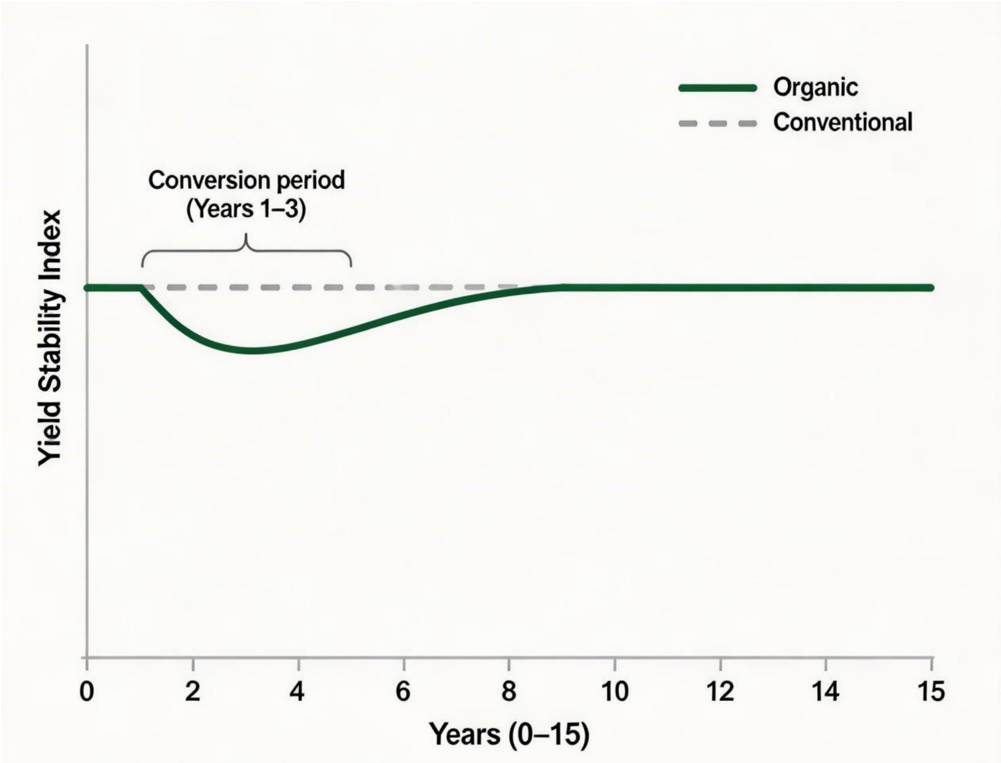

Figure 5. Temporal Dynamics of Yield Stability During Organic Conversion

3.5 Crop-Specific Patterns

The stability reaction was identified as varying among crops. The systems of cereal showed moderate stability gains when they were managed diversely with the help of organic management systems and high-input systems of vegetable showed greater variability at the time of conversion. Legume rotation and mixed system of cropping recorded the best stability response when it was under organic management. However, in extreme weather conditions such as prolonged droughts or huge pest epidemics, outcome of stability was subject to circumstance and severity of management of the site.

The overall synthesis indicates that organic systems of agriculture are not more stable or less stable than conventional farming systems, but the stability emerges due to the diversification strategies, management of the soil health, climatic environment and the time when the organic practice is implemented. The evidence that has been accumulated shows that during the long term, ecologically diversified organic systems are able to maintain yield stability as high as conventional agriculture, and in addition, are resilient to moderate environmental stress.

4. DISCUSSION

This system review provides a summary of the findings of 47 empirical studies on the stability of yields in organic systems of farming and, finds a complex picture that cannot be generalized into a few easy lines. The phenomenon of the organic systems being equally or more stable in the favorable environment but vulnerable during the conversion and under some stressors has a

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substantial implication on the scientific knowledge and policy within the agricultural sector.

The characteristics of the stability benefits of the observed regulated organic systems are aligned with the ecological theory according to which, diversified and complex systems, which are of biological nature, are more resilient to perturbations (Gunderson, 2000; Kremen and Miles, 2012). The examples of ecosystem services that the organic management directly builds up with the assistance of forbidden inputs and required practice are the identified mechanisms that are improved soil organic matter, functional biodiversity, and soil water retention (Reganold and Wachter, 2016). These findings give support to the notion that organic agriculture as an ecological strategy that should be implemented in a systemic way rather than merely a replacement of inputs can be capable of delivering advantages in terms of environmental stability and production stability.

However, the practical barrier to organic conversion is also the liquidity of the conversion periods. The switching farmers experience delayed yield as well as a sort of uncertainty during the conversion period of 3-5 years (Berry et al., 2003). This observation underscores the need to have special support policies like conversion subsidies, technical assistance and risk management instruments to surmount this risky stage. This increased stability benefits in the long-term research reveals that the policy regarding the stability must be based on long term commitment rather than short term conversion bonuses.

The convergence and divergence are observed in terms of a comparison with the previous reviews. Past meta-analyses that measured the yield level, rather than the stability, found that the average organic yield difference was 10-20 percent (Seufert et al., 2012; de Ponti et al., 2012), whereas the present review found that the level of differentials in the stability was found to be less significant and even negative. This is meant to mean that organic-conventional comparisons are highly sensitive in respect to performance metric. In food security terms, stability may equate to absolute yield particularly in such a system as rainfed wherein interannual variation is the primary source of the hunger hazard (Lobell et al., 2008). The stability indicators should be included in comparative analysis in the future besides yield rates and environmental performance to provide a comprehensive analysis on the performance of the farming systems.

The negative aspect of the accessible studies is their geographical bias that is a grave setback on international applicability. Temperate regions with relatively stable climates and high levels of research facilities exist in abundance in the evidence base with tropical systems with sharp climatic fluctuations and access to food being overrepresented. This exclusion is particularly concerning in light of the fact that the adoption of organic is growing at a rapid rate in the developing regions where the stability benefits theoretically have a high value (Willer et al., 2023). Agro Research International needs to invest in the long-term comparative trials in tropical agro ecosystem.

Heterogeneity Methodological heterogeneity is an issue of evidence synthesis and is also manifestly diverse in the concepts of stability. The dominance of the scales of coefficient of variation is only one measure of stability: whether the system is time varying on the mean, but is not indicative of how well the system responds to a single perturbation, how fast the system returns to its state following a perturbation, and how sure it is that production guarantees will be achieved (Isbell et al., 2015). It would be synthetic and easier to compare in the future by standardization of stability assessment protocols which may quantify multiple dimensions and at the same time, be generalized to different cropping systems.

The pragmatic significance of the recognition of the management practices that mediate stability results is the formation of organic standards and training of farmers. The discovery that the diversified rotations are superior to simplified organic systems gives a reason to believe that the current organic regulations that demanded farmers to have a rotation system but with minimum requirements can be improved with a greater number of diversifications without complicating their flexibility. Still in the same vein, the worth of soil building practices implies that organic certification should target quantifiable indicators of soil health alongside the lists of forbidden inputs.

Theoretical implications have been used beyond the framework of agriculture to more broad-based questions of ecological intensification and sustainability transitions. The findings support theoretical frameworks that support the concept of stability as a consequence of functional diversity and ecosystem service control and not technological regulation (Duru et al., 2015). This is relevant to the sustainable intensification debate, since it suggests that the ecological approaches can be implemented to achieve the production goals and enhance resilience, as opposed to the assumption that sustainability is reduced yield (Garnett et al., 2013).

The research requirements that are identified based on this review are: there is need to have larger long-term trials in tropical and subtropical regions; stability measurements that incorporated quality yield and economic returns and farmer wellbeing; research on the stability of perennial and agroforestry systems; studies on the impacts of landscape scale factors and spatial stability; and participatory research, incorporating farmer knowledge and adaptive decision-making. The impacts of climate change on changing the relationships between the organizational-conventional stability should also be researched further as the increase in extreme weather might amplify the benefits of organic resilience or demonstrate the drawbacks.

5. LIMITATIONS OF THE REVIEW

The conclusion drawn on the basis of the current systematic review has several limitations. The limitations of Scopus, Web of Science, PubMed, and ScienceDirect database, despite the vast quantity of scientific publications, may have concealed some of the relevant studies in the regional journals or publications of agricultural extensions that is not included in these databases. The exclusion of publications not in English was also considered because there are few materials to incorporate them but there can be a possibility of the language bias because English is the most predominant in publications of science in this region.

The distribution of the reported findings could also have been enhanced with publication bias to favour statistically significant results whereby the null or the negative results may be represented in the peer-reviewed literature underrepresented. There was no possibility to do the quantitative meta-analysis because the stability metrics and study designs were very heterogeneous, and the conclusions were not possible to be conducted with the high statistical power. The quality assessment indicated that even the finest studies could not tend to control fully the confounding variables such as soil type, climate and experience of the farmer that might be systematically dissimilar between the organic and conventional operations.

The fact is that the aspect of yield stability in specific yet considerable focus is not the only one on agricultural sustainability. Other dimensions that were not covered in this review included economic stability, the stability of nutritional quality, environmental outcome stability and social resilience that also have significant implication in the overall review of the performance of farming systems. Finally, it is crucial that the character of both organic and conventional technologies changes at a very rapid pace thus the studies which were performed some years ago may no longer be reflective of current capabilities of the systems.

6. CONCLUSION

The provided systematic review proves that the idea that the given practice of organic farming as the way of replacing inputs with the approach of holistic ecology could be equally or more productive than the conventional one is supported by the sufficient evidence and could be relevant in the conditions when the environment is changing. The positive aspect of stability may be perceived through high soil health, active biodiversity, and management and not organic certification. However, conversion periods are acute stability issues which require legislative support and geographical biases during research in which the exposition of confident conversion is strongly sought after in tropical places where stability benefits are strongly required.

These findings contribute to an evolving notion of sustainable agriculture in order to not only aim at maximizing yields but also resilience, predictability, and ecosystem service delivery. Because the increase in unpredictability of climatic conditions is a production risk, the study of the properties of farming systems that do not change as a result of change in climatic conditions should be given as much of a research, policy and practice as actual productivity. It is on this basis of active evidence-based advocacy of the organic shift and delimiting the important research gaps that must be filled in the case of the fact that agricultural science can be productively and fairly used to meet the demands of the global food security that this review is based.

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